Title
Childhood food insecurity: exploring long-term impacts and a public policy mitigation strategy

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Publication Date
2020

Peer reviewed|Thesis/dissertation

Childhood food insecurity: exploring long-term impacts and a public policy mitigation strategy

by

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A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Epidemiology

in the

Graduate Division

of the

University of California, Berkeley

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Spring 2020

Abstract

Childhood food insecurity: exploring long-term impacts and a public policy mitigation strategy

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The physiological, biological, and metabolic impacts of food insecurity experienced in childhood may influence health throughout the lifecourse. In this three-paper dissertation, we explore whether a cohort of Black and White women's experiences of childhood food insecurity are associated with their weight in young adulthood, their weight in midlife, as well as the weight of their children. In addition, we also investigate whether a direct federal income transfer program targeting families with children can improve food insecurity parameters in Canada, particularly among economically vulnerable groups.

Paper 1 and Paper 2 derive data from one site of the National Heart, Lung and Blood Institute Growth and Health Study (NGHS). NGHS is a longitudinal cohort that recruited 883 9-10-year-old Black and White girls in 1987/8 from Contra Costa County, California. Participants provided health, lifestyle, and anthropomorphic data from annual clinic visits and questionnaires for ten years (through 1997/8). From 2015-2019, researchers re-recruited 624 original participants (ages 36-43) and 559 of their children (boys and girls, ages 2-17) to participate in a second wave, which implemented a retrospective measure to gauge the frequency in which the quantity and diversity of their available food was impacted by resource shortages from ages 5-11. We used responses to characterize experiences of childhood food insecurity.

Paper 1 assesses the relationship between childhood food insecurity and Body Mass Index (BMI) in young adulthood (age 18-20) and midlife (age 36-43) among Black and White women. We identified a higher average BMI among Black women reporting moderate childhood food insecurity than Black or White women reporting full food security in young adulthood (N=593) that abated by midlife. As well, a substantially larger average BMI among White women reporting severe childhood food insecurity compared to White women reporting full food security during midlife (N=617). These findings suggest that childhood food insecurity may have a lasting association with weight status and that racial differences and age moderate the relationship between childhood food insecurity and BMI.

Paper 2 investigates whether maternal childhood food insecurity is associated with odds of overweight/obesity among offspring (N=483), presenting findings for effect modification by age (continuous), current household food security status (food secure vs. food insecure) and maternal race (Black or White). We found no significant difference in the odds of overweight/obesity among most levels of food insecurity, but significantly lower odds among children whose mothers reported moderate child food insecurity. This relationship was strongest

among children currently living in food secure homes, with White mothers, and between the ages of 2-5, respectively. We believe that mothers' desire to protect their children from their own adverse experiences may serve as a protective factor against food and dietary behaviors that may increase overweight/obesity risk.

Paper 3 assesses whether the roll-out of the Canada Child Benefit (CCB), a federal direct income transfer program, offered protection against food insecurity among Canadian households with children among three groups with different income thresholds: households reporting any income (N=41,455), the median income or less (N=18,191) and the Low Income Measure (LIM) or less (N=7,579). Data are derived from the Canadian Community Health Survey (CCHS), an annual, cross-sectional study that collects health, sociodemographic, and health-related information at the sub-provincial level from a representative sample of Canadians.

Households with children experienced greater drops in the likelihood of experiencing severe food insecurity following CCB than those without, most dramatically among those reporting the LIM or less, which suggests that CCB disproportionately benefited families most susceptible to food insecurity. As well, that food insecurity may be impacted by even modest changes to economic circumstance, speaking to the potential of income transfers to help people meet their basic needs.

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Acknowledgments

I would like to thank my dissertation committee for bringing this document to life: Barbara Laraia, Patrick Bradshaw, and Darlene Francis. Barbara, your ability to beautifully weave a narrative from my jumbled thoughts will never cease to amaze me. Thank you for your masterful edits, excitement, and mentorship throughout the writing process as well as my tenure as your advisee. Patrick, I'm so appreciative of the energy you put into helping me ensure that my analyses were methodologically sound. Thank you for your guidance and entertaining my endless list of questions. Consider the p-value benched. And Darlene, thank you for centering the ultimate goals of public health and bringing our intentions as researchers front and center; you have made me a more thoughtful epidemiologist and person. I also owe a special thank you to Valerie Tarasuk, whose invaluable insights and mentorship shaped Paper 3. I'm grateful to you for the opportunity to work together and your relentless pursuit of justice.

I would like to recognize Art Reingold, Jack Colford, and Alan Hubbard for serving on my qualifying exam committee. As well, thank the 2016 and adjacent Epidemiology cohorts for their thoughtful feedback in and outside of class over the past four years. To the women who have kept me and our department(s) afloat – Janene Martinez, Carol Hui, Sumaiya Elahi, and Lauren Krupa – your assistance has been invaluable. Thank you, thank you!

There would be no National Growth and Health Study (or dissertation) without Kristy Brownell, Rachel Perera, Hiba Abouslemain, Ingrid Feng, Sabrina Clermont, Barbora Jurigova, Robin Friebur, and our committed team of volunteers. I am so lucky to have worked with each of you. The heart, humor, and intelligence you brought to the study is remarkable. Thank you for giving NGHS your all and peppering my life with such beautiful friendships. Considerable thanks are also in order to the Spring 2019 Tarasuk Lab, Toronto RDC, and University of Toronto staff who made my Canadian research venture possible. In particular: Fei Men, Andrée-Anne Fafard St. Germain, Carmina Ng, and Rory McKewan.

To the Laraia Lab, past and present – May Lynn Tan, Tashara Leak, Irene Headen, Ryan Gamba, Chris Chau, and Dorothy Chiu – I am grateful for your sage advice and the remarkable example that each of you has set. Dorothy, if only our time together weren't cut short! Chris, I owe you the world for the steadfast patience, kindness, and joy you brought to our little office. Thank you for both being a snack and helping me fetch them. Speaking of snacks... Shalika Gupta, you are a brilliant epidemiologist and pal. My brain, heart, and stomach are so grateful to you for everything. And Jung Kim. I'm not even sure where to begin, dear friend. You have brought so much light and love to this experience. Thank you for being you and leaving your mark on Cal, and the academy at large. It desperately needs you.

To past advisors and forever mentors – Kris Madsen, Mahasin Mujahid, Robin Flagg, Heidi Gjertsen, Dan Solomon, Emily Lo, Doug Brugge, Kevin Irwin, and Edith Balbach – thank you for investing in me and my future. I hope to do well by you and the future of public health. And to my students: you've been an inspiration. Thank you for challenging me AND the status quo. I can't wait to see how you change the world.

My loved ones outside of the ivory tower – you know who you are – I could have never gotten here without you. Thank you for reading my works in progress, feeding me treats 'n memes, making it across city, state, or country lines to be by my side, and patiently listening to my self-righteous rants over the past six years, in addition to the 24 before that. You lift my spirits and warm my heart. I eagerly await our next hug(s).

I also owe a significant thank you to my generous funders and grantors: the Soroptimist Foundation, National Institute of Health, Joannah and Brian Lawson Centre for Child Nutrition at the University of Toronto, Canadian Institutes of Health, and the Edward Hildebrand Fellowship awarded by the UC Berkeley Canadian Studies Department for their generous financial support.

Lastly, I would like to acknowledge the participants of the National Growth and Health and Canada Community Health Studies. I am grateful for your time, efforts, and trust.

Introduction

Childhood food insecurity and obesity

Food insecurity is defined by the US Department of Agriculture (USDA) as a lack of consistent access to enough food for an active, healthy life.[1] In 2018, it impacted approximately 11.1% of US and 12.7% Canadian households, disproportionately affecting low-income families with children.[1,2] Given its demonstrated impact on dietary quality, quantity, and subsequent eating behaviors, its impact on children's overweight/obesity risk has been of particular concern.[3-16] Numerous studies have assessed their coexistence,[16-23] but few have explored its long term implications.

Food insecurity is strongly associated with the consumption of nutrient-poor and calorie-dense foods, compensatory food binges following periods of intermittent deprivation, as well as elevated levels of chronic stress, which may all lead to metabolic dysregulation. [3-15, 24, 25] Individually and collectively, these factors can substantially increase susceptibility to excess weight gain. Their effects may be particularly potent in childhood. Changes to eating behaviors, food preferences, and/or metabolic health may solidify during this time, with the potential to impact health throughout the lifecourse and into subsequent generations.[26-28]

Human and animal studies have demonstrated that there is an association between females' early experiences of food insecurity and the presence of overweight/obesity risk factors in adulthood, as well as among offspring.[16,29-31] A study of multi-generational mother-child bonnet macaque monkey dyads found that intermittent food deprivation – mimicking human experiences of food insecurity – among offspring's early life was directly associated with maladaptive eating behavior and weight gain of these offspring in adulthood, long after the experience had passed.[29] In addition, researchers also identified metabolic dysregulation (favoring weight gain and retention) among formerly food insecure mothers as well as their offspring.[29,30] Two qualitative studies identified similar eating behaviors among mothers who had experienced food insecurity in early life; one found that these behaviors were also visible among their children (though it had no effect on either's weight (N=30)).[16,31] To our knowledge, there is an extremely limited body of literature exploration the long-term effects of this relationship, with no conclusive evidence to substantiate or negate it.

The first two aims of this dissertation build upon the literature by exploring the association between childhood food insecurity and excess weight in young adulthood (age 18-20), midlife (age 37-42), and offspring (age 2-17) among a cohort of Black and White women and their children. We believed that the impacts of structural racism would differentially impact women's experiences of food insecurity as children, as well as their long-term weight trajectory, so we explored how race modified this relationship among adult participants. Among offspring, we assessed how maternal race might influence this relationship in addition to child's age and several sociodemographic factors associated with excess weight risk: sex, current household food security status, and mother's weight.

Past food insecurity measurement

One potential challenge to this assessment is the dearth of standardized, practical childhood food security measurements. The USDA's 18-item Household Food Security Survey Module (HFSSM),[32] considered the field's gold standard, contains 8 items regarding childhood food security specifically but faces several limitations in capturing a child's true experience: 1) it measures the experience of a household (which may vary person-to-person) rather than that of one specific child 2) a parent or guardian must respond on behalf of their children, rendering the data prone to misreport or bias 3) measurement windows are restricted to the past 12 months, forfeiting the ability to measure long-term exposure without engaging in a longitudinal study and 3) several items lack concrete or universal interpretation, such as those pertaining to concerns about food and those regarding a balanced diet. Though the 8-item child items can also be used as a standalone measure,[32] the items also fall prey to many of the same issues – as does the validated 9-item scale that was created for among youths 12 and older to self-report.[33] Though a more precise tool, the latter 1) cannot be administered to children under 12, precluding measurement during key developmental windows in early childhood, and 2) is recommended to cover only the past thirty days,[32] eliminating the possibility of assessing chronic exposures. The 12-item Cornell/Radimer scale, of which the 18-item HFSSM is modeled from, has been similarly used to gauge childhood food insecurity and shares the same limitations.[34]

A more recently developed tool, the Child Food Security Assessment (CSFA),[35] directly and holistically assesses food insecurity among children and adolescents. It focuses on the cognitive, emotional, physical, and reactive response to indications of food insecurity. While these dimensions provide a more comprehensive understanding of the ways in which children are impacted by this experience, the CFSA may pose challenges for younger children (<8 years old, as indicated by the validation study) who may not grasp the measured concepts. As well, similar to the 9-item USDA HFSSM youth survey, it may be challenging to capture experiences spanning over large swaths of time. To our knowledge, additional measurements of childhood food insecurity used in the US are based off of non-standardized interview questions, making inter-study assessments difficult. Given the challenges and financial constraints posed by conducting repeated measurements, exploring the use of a validated, retrospective measurement is key for improving our understanding of the long-term impacts of childhood food insecurity.

We explored Aims 1 and 2 by analyzing responses to a modified version of the validated Past Food Insecurity Scale,[31] which retroactively captures chronic experience(s) of food insecurity between the age of 5-11. This measure focuses on reductions in food quantity and diversity by gauging the frequency in which the participant in question identified food shortages among themselves, their parents, and their families, rationed meat, and involuntarily ate the same foods routinely. While it does not explicitly ask about feelings of stress, we believe they are likely to be experienced in tandem with indications of deprivation and subsequently captured by these items, as suggested by the scoring of the HFSSM. The scale is concrete, assesses a child's individual experiences, and captures long-term exposure; though also imperfect for those reasons, it serves as a practical and cost-effective tool for gauging the longitudinal implications of child food insecurity. In addition to researching our study questions, this dissertation serves the dual purpose of validating and testing this measure in a new study population as well.

Food insecurity mitigation

There are a number of large-scale policies and programs to mitigate food insecurity among households with children, but the persistence of this condition warrants exploration of their efficacy and potential avenues for improvement. In the US, the Supplemental Nutrition Assistance Program, Special Supplemental Nutrition Program for Women, Infants, and Children, and National School Lunch and Breakfast Program(s) comprise the vast majority of federal assistance for families.[36] Each program centers around food purchase and/or receipt; eligibility requirements and the application process varies by state or region, as does eligible food availability, quality, and cost. In contrast to the US, Canada has historically addressed problems of economic hardship through direct income transfer programs in which eligible individuals apply through one of several streamlined processes and begin receiving monthly direct deposits. Charitable programs and donations (e.g., food banks) provide additional assistance. In some instances, notably seniors' pensions, the income transfer approach has provided strong protection against food insecurity.[37] But, the steady prevalence of food insecurity among other Canadian populations has suggested that additional measures are necessary to eradicate this socioeconomic condition.[2]

On July 20, 2016, the federal government implemented the Canada Child Benefit (CCB) to help strengthen low- and middle-class households with children.[37] The policy provides tax-free financial assistance based on their household income and number as well as age of children. During its first year of implementation, it issued an average of $6,800 (CAN) to eligible homes; $2,300 more per year compared to the previous multi-pronged, universal assistance programs that ran under the prior administration.[38] Initial estimates stated that this legislation would reach 90% of Canadian families and lift 300,000 children out of poverty[38] – presumptively, lowering rates of food insecurity as well. The third aim of this dissertation is to assesses whether CCB is associated with changes in the prevalence of food insecurity during its first year of implementation among households reporting any income, the median income or less, and the low income measure or less.

Formal assessments of policy interventions at this scale are still in their infancy; our findings will help to elucidate whether direct income transfers are effective at reducing the prevalence of food insecurity among households with children, with a focus on economically vulnerable populations. As the efficacy of both countries' federal assistance policies are being contested, it is germane to identify whether this is an effective strategy. We hope our findings will be useful in informing the future of CCB, along with analogous programs in the US.

Paper 1: Childhood food insecurity and weight status into young and middle adulthood

INTRODUCTION

The prevalence of excess weight in the United States has reached an all-time high: nearly 40% of adults are now classified as obese.[39] The individual and societal consequences are substantial. Obesity is strongly correlated with cardiovascular disease, Type-2 diabetes, cancer, mental illness, and permanent disability as well as all-cause mortality.[40] Resulting obesity-related medical expenditures are estimated to be between $147 billion and $210 billion dollars per year.[41] These do not include indirect costs such as health-related workplace absenteeism and sub-par productivity, nor the financial, emotional, or physical tolls of weight-based discrimination. Identifying and subsequently mitigating its risk factors is imperative.

A wealth of evidence suggests that obesity risk emerges long before adulthood.[42-45] Eating behaviors, food preferences, and metabolic health begin to solidify at a young age; subsequently, threats to healthful habits or physiological stressors during childhood may have life-long repercussions on weight status.[16,26-28,46] Food insecurity, defined by the United States Department of Agriculture as a lack of consistent access to enough food for an active, healthy life,[1] may be particularly potent. This socioeconomic condition disproportionately affects households with children and is strongly associated with several key obesity risk factors.[1] Chiefly, altered diet quality, dysregulated eating behavior(s), and potential stress-related metabolic shifts that may result from intermittent food access.

Food insecure households are more likely to consume affordable, shelf-stable items that are higher in sodium, fat, cholesterol, and calories in lieu of fresh fruits, vegetables, and other nutrient dense options, which may be costlier and/or entirely unavailable in lower income neighborhoods.[47-50] As well, these households experience excessive dysregulated eating resulting from intermittent food access and the compromised psychosocial functioning, depression, and anxiety that frequently accompany food insecurity.[15,17,24,51,52] Moreover, stress incurred from food insecurity may lead to metabolic changes that favor weight gain and retention regardless of eating behavior or caloric intake.[53-54] The singular and collective impacts of these factors can substantially increase an individual's probability of becoming overweight or obese over time; especially with multiple insults over time and at critical points of growth and development.

Though we have observed evidence that childhood food insecurity may lead to obesogenic eating behaviors into adulthood,[16] assessments of the relationship between childhood food insecurity and subsequent weight status have produced inconsistent findings that vary by sex, age, and length of observation.[17-23, 55-61] Many of these analyses are cross-sectional, compromising our ability to gauge the causal impacts of childhood food insecurity. As well, the study windows for all but one of the studies that we are aware of conclude before adulthood, precluding researchers from detecting lasting metabolic and diet-related changes to weight; and the one study that does assess adult weight status has a sample size of 30.[16] Furthermore, none have looked at how racial identity may be associated with the association between childhood food insecurity and subsequent weight status over time. This is a considerable gap in the literature given that many communities of color are disproportionately burdened with both food insecurity and obesity risk.[1,39] Systemic racism creates additional economic, interpersonal, and structural barriers to health that may exacerbate the impacts of food insecurity and related stress, including comfort eating as a coping mechanism.[62-66]

This analysis explores whether childhood experiences of food insecurity (as measured by the Past Food Insecurity Scale (PFI)[31]) are associated with Body Mass Index (BMI), an indicator of obesity, in young adulthood (age 18-20) and midlife (age 37-42) among a cohort of Black and White women that grew up in Contra Costa County, CA. We hypothesized that the severity of childhood food insecurity is directly associated with relative increases in BMI, with the most profound effects materializing in midlife. We also hypothesized that the experiences of food insecurity among Black women were more severe, disproportionately impacting their weight status over time. Our analyses build upon the existing body of literature by improving our understanding of the long-term ramifications of food insecurity, as well as elucidate a potential pathway to one of the most pervasive epidemics of the 21st century.

METHODS

National Growth and Health Study

Data were derived from survey responses and anthropometric measurements collected during the first and second waves of the National Heart Lung and Blood Institute's National Growth and Health Study (NGHS).[67] Wave 1 of NGHS took place from 1987-1999. It sought to identify racial differences in the development of obesity and subsequent cardiovascular disease risk leading up to and throughout adolescence. Investigators recruited 9 to 10-year-old Black and White girls from three field centers across the United States to participate in annual study visits until they were 18 to 20 years of age. In 2015-2019, the Western Contra Costa County, CA site re-recruited the original participants to assess associations between childhood risk factors and health in middle adulthood (36 to 43 years of age, hereby referred to as Wave 2).

Study Sample

Wave 1 eligibility criteria were: 1) living in and attending an elementary school in Western Contra Costa County, CA; 2) identifying as Black or White and living in racially concordant households; 3) having parents or guardians who self-identified as the same race as their child; 4) being within two weeks of age 9 or 10 at the time of the first clinical visit; and 5) parental/guardian consent. Women were considered eligible for Wave 2 if they had participated in the first wave of the study, did not have a baby or miscarry within three months of recruitment, and were not pregnant, living outside of the United States, or institutionalized. Eight-hundred eighty-three girls participated after the first year of the first wave of NGHS. Of the 883 girls, 29 were ineligible due to death, pregnancy, living outside the country or institutionalized (see Cohort Paper); 624 of the 854 eligible original participants (73%) re-enrolled in the second wave. We chose to omit participants without complete exposure (N=1) and outcome (N=30 for young adulthood, N=6 for midlife) data, bringing our final samples to 593 for the Wave 1 "young adulthood" and 617 for the Wave 2 "midlife" analyses.

Data Collection

Wave 1, young adulthood: Participants and their parent(s) or guardian(s) were asked to report individual and household-level sociodemographic information and personal as well as family medical histories during their first visit. Health behaviors, perceptions of social, psychological, as well as physical wellbeing, and anthropometric measurements were collected annually throughout the study period. Visit protocols are thoroughly described in the original cohort paper.[67]

Wave 2, midlife: Participants were classified as "local" if they lived within 60 miles of the study center and "distant" if they did not. Both were asked to complete an online or paper baseline survey with items pertaining to similar information collected during Wave 1, several retrospective and current assessments of food and financial insecurity, as well as self-reported height and weight. Local participants had their height and weight measured by study staff; distant participants were asked to self-measure using a standardized set of tools and instructions using the National Health and Nutrition Examination Survey protocol.[68] Participants received remuneration and provided verbal and/or written consent for each task. The UC Berkeley Institutional Review Board approved all study protocols.

Exposure

Childhood food insecurity was measured using a modified version of the PFI[31] implemented in Wave 2. This scale– originally used among Latinx immigrant mothers –contains seven items in total which primarily assess the frequency in which participants experienced reductions in the quantity and diversity of food. Participants were asked which experiences were "true for [them] when [they] were in elementary school (before age 12)." All items refer to childhood, except one that gauges current maternal feeding practices. Affirmative responses ('sometimes' or 'often') to each question received a score of one and negative responses ('rarely' or 'never') received a score of zero. Scales were scored with values between 0 and 7, with higher scores indicating greater severity of childhood food insecurity.

Though the full seven item scale was implemented in the Wave 2 survey, we omitted two items while scoring to improve internal consistency and validity among our sample: Q6, 'do you feel you need to give your child special foods that you didn't have as a child?' and Q7, 'I worked as a child to earn money to help my family buy food'. Both were weakly correlated with the other five items (r=0.17-0.33 for Q6, r=0.0.24-0.36 for Q7) with substantially lower item-test and re-test correlations (0.51 and 0.38 for Q6, 0.57 and 0.35, respectively). A principal component analysis also revealed that excluding Q6 and Q7 made the scale more unidimensional, increasing the percentage of variance captured by the first component increased from 52.8% to 66.9%. Given that 95 participants (15%) did not have children, dropping Q7 also eliminated artificial inflation of mothers' childhood food security status relative to non-mothers. Characteristics for the remaining five items (listed below) demonstrated internal consistency (Cronbach's alpha: 0.86, item-test correlations between 0.80-0.83, and re-test correlations between 0.64-0.75). To test validity, we assessed the strength of association between the final scale and four baselines sociodemographic factors that are consistently correlates of food insecurity.[1] Higher scores were significantly associated ($p<0.05$) with lower childhood household income and educational attainment, growing up in a single parent home, and identifying as Black.

Past Food Insecurity: 5-item scale

1. My family ate the same foods every day because there was not enough money or resources for other foods.
2. There were times of the month or year when my family ran low on food.
3. We had to divide very small amounts of meat among family members because there wasn't enough for everyone.
4. There were times when my parents/guardians did not have enough to eat.
5. There were times when I did not have enough to eat.

As we were uncertain that the distances between values 0-5 were uniform, we adopted an approach represented in the literature, and converted the continuous scale into a four-category variable signifying full food security (score of 0), marginal food insecurity (score of 1), moderate food insecurity (score of 2-3), and severe food insecurity (score of 4-5). Associations between the categorical variable and aforementioned predictors of food insecurity did not change.

Outcome

We used continuous body mass index (BMI) to gauge differences in weight in the final year of Wave 1 (age 19-20, young adulthood) and Wave 2 (age 36-43, midlife). BMI was derived by dividing the clinical/standardized weight in kilograms by height in meters, squared. To reduce the probability of selection bias and maximize statistical power, we used self-reported height and/or weight from the baseline survey in lieu of clinical/standardized measures when the latter were unavailable in midlife (N=111). The correlation between self-reported and clinical BMI (N=495) was 98.4%, and the mean difference was 0.52 units. There was no differential misclassification by race, age, income, education, reports of weight-based discrimination, or days between clinical measurements and the baseline survey. We did, however, find that reported BMI significantly decreased by 0.1 units with each one-unit increase in clinical BMI, suggesting slight differential misclassification by weight.

Confounder Identification

Although different factors influence obesity risk in young and middle adulthood, we anticipated that variables preceding early adolescence have a similar influence on BMI at both time points. As such, we constructed one Directed Acyclic Graph (DAG) based on the literature to identify potential confounders for BMI in young adulthood and midlife (Figure 1). The DAG indicated we should adjust for race, baseline household income and highest household educational attainment as indictors of socioeconomic status, and living with a single parent, birth order, and number of siblings to capture family structure as well as the participants' position within it. In addition, we accounted for participants' Wave 1 baseline (age 9/10) BMI, as well as their biological parents' BMI and self-reported health status to gauge biological obesity and health risks, which might also lead to or exacerbate food insecurity.

Missing Data

Approximately 11.1% (N=66) and 11.5% (N=71) of participants were missing data for at least one covariate in the young adulthood and midlife analyses, respectively. Parental BMI (N=48 in young adulthood, N=53 in midlife) and health status (N=46 in young adulthood, N=49 in midlife) had the greatest percentage of unobserved values followed by household income (N=13 in both analyses) and participants' baseline BMI (N=6 in both analyses). The majority of missingness resulted from our limited sample of biological parent survey responses. Although BMI and self-reported health may contribute to one's survey participation, we believe that the probability of either factor dictating missingness relative to other factors is low. As such, we assumed that data were Missing at Random and could use multivariate imputation by chained equations (MICE) to predict missing values.[69] Using Stata's MICE package[70] we generated fifty complete datasets imputing values for young adulthood and midlife covariates, respectively. Imputation models for both variables used predictive mean matching to impute continuous values for participants' childhood BMI and their parents' BMI, and multinomial logistic regressions to impute categorical values for income and parents' health. Each incorporated the exposure, outcomes, covariates, and other variables that we believed could predict values for the unobserved data points. Twenty iterations were used to create each imputed dataset.

Statistical Analysis

We conducted descriptive analyses to assess the sociodemographic composition of our population as well as the distribution of our outcomes and exposure. BMI was heavily right-skewed in both young adulthood and midlife and closely resembled a gamma distribution; probability plots supported this assumption. We ran two generalized linear models assuming a gamma distribution for the outcomes, with log-link and robust standard errors to produce the mean ratios (MR) between women reporting childhood food security and three levels of food insecurity, adjusting for all of previously identified covariates and participants' age at the time of their height and weight measurements. In addition, we calculated the expected marginal means for each group to assess how different levels of childhood food insecurity influence absolute BMI and subsequently, obesity risk.

Wald tests were used to assess each interaction term. Per the guidance of Selvin (2004),[71] we used a level of 0.20 to determine statistical significance for interaction. We conducted adjusted main effect models for time points with insignificant interactions. Finally, to ensure that our inclusion of self-reported height and/or weight did not impact our final results, we conducted a sensitivity analysis restricted to clinically-measured (rather than self-reported) anthropometric measurements (N=505) taken during midlife. All analyses were carried out using Stata 14 (College Station, Texas).

RESULTS

There was a fairly even racial distribution within the sample: 49% of participants identified as Black, 51% as White. The majority grew up in a household with two parents, one or more siblings, an annual income greater than $20,000 (in 1987/8 USD, approximately $45,200 in 2020 USD), and a parent or guardian who had attended some college or more. On average, women entered the study at 9.5 years of age with a BMI of 18.8 – the upper end of healthy weight for that age. Their parents had an average BMI of 26.1 (overweight) and primarily reported being in good to excellent health. However, Black participants were more likely to grow up in homes with lower household educational attainment, lower household income, a single parent, and a parent with higher BMI as well as fair or poor health More details can be found in **Table 1.1**.

Approximately one-third of participants reported experiencing some level of food insecurity as children: 14% marginally insecure, 9% moderately insecure, 9% very insecure. With regard to race, black women reported higher rates of childhood food insecurity than white women (38% vs. 27%), with most pronounced differences in marginal (18% vs 10%) and severe (12% vs 7%) childhood food insecurity. However, the prevalence of moderate childhood food insecurity was slightly higher among White women than Black women (10% vs. 9%) (**Table 1.2).** BMI consistently increased with age across the sample but varied by race as well. By young adulthood, Black women had an average BMI of 26.6 (classified as overweight) compared to White women, who had an average BMI of 24.2 (classified as normal weight). The difference more than doubled by midlife: Black women had an average BMI of 34.1 (classified as obese), White women, 29.3 (classified as overweight) (**Figure 1.2**).

Race did not significantly modify the effects in young adulthood (p=0.2078); we present the main effects in **Table 1.3**. Women who reported moderate and severe childhood food insecurity had a higher average BMI than women reporting full childhood food security (MR: 1.04, 95% CI: 1.00, 1.09 and MR: 1.04, 95% CI: 0.99, 1.10, respectively) but the confidence intervals surrounding both estimates encompassed the null. To adhere to our aim of assessing this relationship by race, we also presented the stratified results in **Table 1.3**. White women reporting marginal and moderate childhood food insecurity had no discernable difference in BMI relative to White women reporting full food security; those reporting severe childhood food insecurity were heavier on average (MR: 1.06, 95% CI: 0.97, 1.15). Black participants reporting any level of childhood food insecurity had larger average BMI than White women reporting childhood food security (referent group). However, this difference was only significant among Black women reporting moderate childhood food insecurity (MR: 1.11, 95% CI: 1.03, 1.20). Within strata, the coefficient was in the hypothesized direction among Black women who did not report full childhood food security, but statistically significant only among those reporting moderate childhood food insecurity (MR: 1.09, 95% CI: 1.01, 1.18).

Race significantly modified the exposure/outcome relationship by midlife (p=0.1075). At this time point, the relationship between childhood food insecurity and BMI intensified among White participants, as did racial disparities (**Table 1.3**). White women reporting any level of childhood food insecurity had a larger average BMI than White women reporting full food security; differences were most pronounced among those reporting severe childhood food insecurity (MR: 1.10, 95% CI: 1.00, 1.20). Among Black women, each category of childhood food security was associated with a larger average BMI than White women reporting full food security (the referent group). Black women reporting marginal (MR: 1.18, 95% CI: 1.10, 1.26) and moderate (MR: 1.17, 95% CI: 1.07, 1.27) childhood food insecurity had the greatest pronounced differences. Stratified results revealed no meaningful differences in BMI by childhood food security status among Black participants. Nevertheless, reports of marginal and moderate childhood food insecurity were associated with a larger average BMI than women reporting full food security, although reports of severe childhood food insecurity were associated with a slightly lower average BMI.

The marginal effects of childhood food insecurity are displayed in **Table 1.4,** revealing that all women were overweight or obese regardless of food security status. Sensitivity analyses (*Appendix A*) revealed that omitting women with self-reported height and/or weight did not meaningfully impact the magnitude or direction of the relationship between childhood food insecurity and adult BMI in midlife.

DISCUSSION

We explored the association between childhood food insecurity with BMI in young adulthood and midlife among a cohort of Black and White women. Generally, perception and memory of not having enough quantity and variety of food choice during childhood between 5-11 years of age were validated against historic socioeconomic information during that time period. Childhood food security status seems to have lasting influence on BMI in young adulthood and midlife. However, differences in BMI we observed by childhood food security status were insubstantial with the exception of young Black women reporting moderate childhood food insecurity (which likely drove the observed association in the main effects model), and midlife White women reporting severe child food insecurity. Racial identity significantly modified this relationship revealing differences among White and Black women, though not in the way that we had hypothesized.

The association between childhood food insecurity and BMI among White women appeared to be fairly consistent, with the most severe recollections of childhood food insecurity associated with the most substantial and significant increase in BMI by midlife. These findings reflect several patterns that have been previously identified in the literature. For example, a study conducted by Olsen et al. found that poverty-associated food deprivation in childhood was significantly associated with obesogenic food preferences and patterns among primarily White adult women; as well, higher rates of emotional eating in response to stress,[16] which have been observed elsewhere in the literature as well. As severe forms of childhood food insecurity are also associated with compromised mental wellbeing in adulthood, the cumulative effects of poor diet quality, dysregulated eating, and long-term mental health repercussions coupled with age-related metabolic changes may work in tandem to exacerbate the risk of weight gain, and as a result, BMI, over the life course.[72-75]

However, we found the reverse pattern was true for Black women: by midlife, the association between moderate child food insecurity and BMI abated, and women reporting severe childhood food insecurity had the lowest average BMI within this group. As well, the significant differences we observed among food insecure Black women relative to food secure White women subsided when we reassigned the reference group. These patterns suggest that factors extending beyond food insecurity may influence the observed racial differences in BMI, potentially masking the relationship. Although Black women within and outside of the context of this sample have higher rates of food insecurity and larger BMI than White women,[1,39] our results echo the findings of two other studies suggesting that the factors may be correlated rather than causal. [76,77] Sources of stress and hardship resulting from institutionalized and interpersonal racism underlie both the exposure and outcome and might play a more substantial role in determining long-term metabolic and/or eating related BMI changes than food insecurity in and of itself.[78-80] As their collective impacts take a progressively greater toll over time, the impacts of food insecurity alone may actually become less apparent. We see potential evidence of this effect in the attenuation of the relationship between moderate childhood food insecurity from young adulthood to midlife among Black women.

These findings should be interpreted with several limitations in mind. First, BMI is an imperfect measure of adiposity, particularly among Black women. Standardized BMI value ranges that correspond with different levels of health risks may not apply across diverse racial and ethnic groups.[65] Anthropometric measures that directly capture fat mass, and in particular visceral fat, would be more effective at capturing health risks stemming from food insecurity across both racial groups.[81] Second, using a retrospective assessment of childhood food security during elementary school, spanning the course of 6-8 years may have introduced non-differential exposure misclassification and imprecision. Though our internal validity assessment indicated that higher childhood food security scores were strongly and directly associated with predictors of food insecurity at baseline when the girls were between 9 and 10 years old, it is still possible that participants may have misremembered their experiences thirty years after they took place. In particular, earlier, infrequent, and/or less severe episodes of food insecurity may have been underreported relative to those that were later, consistent, and/or extreme, thus skewing the true prevalence of all but the severe food insecurity categories. Similarly, we have no way of accounting for the duration of experiences, or at what point(s) they took place during elementary school and/or a girl's specific stage of development, which may impact their potency. Given the uncertainty of timing, it is also possible that our confounding variables (measured at 9/10 years of age) proceeded our exposure (measured between 5-11 years of age), leading to the adjustment of factors along the causal pathway.

Third, we cannot discount the presence of unmeasured confounding and subsequent randomization violations due to a lack of collected information (e.g., participants' food environment(s), levels of social support, parents' employment status, and specifics regarding competing expenditures such as healthcare costs, child support, debt, etc.) or the restriction of values to one cross-section (9-10 years of age) that may not have reflected the child's entire childhood. Fourth, our sample limited our external generalizability and statistical power. Six hundred sixteen women with a disproportionately high prevalence of overweight/obesity may not accurately reflect the general population, especially given the small cell sizes and subsequent variability that arose from stratifying women by four-category food security status and race.

CONCLUSION

Despite the limitations, we believe this study provides important contributions to the literature. It is the first to our knowledge that assesses the relationship between childhood food insecurity and excess weight into middle adulthood, shedding light on potential long-term effects. As well, it is the only longitudinal assessment of this relationship with a focus on racial disparities within a Black and White cohort. Though it is by no means conclusive, this analysis has contributed to the growing body of literature that demonstrates the potency of childhood exposures throughout the life course. Future studies should expound upon our findings by isolating and quantifying the influence of potential mechanisms along the causal pathway. Understanding which, if any, elements of childhood food insecurity are most potent will be most helpful in crafting effective interventions to mitigate their effects. As well, consider it in the context of upstream factors to elucidate the impacts of food insecurity relative to other obesity risks.

FIGURES

Figure 1.1 Directed Acyclic Graph depicting relationship between childhood food security status and BMI in adulthood (age 18-20) and midlife (age 36-43)

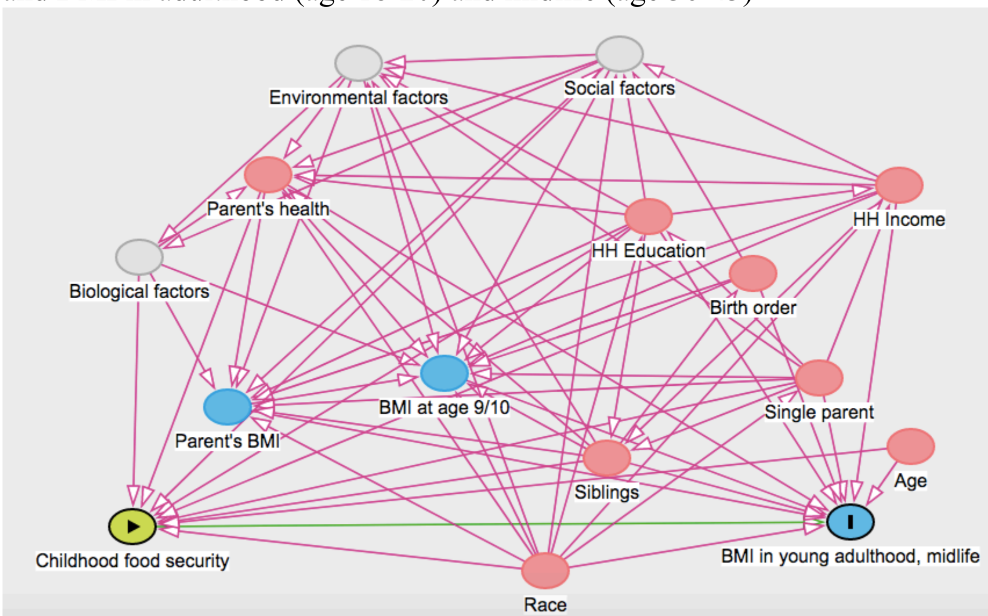
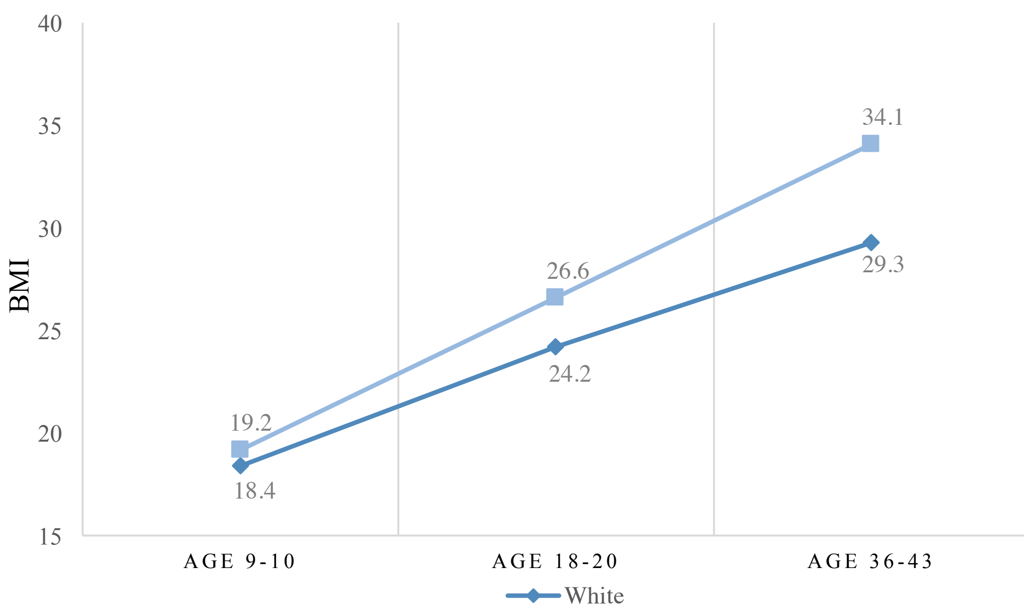


Figure 1.2 NGHS participants' BMI at 9/10, 18-20, and 36-43 years of age, stratified by race



TABLES

Table 1.1 Distribution of participants' sociodemographic characteristics at baseline and follow-up of California sites of the NHLBI Growth & Health Study (N=617)

	White (N=315)	Black (N=302)	Total (N=617)
Characteristics at Baseline, Wave 1			
Age (N=617)	9.5 (0.6)	9.5 (0.5)	9.5 (0.5)
Household education (N=617)			
High school or less	61 (19.4)	72 (23.8)	133 (21.6)
Some college	118 (37.5)	169 (56.0)	287 (46.5)
College+	136 (43.2)	61 (20.2)	197 (31.9)
Household income (N=604)			
<$10,000	21 (6.7)	96 (32.8)	117 (19.4)
$10,000-19,999	39 (12.6)	68 (23.2)	107 (17.7)
$20,000-30,999	98 (31.6)	76 (25.9)	174 (28.8)
$40,000+	153 (49.2)	53 (18.1)	205 (34.1)
One parent home (N=617)	64 (20.3)	138 (45.7)	202 (32.7)
Siblings (N=617)			
None	75 (23.8)	65 (21.5)	140 (22.7)
One	161 (51.1)	101 (33.4)	262 (42.5)
Two	53 (16.8)	88 (29.1)	141 (22.9)
Three+	26 (8.3)	48 (15.9)	74 (12.0)
Birth order (N=617)			
First	170 (53.9)	137 (45.4)	307 (49.8)
Second	101 (32.1)	96 (31.8)	197 (31.9)
Third	33 (10.5)	47 (15.6)	80 (13.0)
Fourth+	11 (3.5)	22 (7.3)	33 (5.4)
BMI (mean, SD) (N=611)	18.4 (3.5)	19.2 (4.1)	18.8 (3.8)
Parent's health (N=568)			
Very good or excellent	165 (56.9)	99 (35.6)	264 (46.5)
Good	96 (31.0)	129 (46.4)	224 (39.6)
Fair or poor	29 (10.0)	50 (18.0)	79 (13.9)
Parent's BMI (mean, SD) (N=564)	25.1 (5.4)	27.1 (6.7)	26.1 (6.1)
Characteristics in Young Adulthood, Wave 1			
Age (Mean, SD) (N=593)	18.5 (0.7)	18.6 (0.7)	18.6 (0.7)
BMI W1 (Mean, SD) (N=593)	24.2 (5.6)	26.6 (7.3)	25.4 (6.6)
Characteristics in Young Midlife, Wave 1			
Age W2 (Mean, SD) (N=617)	39.5 (1.4)	39.5 (1.2)	39.5 (1.3)
BMI W2 (Mean, SD) (N=617)	29.3 (8.0)	34.1 (9.5)	31.7 (9.1)

Table 1.2 Distribution of NGHS participants' childhood food security status, stratified by race (N=617)

	White (N=315)	Black (N=302)	Total (N=617)
FS	230 (73.0)	187 (61.9)	417 (67.6)
Ma FI	31 (9.8)	54 (17.9)	85 (13.8)
Mo FI	31 (9.8)	26 (8.6)	57 (9.2)
Sev FI	23 (7.3)	35 (11.6)	58 (9.4)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Table 1.3 NGHS participants' mean BMI ratios, by race and childhood food security status in young adulthood (N=593) and midlife (N=617)

	Total RM (95% CI)	N	White RM (95% CI)	N	Black RM (95% CI)	Black strata RM (95% CI)
Young Adulthood (Age 18-20)						
FS	-ref-	225/306	-ref-	179/287	1.02 (0.98, 1.05)	-ref-
Ma FI	1.01 (0.98, 1.05)	30/306	1.00 (0.96, 1.05)	51/287	1.03 (0.98, 1.09)	1.02 (0.97, 1.07)
Mo FI	1.04 (1.00, 1.09)	31/306	1.00 (0.96, 1.04)	24/287	1.11 (1.03, 1.20)	1.09 (1.01, 1.18)
Sev FI	1.04 (0.99, 1.10)	20/306	1.06 (0.97, 1.15)	33/287	1.05 (0.98, 1.13)	1.04 (0.97, 1.11)
Midlife (Age 36-43)						
FS	--	230/315	-ref-	187/302	1.11 (1.06, 1.16)	-ref-
Ma FI	--	31/315	1.04 (0.95, 1.13)	54/302	1.18 (1.10, 1.26)	1.06 (0.99, 1.13)
MoFI	--	31/315	1.02 (0.95, 1.09)	26/302	1.17 (1.07, 1.27)	1.05 (0.97, 1.14)
Sev FI	--	23/315	1.10 (1.00, 1.20)	35/302	1.07 (0.98, 1.17)	0.96 (0.88, 1.04)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure
Measure of interaction on additive scale (95% CI).
RMD adjusted for number of parents, number of siblings and birth order, household educational attainment, household income, BMI at age 9/10, parent's health status, parent's BMI, and age at time of measurement (e.g., young or middle adulthood)

Table 1.4 NGHS participants' predicted mean BMI in young adulthood (N=593) and midlife (N=617), by race and childhood food security status

	Total (BMI, 95% CI)	White (BMI, 95% CI)	Black (BMI, 95% CI)
Young Adulthood (Age 18-20)			
FS	24.70 (24.33, 25.05)	24.50 (24.01, 25.01)	24.87 (24.30, 25.46)
Ma FI	24.99 (24.20, 25.81)	24.59 (23.53, 25.69)	25.35 (24.20, 26.56)
Mo FI	25.66 (24.67, 26.70)	24.49 (23.63, 25.39)	27.16 (25.28, 29.18)
Sev FI	25.74 (24.48, 27.06)	25.88 (23.80, 28.15)	25.81 (24.28, 27.44)
Midlife (Age 37-42)			
FS	30.8 (30.21, 31.48)	29.27 (28.38, 30.19)	32.54 (31.58, 33.53)
Ma FI	32.43 (30.97, 33.96)	30.33 (28.02, 33.84)	34.46 (32.57, 36.47)
Mo FI	31.81 (30.32, 33.37)	29.83 (28.10, 31.68)	34.19 (31.66, 36.93)
Sev FI	31.24 (29.45, 33.13)	32.19 (29.61, 35.00)	31.25 (28.87, 33.82)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Paper 2: Association between maternal childhood food insecurity and offspring overweight/obesity risk

INTRODUCTION

The United States Department of Agriculture (USDA) defines food insecurity as a lack of consistent access to enough food for an active, healthy life.[1] The US began measuring food insecurity in 1995, following high rates of hunger and an uptick in people seeking emergency food assistance throughout the 1980s.[82-84] Its prevalence has steadily persisted; among households with children, it has not dipped below 17% since monitoring began.[85]

Research over the past two decades has demonstrated that early experiences of food insecurity can leave an indelible mark on nutritional health throughout childhood and adolescence. It is strongly associated with nutrient deficiencies, disrupted eating patterns and behaviors, and elevated levels of stress and anxiety; the latter of which affects the quantity, quality, and storage of nutrients as well as metabolic regulation.[3-13,24,48] Such impediments during early life are hypothesized to extend throughout and beyond the lifecourse to the next generation,[14,86] potentially influencing transgenerational obesity risk.

A study of intergenerational mother-child bonnet macaque monkey dyads found that intermittent food deprivation (mimicking human experiences of food insecurity) among mothers during their offspring's early life was directly associated with obesity risk among offspring.[29] Mother macaques subjected to intermittent food deprivation showed signs of anxiety (e.g., aggression toward other bonnet macaques) and less attachment to their offspring (e.g., less licking and grooming). These stress related behaviors due to uncertainty about food are hypothesized to confer the risk of stress on offspring, even when enough food is eventually found. The hypothesized biological mechanism that may be driving these associations is a potential increase in corticotrophin-releasing factor (CRF), which may be expressed in response to subjection to food insecure environments.[29,30] CRF is a peptide hormone activated by the stress response, which is strongly associated with adaptive eating behavior (including a preference for "comfort food") and increased weight, body mass index (BMI), and abdominal circumference, particularly among females.[29,30] In the same study of bonnet macaque monkeys, researchers found that subjects with early experiences of mother's "food insecurity" sustained disproportionately high levels of CRF throughout their lives, even after regaining consistent access to food.[30] Moreover, they also discovered high levels of CRF were common in their offspring who had not experienced food deprivation, suggesting intergenerational transmission.[29]

Humans have similar biological reactions to extended periods of stress; prolonged exposure triggers the hypothalamic pituitary adrenal (HPA) axis, which releases a number of hormones that shift metabolic functions towards a catabolic state, incidentally promoting weight gain and retention.[53,54] Like the bonnet macaques, HPA dysregulation in humans may lead a predilection for highly palatable and caloric "comfort" foods as well. Research conducted by Olson et al. bolsters this hypothesis; their team identified an association between poverty-associated food deprivation in childhood and obesogenic food-related parenting practices in adulthood, which subsequently materialized in their children's eating behaviors and patterns.[16] However, conclusive impacts on whether early experiences of food insecurity impact offspring's weight status remains to be seen.

Understanding the relationship between childhood food insecurity and its influence on subsequent generations' weight and metabolic health is critical for elucidating and subsequently working to alleviate factors contributing to obesity risk for millions of people, their families, and future generations. This analysis assesses the extent to which maternal experiences of childhood food insecurity influence their offspring's overweight/obesity risk among a cohort of Black and White women that grew up in Contra Costa County, CA and their children. We used the Past Food Insecurity Scale[31] to retrospectively capture women's childhood experiences of food insecurity during in the 1980's, when rates of food insecurity began to rise across the US. As well, this paper explores whether this relationship is modified by sociodemographic factors that may influence the intensity in which maternal childhood food insecurity could materialize: child's age and gender, mother's race, and current household food security status.

METHODS

National Growth and Health Study

Data were derived from survey responses and anthropometric measurements collected during the first (1987-1998) and second (2015-2019) waves of the National Heart Lung and Blood Institute's National Growth and Health Study (NGHS).[67] Wave 1 sought to understand Black-White differences in the development of obesity and cardiovascular disease risk throughout adolescence. Investigators at three field centers across the United States recruited 9 to 10-year-old Black and White girls to participate in annual study visits until they were 18-20 years of age. Over fifteen years after Wave 1 concluded, researchers recruited original participants from the Contra Costa, CA site to assess the long-term and intergenerational impacts of childhood and adolescent exposures with a focus on identifying racial disparities in cardiovascular risks as well as origins (Wave 2).

Study Sample

Our study sample was comprised of women who participated in Wave 1 and 2 of NGHS and their offspring. Eligibility for the first wave of the site was contingent upon: 1) identifying as Black or White and living in racially concordant households 2) having parents or guardians who self-identified as the same race as their child 3) being within two weeks of age 9 or 10 at the time of the first clinical visit 4) parental/guardian consent. Adult participants were considered eligible for the second wave if they had participated in the first wave of the study, did not have a baby or miscarry within three months of recruitment, and were not pregnant, living outside of the United States, or institutionalized. Offspring were considered eligible if: 1) their biological mothers participated in both waves of NGHS 2) they were between 2-17 years of age at the time of their family's enrollment if until September 2017 or between 2-15 thereafter[*] 3) they received parental consent, regardless of age, and provided personal consent if age 12 or older.

Of the 854 total eligible women, 624 participated in both waves of the study. Collectively, they reported 1,266 biological children; 98 women had no children, 124 women had no eligible children in the study, and 402 mothers (64%), had 648 children that met the offspring eligibility criteria.[28] We omitted children without complete exposure (N=1) and measured clinical outcome data (N=164, described below). The final sample consisted of 483 children (75%) and 297 mothers (74%). Chi-square testes revealed that eligible children were significantly more likely ($p<0.05$) to have White mothers (63%), live in food secure homes (60%), and have higher household incomes (64% more likely to have annual incomes greater than $90,000) as well as educational attainment (66% more likely to have highest attainment be equivalent to college or more) than the ineligible

[*] In September 2017, the protocol for participants living more than 60 miles away changed so that only one child per family could enroll.

sample; there were no statistically significant differences between our analytic sample and non-participating eligible children.

Data Collection

In Wave 1, Original participants – then children – and their parent(s) or guardian(s) were asked to report individual and household-level sociodemographic information during their first visit. Self-reported personal and family medical histories, health behaviors, and perceptions of social, psychological, as well as physical wellbeing were collected every year, as were staff measured height and weight. Visit protocols are thoroughly described in the first cohort paper.[67]

In Wave 2, the original adult participants, now adults, were asked to complete an online or paper survey that contained items similar to those collected during Wave 1, as well as several retrospective and current assessments of food and financial insecurity. Current household food security status was measuring using the United States Department of Agriculture's Household Food Security Module (HFSSM).[32] Local (≤60 miles of the UC Berkeley study site) adults and children had their anthropometric measurements, including height and weight, taken by study staff using the National Health and Nutrition Examination Survey protocol.[68] Distant participants were asked to measure and weigh themselves and their children using the same standardized set of tools and instructions.

The UC Berkeley Institutional Review Board approved all study protocols.

Exposure

Maternal childhood food insecurity was measured using a modified version of the Past Food Insecurity Scale[26] in Wave 2. It contains seven items in total. Each aims to assess the frequency in which participants experienced behaviors associated with food insecurity during elementary school before the age of 12. All but one of the items are retrospective, which asks about current maternal feeding practices. The full scale can be found in *Appendix B*. Affirmative responses ('sometimes' or 'often') to each question received a score of one and negative responses ('rarely' or 'never') received a score of zero. Survey respondents receive a total score that falls within 0 and 7, with higher scores indicating greater severity of food insecurity.

Though the full scale was implemented, we omitted two items to improve internal consistency and validity among our sample: Q6, 'do you feel you need to give your child special foods that you didn't have as a child?' and Q7, 'I worked as a child to earn money to help my family buy food'. Both were weakly correlated with the other five items (R=0.17-0.33 for Q6, R=0.0.24-0.36 for Q7) with substantially lower item-test and re-test correlations (0.51 and 0.38 for Q6, 0.57 and 0.35, respectively). Notably, the latter also had a weak correlation with child's Body Mass Index (BMI) (ρ=0.09). A principal component analysis also revealed that excluding the two items made the scale more unidimensional. Variance captured by first component increased from 52.75% to 66.85%, and eigenvalues for the second component were smaller (0.64 vs. 0.88). Characteristics for the remaining five items demonstrated internal consistency (Cronbach's alpha: 0.86, item-test correlations between 0.80-0.83, and re-test correlations between 0.64-0.75). To test validity, we assessed the strength of association between the final scale and four baselines sociodemographic factors that are consistently correlates of food insecurity.[1] Higher scores were significantly associated ($p<0.05$) with lower childhood household income and educational attainment, growing up in a single parent home, and identifying as Black.

As we were uncertain that the distances between values were uniform, we converted the five-item continuous scale into a four-category variable representing full food security (score of 0), marginal food security (score of 1), moderate child food insecurity (score of 2-3), and severe food insecurity (score of 4-5). We conducted chi-square tests to re-assess associations with the aforementioned predictors of food insecurity and found that they were effectively unchanged and statistically significant ($p<0.05$).

Outcome

Children were classified as overweight or obese based on their BMI-for-age percentile. Percentiles were derived using the US Center for Disease Control's online Child and Teen BMI calculator, which first computes a child's BMI (weight (kg)/height $(m)^2$) and then determines where it falls within the distribution of BMI values of the same age and gender.[87] Children with a BMI percentile greater than or equal to 85% are considered overweight; those with a BMI percentile greater than or equal to 95% are considered obese.[88] Given our relatively small study sample, heavily right-skewed distribution of BMI percentiles, and near absence of underweight participations (N=9), we choose to treat our outcome as a binary measure, classifying overweight and obese children as the group of interest and normal and underweight children as their reference.

Confounder Identification

We identified variables that might influence our exposure-outcome relationship from the literature and mapped them out using a Directed Acyclic Graph (DAG) (Figure 1). To avoid blocking potential causal pathways, we strictly focused on factors that could pre-date mothers' exposure to past food insecurity: their childhood household income and educational attainment as indictors of socioeconomic status, number of parents and siblings as a representation of family structure, as well as their Wave 1 baseline BMI in addition to their biological parents' (the offspring's grandparents') BMI and self-reported health status to capture biological obesity risk and factors that may have led to or exacerbated childhood food insecurity.[1,89,90]

Missing Data

Approximately 9% (N=43) of Wave 2 offspring were missing data for at least one covariate. Their biological grandparents' self-reported health status (N=25) and measured BMI (N=23) had the greatest percentage of unobserved values, followed by their mother's household income (N=12), current household food security status (N=4) and Wave 1 baseline BMI (N=4). The majority of missing values from grandparents' BMI and health status resulted from an absence of Wave 1 parent survey responses, which were either filled out by another family member (N=16) or missing without explanation (N=10). Although BMI and self-reported health may contribute to one's ability or desire to take a survey, we believed the likelihood of either dictating missingness relative to external factors was fairly low.

We assumed data were Missing at Random and could use multivariate imputation by chained equations (MICE) to predict missing values.[69] Using Stata's MICE package[70] we used predictive mean matching to impute continuous values for mothers' childhood BMI and their parents' BMI, and multinomial logistic regressions to impute categorical values for income and grandparents' health, generating 50 complete datasets. Each incorporated the exposure, outcomes, covariates, and other variables that we believed could predict values for the unobserved data points. Twenty iterations were used to create each imputed dataset.

Statistical Analysis

First, we conducted descriptive analyses to assess the sociodemographic composition of each participant and their family in addition to the distribution of our exposure and outcome variables. To account for potential clustering by families, we implemented a series of general estimating equation (GEE) models assuming a binomial distribution and log-link to calculate the population average odds ratio of overweight/obesity for each level of maternal childhood food insecurity (marginal, moderate or severe child food insecurity) relative to full food security. We assumed that outcomes for subjects within a family were equally correlated and therefore assumed an exchangeable covariance structure; however, we computed robust standard errors in the case of model misspecification, as well. In addition to the population average odds ratios, we also calculated the population average odds for each (sub)population by computing the post-estimation marginal effects after each model.

Our first analysis assessed the unadjusted relationship between maternal childhood food security status and odds of offspring overweight/obesity. Next, we ran a multivariate model that adjusted for confounding variables (described above) as well as child's age. We conducted five interaction models to assess whether children and mother's characteristics modified the effects of our exposure-outcome relationship. To accommodate limited statistical power, we ran them separately, incorporating an interaction term for age (continuous) gender (male/female; also served as a proxy for biological sex), current household food security status (food secure/insecure), as well as maternal overweight/obesity status (overweight/obese vs. not) and maternal race as a proxy for child's race (Black/White), respectively.

A child may be particularly vulnerable to obesity risk factors at different stages of development and sexual maturation; age and biological sex play therefore critical roles in determining susceptibility.[91] As well, gendered differences in food preferences, modeled behaviors, energy consumption, and energy expenditure may dictate differential obesity risks, as would current household food security status and maternal weight.[91,92] Lastly, structural and interpersonal barriers differentially impact the lived experiences of Black and White women, which may not only exacerbate experience of food insecurity, but additional underlying factors that contribute to obesity as well.[79,80] Though we were interested in exploring differences within and between these interactive effects, our small sample size compromised our ability to assess the intersectional nuances of our exposure-outcome relationship. Wald tests were used to assess the significance of each interaction. Per the guidance of Selvin (2004),[71] we used a significance criterion of 0.20, and present the findings of those that fell below it.

After running all GEE models, we ran a post-hoc logistic regression to determine whether affirmative responses to any of the five components of the Past Food Insecurity scale were differentially associated with odds of overweight/obesity. Then, we cross-tabulated affirmative responses to each of the five items with the categorical food security measure to identify whether women reporting different measures of food insecurity were more likely to respond to certain items.

All analyses were conducted using Stata 14 (College Station, Texas).

RESULTS

Descriptive statistics

On average, child participants were 9.2 years of age (SD: 4.2) and had 1.4 siblings (SD: 1.1); 0.6 (SD: 0.5) of which were in the analysis sample (**Table 2.1**). Over half were girls (51%) and classified as under/normal weight (55%). Their mothers were 39.2 years of age (SD: 1.0) predominantly overweight/obese (76%), and had a fairly even racial distribution (51% White, 49% Black). Almost 70% of mothers reported full food security during childhood; 14% reported marginal, 10% reported moderate, and 7% reported severe food insecurity. About 20% reported current household food insecurity. During their Wave 1 baseline visit, approximately one-third of mothers reported living in households with a collective income greater than $40,000 (1988 USD) (35%), educational attainment of college or more (31%), and a single parent (34%). They had an average BMI of 18.3 (SD: 3.4), which is classified as normal weight for 9-10 year-old girls. Their parents had an average BMI of 25.9 (SD: 5.9) (overweight) and generally reported being in good or better health (86%).

Main effects

In crude models, children whose mothers reported marginal or severe childhood food insecurity had greater odds of overweight/obesity compared to children whose mothers reported full food security; the odds of overweight/obesity among children whose mothers reported moderate child food insecurity were about fifty percent lower (OR: 0.53, 95% CI: 0.27, 1.02) (**Table 2.2**). In adjusted analyses, the direction of association changed by maternal report of marginal and severe childhood food insecurity but remained insignificant. Odds of overweight/obesity among children whose mothers reported moderate child food insecurity vs. full childhood food security were substantially lower and statistically significant (OR: 0.32, 95%: 0.15, 0.69).

Effect modification

Interactions between the identified effect modifiers of current food security status (p=0.1346), maternal race (p=0.1291), and child's age (p= 0.0192) reached statistical significance; child's gender (p=0.4921) and maternal overweight/obesity status (p=0.3478) did not. Select results from current food security, maternal race, and child's age interactions are shown in **Table 2.3.1** and **Table 2.3.2**.

<u>By current food security status:</u> Similar to the main effects model, food secure children whose mothers reported moderate childhood food insecurity had lower odds of overweight/obesity compared to the reference group (OR: 0.29, 95% CI: 0.11, 0.76). We observed similar patterns among food insecure children, but the association was insignificant. The direction and strength of association between maternal marginal childhood food insecurity and offspring odds of overweight/obesity changed by food security status; food secure children had higher odds of being overweight/obese than the reference group (OR: 1.15, 95% CI: 0.61, 2.17), but they were lower among food insecure children (OR: 0.30, 95% CI: 0.11, 0.83).

<u>By maternal race:</u> Moderate maternal childhood food insecurity was associated with lower odds of overweight/obesity within races. Significantly, among children with a White mother (OR: 0.23, 95%: 0.07, 0.79). Children with a Black mother reporting marginal childhood food insecurity had higher odds of overweight/obesity than the Black or White reference group; however, this relationship was statistically insignificant.

By age: The odds of overweight/obesity increase with age among children whose mothers reported childhood food insecurity (Table 2.3.1) and vary by status; most remarkably among children whose mothers reported moderate (OR: 1.21, 95% CI: 1.05, 1.38) and severe (OR: 1.23, 0.98, 1.51) childhood food insecurity. Children whose mothers reported full food security experience decreased odds with age (0.98, 95% CI: 0.92, 1.04).

Post-hoc analyses

Post-hoc analyses revealed that Item 1 ("my family ate the same foods every day because there was not enough money or resources for other foods") was significantly associated with lower odds of overweight/obesity (OR: 0.27, 95% CI: 0.12, 0.57), whereas Item 3 ("we had to divide very small amounts of meat among family members because there wasn't enough for everyone") was significantly associated with higher odds (OR: 3.87, 95% CI: 1.30, 11.50) (**Table 2.4**). Item 2 ("There were times of the month or year when my family ran low on food") comprised the majority of marginal food security scores, and women reporting moderate child food insecurity most often responded affirmatively to Item 1 and Item 2 (**Table 2.4**).

DISCUSSION

We assessed the relationship between maternal childhood food insecurity and odds of offspring overweight/obesity among a cohort of children ages 2-17. Counter to our hypothesis, we found no notable difference in the odds of overweight/obesity among most levels of food insecurity in our main effects model. Surprisingly, we did find consistency in the direction of the coefficient showing an association with lower odds of overweight/obesity, and this reached statistical significance among children whose mothers reported moderate childhood food insecurity. Furthermore, our stratified analyses revealed that the association between maternal childhood food insecurity and reduced odds of overweight/obesity was strongest among children currently living in food secure homes, White children, and children between the ages of 2-5. We also observed trends indicating that the relationship between marginal and severe food insecurity and overweight/obesity varied by age, race, and current food security status, but few reached statistical significance.

The counterintuitive, but consistently strong and statistically significant finding among children whose mothers reported moderate childhood food insecurity suggest that elements of this experience may be protective against odds of overweight/obesity among offspring. This relationship could be explained through two potential and related mechanisms, based on the frequency of their responses to specific past food security measurement items. Most women who reported past food security affirmed item 1, which captured reliance on the same foods during childhood. This in turn may be related to mothers' avoidance of potentially obesogenic foods stemming from frequent consumption during her childhood and therefore influencing her children's diet in a positive way. The second item captured the insufficient availability of meat during childhood, which we believe could be related to mothers' desire to adequately feed their children nutritious proteins stemming from an insufficiency in their childhood. Evidence of childhood food avoidance has been identified in the literature. Participants from Olson et al.'s 2008 study voiced that consistent consumption of the same foods led to evasion in adulthood; this sentiment was shared by several participants in a study of Latinx mothers who grew up experiencing food insecurity.[16,31] Women from both studies also expressed a strong desire for their children to have better food experiences than they did. The majority of the previously food insecure women in Kuyper's study reported wanting to give their children "more food, better quality foods, or foods they did not have." [31] Participants from Olson et al.'s study population did discuss which types of food they wanted to provide for their children, but researchers noted an emphasis on having enough, potentially preventing the transfer of food-related stress and dysregulated habits from mothers to their children.[16]

Our participants' childhood experiences of food insecurity were concurrent with the dietary shift during the 1980s and 1990s towards more processed, caloric foods across the United States.[93] As food insecurity is associated with the consumption of low-nutrient, calorie-dense items, it is probable that similar to mothers from Kuyper[31] and Olson's[16] studies, participants who reported this experience in childhood may be more inclined to avoid these items as adults, favoring a more diverse diet for themselves and their children (given the resources). Because the reverse relationship between moderate childhood food insecurity and odds of overweight/obesity was strongest among young children – whose eating is likely to be entirely dictated by external influences – as well as food secure children, we believe this could be the case. Racial differences may also indicate varying levels of material protection. Black women's incomes are 21% lower than White women's on average; they are also more likely than White women to live in food deserts, where healthy foods are harder to obtain.[94,95]

Although this study considers previous experiences of food insecurity rather than the present, these findings are consistent with the notion that in the US, the lived experience of food insecurity among adults is associated with parents' behavior to protect their children from it.[34,96] We do see suggestions of this in the present, however, among mothers who reported marginal childhood food insecurity now living in currently food insecure homes.

It is important to interpret these findings in light of their limitations. Our sample is heavier than the general population; about 45% of children classified as overweight or obese, whereas the country average is closer to one-third.[97] Moreover, the predicted odds of overweight/obesity among children whose mothers reported full childhood food security are 0.93 in our main effects model. Although the predicted odds were fairly high for children whose mothers reported marginal or very moderate child food insecurity as well (0.79 and 0.78, respectively), the probability of overweight/obesity in our reference group may have overshadowed what might otherwise be considered substantial risks of overweight/obesity in a more standardized population. In addition, the small percentage of children whose mothers reported each level of food insecurity (7-13.5%) also impeded our statistical power and ability to generalize our findings. Experiences of the mothers of 34-65 children may not represent the true odds of overweight/obesity present in the general population. Even if it did, the amount of variability introduced by using such small samples could render the truth undetectable. This point is especially pertinent for our interaction models, which stratified our food insecure population into cell sizes as small as N=13.

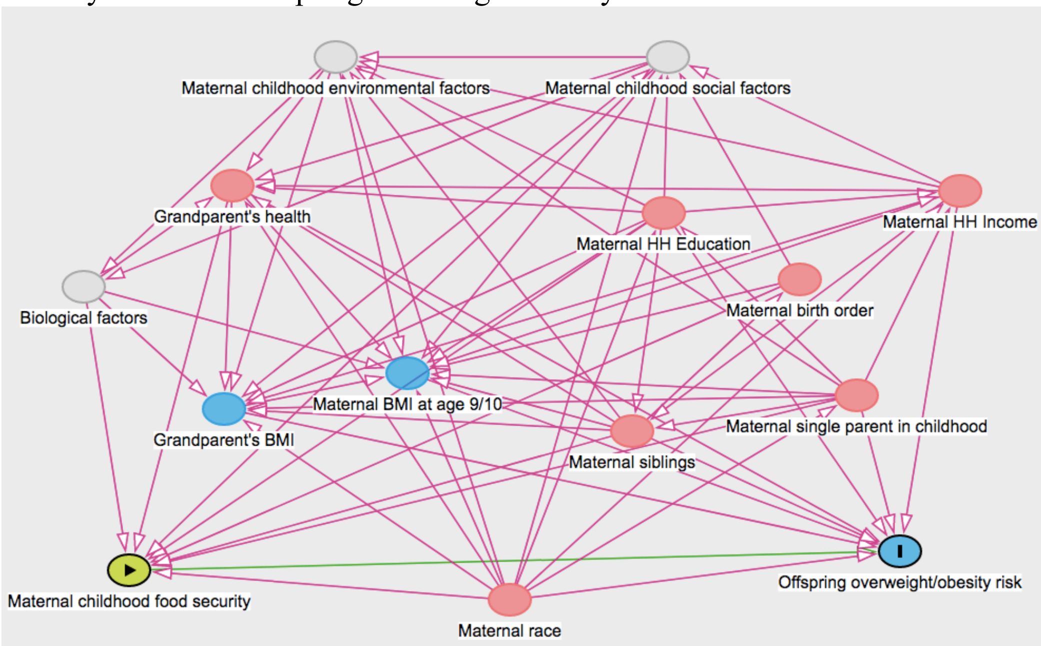
As well, unlike the experimental study among bonnet macaque monkeys, experiences and long-term recollections of childhood food insecurity are not uniform. The bonnet macaque mothers were all exposed during their offspring's infancy;[29,30] in our sample, we don't know the precise time point that mothers experienced food insecurity, or whether it was consistent with a specific developmental period. While the past food security measure we used to gauge our exposure had excellent internal reliability and multiple indications of validity, the severity of collective experiences and subsequent threats to health likely varied substantially; women needed to have a certain number of experiences, rather than an explicit set of experiences, to be grouped together. A more exact measurement of the length, timing, similarity, and severity of food security during childhood would enable researchers to identify the impacts of a more precise experience. However, creating and implementing one among humans has been challenging: even the gold standard for food security measurement, the HFSSM, is privy to many of these issues, despite a substantially shorter measurement window. In addition, measuring offspring's body mass over time (and at the same time/age points) would better account for the influence of unique developmental trajectories. Though our outcome was methodologically sound, by restricting analyses to singular cross-sectional measurements from children aged 2-17, we may have missed critical time point(s) that maternal childhood food insecurity's influence may materialize in offspring, as well as its overall average impact.

CONCLUSION

Although non-conclusive, we believe these analyses laid some of the groundwork for exploring the association between childhood food security status and offspring odds of overweight/obesity, and offer maternal protection as an explanation for lower odds of overweight/obesity among offspring born to food insecure mothers. Ideally, future studies will have larger, representative samples and more precise/repetitive measurement to more conclusively determine what, if any, relationship exists between the two factors in the general population, and how it may change by race, age, gender, maternal weight, and current food security status. As well, build upon our understanding of the potential mechanisms by exploring the pathways (e.g., stress-related HPA dysregulation, behavioral modeling) in which food insecurity might influence intergenerational transmission overweight/obesity risk.

FIGURES

Figure 2.1 Directed Acyclic Graph depicting relationship between maternal childhood food security status and offspring overweight/obesity risk



TABLES

Table 2.1. Distribution of participants' sociodemographic characteristics at baseline and follow-up of California sites of the NHLBI Growth & Health Study

	Children (N=483)
Wave 1: Characteristics during childhood	
Maternal childhood food security status	
Food security	335 (69.4)
Marginal food insecurity	67 (13.9)
Moderate food insecurity	47 (9.7)
Severe food insecurity	34 (7.0)
Maternal single parent	166 (34.4)
Maternal household education	
High school or less	100 (20.8)
Some college	234 (48.7)
College or more	149 (30.6)
Maternal house income (1988 USD)	
<$10,000	95 (20.2)
$10,000-19,999	79 (16.8)
$20,000-39,999	131 (27.8)
$40,000+	166 (35.2)
Maternal baseline BMI (mean, SD)	18.3 (3.4)
Maternal baseline overweight/obese	147 (30.7)
Grandparent's BMI	25.9 (5.9)
Grandparent's health	
Very good or excellent	219 (48.0)
Good	176 (38.4)
Fair/poor	63 (13.8)
Maternal race	
White	247 (51.1)
Black	236 (49.1)
Wave 2: Children and mothers	
Children's age (mean, SD)	9.2 (4.2)
Children's gender	
Female	247 (51.1)
Male	236 (48.9)
Children overweight/obese	216 (44.7)
Children's no. of siblings (mean, SD)	1.4 (1.1)
Children currently food insecure	96 (20.0)
Maternal age (mean, SD)	39.2 (1.0)
Maternal overweight/obese	367 (76.0)

Table 2.2 Odds of offspring overweight/obesity risk (>85th percentile) among children of NHLBI National Growth & Health participants by maternal food insecurity, relative to maternal food security (N=483)

		OR (95% CI)	
		Unadjusted Model	**Adjusted Model**
Food Secure	335/483	-ref-	-ref-
Ma FS	67/483	1.03 (0.58, 1.82)	0.80 (0.46, 1.38)
Mo FS	47/483	0.53 (0.27, 1.02)	0.32 (0.15, 0.69)
Sev FI	34/483	1.34 (0.77, 2.32)	0.81 (0.42, 1.58)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Table 2.3.1. Odds ratios for offspring obesity risk by maternal childhood food insecurity, offspring's current household food security status, and maternal race (N=483)

		OR (95% CI)		OR (95% CI)		OR (95% CI)
	N	**Current FS**	**N**	**Current FI**		**Within FI strata**
FS	286/383	-ref-	45/96	1.12 (0.61, 2.07)	--	-ref-
Ma FI	49/383	1.15 (0.61, 2.17)	18/96	0.30 (0.11, 0.83)	--	0.54 (0.27, 1.07)
Mo FI	32/383	0.29 (0.11, 0.76)	15/96	0.42 (0.13, 1.41)	--	0.64 (0.29, 1.43)
Sev FI	16/383	0.94 (0.35, 2.51)	18/96	0.80 (0.32, 1.83)	--	0.88 (0.59, 1.31)
		White		**Black**		**Within Black strata**
FS	184/247	-ref-	151/236	1.15 (0.67, 1.97)	--	-ref-
Ma FI	24/247	0.43 (0.14, 1.33)	43/236	1.25 (0.61, 2.56)	--	1.09 (0.57, 2.10)
Mo FI	26/247	0.23 (0.07, 0.79)	21/236	0.51 (0.18, 1.44)	--	0.45 (0.17, 1.19)
Sev FI	13/247	1.65 (0.52, 5.26)	21/236	0.65 (0.28, 1.49)	--	0.57 (0.26, 1.22)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure
N for current food security status analyses reflects the observed values; model population greater by N=4 due to imputation

Table 2.3.2 Increase in offspring odds of overweight/obesity with one additional year of age, by maternal childhood food security status (N=483)

	OR (95% CI)
FS	0.98 (0.92, 1.04)
Ma FI	1.09 (0.95, 1.25)
Mo FI	1.21 (1.05, 1.38)
Sev FI	1.23 (0.98, 1.51)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Table 2.4. Frequency of each past food security item by maternal childhood food security status and association with offspring odds of overweight/obesity (N=481)

	Item 1 (Same foods)	Item 2 (Foods ran low)	Item 3 (Little meat)	Item 4 (Parents didn't have enough food)	Item 5 (Didn't have enough food)
Percentage of affirmative response to PFI item, by childhood food insecurity category					
Ma FI (N=67)	17 (25.4%)	46 (68.7%)	2 (3.0%)	1 (1.5%)	1 (1.5%)
Mo FI (N=47)	30 (63.8%)	42 (89.4%)	5 (10.6%)	16 (34.0%)	15 (31.9%)
Sev FI (N=34)	33 (97.1%)	34 (100.0%)	34 (100.0%)	30 (88.2%)	29 (85.3%)
Odds ratios (95% CI) of overweight/obesity given affirmative response to PFI item					
OR (95%)	0.27 (0.12, 0.57)	1.40 (0.81, 2.39)	3.87 (1.30, 11.50)	0.67 (0.23, 1.90)	1.08 (0.38, 3.05)

Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Transition: moving from long-term impacts to policy solutions

The first two studies included in this dissertation explore some of the potential long-term implications of childhood food insecurity among American women and their offspring. Such assessments are critical for shaping our understanding of the true impacts of this socioeconomic condition. However, it is of equal if not greater importance to also identify solutions that prevent childhood food insecurity, and subsequently, its associated health risks, from manifesting at all.

The following paper takes a preventive approach to the issue of childhood food insecurity by examining the extent to which the prevalence and severity of this condition changed among households with children following the roll-out of a federal income transfer in Canada. Our findings are most relevant to Canadian policy. However, we believe they also speak to the potential of analogous programs (such as the Temporary Assistance for Needy Families, the Earned Income Tax Credit, etc.) in the United States, which experiences similar rates of food insecurity despite its concerted, food-focused approach to combating this condition.

The paper was published in the December 2019 issue of *Preventive Medicine*. All co-authors, committee members, and the Graduate Division of the University of California, Berkeley, have approved it to be used as part of this document.

Paper 3: Money speaks: reductions in severe food insecurity follow the Canada Child Benefit

INTRODUCTION

The increasing prevalence and rising demands for food charity have helped to highlight the pervasiveness of food insecurity across high-income countries.[98-100] Defined as the inadequate or insecure access to food due to financial constraint, food insecurity affects roughly 10% of their populace, although rates vary markedly between nations.[101] In Canada, over 12% of households, nearly 40% of which have children, experience food insecurity.[98] Its individual and collective impacts are substantial.

Among children, exposure is associated with impaired development and increased risk of chronic physical and mental health problems.[102-106] Food insecure adults report higher rates of multiple chronic conditions and poor disease management, compromising quality of life and longevity, and increasing healthcare utilization and costs.[104,107-114] The relationship between household food insecurity and health is graded, with more severe food insecurity associated with higher likelihood of negative health outcomes.[102,107,108]

Food insecurity is tightly linked to socioeconomic vulnerability,[100,101,115] and there is considerable evidence of its sensitivity to public policy interventions that affect household resources.[116] Strong investments in social protection programs appeared to insulate some European countries from rises in food insecurity during the Great Recession,[117] and recent studies suggest that food insecurity in the United Kingdom has increased with cuts to social welfare spending.[100,116] In Canada, several studies have provided indications of improvements in food security among population subgroups in tandem with income-based interventions.[37, 118-121] However, our understanding of the policies needed to promote food security at a population level remains fragmented, constrained by the limited scope and generalizability of existing research. Due in no small part to its strong history of national monitoring, the majority of domestic policy assessments come from the United States, where the Supplemental Nutrition Assistance Program in particular has been extensively evaluated.[122] Yet, extrapolations to other policy contexts are limited due to the restricted and uniquely food-focused nature of United States' programs. The paucity of deliberate policy evaluations from more traditional welfare states prohibits a thorough examination of which social protections may be most relevant to the persistence – or alleviation – of food insecurity, and in turn, how their impact could be optimized within and across other countries.

Recent changes to Canada's child assistance policy have created an opportunity to assess how food security functions relative to changes in a direct income transfer program. In July 2016, the federal government replaced the Child Tax Benefit and Universal Child Care Benefit with a more generous, income-tested program: the Canada Child Benefit (CCB).[38] During its first year of implementation, CCB issued an average of $6,800 to eligible families, approximately $2,300 more than its predecessors.[38] This analysis uses an intent-to-treat, difference-in-difference (DID) design to assess whether Canadian households with children experienced reductions in the prevalence and severity of food insecurity following its roll-out.

METHODS

Policy Intervention

CCB provides tax-free financial assistance to households with children under 18.[123]All primary caregivers meeting specified income requirements and who classify as Canadian residents for tax purposes are eligible to apply.[123] Household benefit amount is determined by adjusted net income, as well as the age(s) and number of children. From July 2016-June 2018, beneficiaries received a maximum of $6,400 per child under 6, and $5,400 per child between 6 and 17.[38] Graduated phase-outs were applied to incomes greater than $30,000 and $60,000, respectively, so that households with incomes up to $249,737 were eligible.[124] Details are described in *Appendix C*. During the first year of implementation, a quarter of beneficiaries had incomes under $30,000, a quarter between $30,000-60,000, and half greater than $60,000.[125]

Data Source

Data were derived from the 2015-2018 cycles of the Canadian Community Health Survey (CCHS). CCHS is an annual cross-sectional survey administered by Statistics Canada. Its multi-stage sampling frame aims to capture 97% of Canadians over the age of 12, excluding full-time members of the Canadian Armed Forces, individuals living on First Nation Reserves or in institutions, and two remote regions of Quebec.[126] Participants over 18 receive household weights to generate a representative sample.[126]

Study Sample

Our sample included any potentially eligible – and childless, but otherwise comparable – households with full food security data and household level survey weights. Exchangeability between treatment and control groups is not vital for DIDs,[127] but increasing their similarities reduces the likelihood that the they experience differential trends leading up to and throughout the course of the study. Respondents that reported retirement or pension savings as their main source of household income, were 65 years of age or older and either living alone or with just a spouse were excluded, as they were unlikely to be eligible for or comparable to households receiving CCB. We also omitted respondents who emigrated within the past two years (due to CCB's residency requirements) and/or were under 18 years old (due to absence of household-level survey weights). We lacked the data to determine eligibility and subsequently exclude households based on adjusted net income, as CCHS reports only a pre-tax income variable that combines market earnings with government transfers (e.g., CCB). Nevertheless, CCB's eligibility thresholds exceed the vast majority of Canadian household incomes,[128] so it is unlikely our sample is populated with many financially-ineligible families. Eight provinces had 2015-2018 food security data available at the time of this analysis; we limited our sample to these jurisdictions.

The full sample contained 41,455 households. However, we were also interested in whether CCB would have differential impacts at lower income thresholds, and generated two subsamples reporting income at or below the pre-tax national median (N=18,191) and income at or below the pre-tax Low-Income Measure (LIM), i.e., half of the national median (N=7,579), respectively.

Outcome

Food security over the past 12 months was measured using an adapted version of the United States Department of Agriculture's 18-item Household Food Security Survey Module (HFSSM).[32] Ten items correspond to adults' food security, eight to children's. Applying Health Canada's classification scheme,[129] we grouped responses into one of four categories based on each household's raw score: food secure, marginally food insecure, moderately food insecure, or severely food insecure. This cross-classification method accounts for the different number of items and conditions used to categorize households with and without children, enabling comparisons to be made between the two groups.[130] However, to determine whether basing household status on responses to the 10-item adult subscale would influence our results, we conducted analyses using this revised classification as well.

Exposure

We constructed four treatment groups defined by presence of children (age <18) in the household and the timing of participants' interviews relative to CCB's implementation. Households with children were considered "treated" and those without, "controls." Participants interviewed during the year leading up to CCB (July 2015-June 2016) were "unexposed" to the policy; those interviewed post-implementation (July 2017- June 2018) were "exposed." Given HFSSM's annual measurement window, we chose to exclude July 2016-June 2017 from our exposure period to eliminate potential carryover effects from the previous programs.

Study Design

DIDs estimates policy impacts by comparing changes in an outcome among a "treated" population to those among a "control" population, before and after implementation.[127] They are especially useful in observational settings, as DIDs do not require treatment groups to experience the same pre-intervention conditions – only the same outcome trends.[127] While this has made DIDs an attractive option for researchers, additional assumptions must be upheld for them to produce valid estimates. [127,131] Notably, these include observing parallel trends in the outcome variable between treatment groups leading up to the policy's implementation and the absence of differential shocks.[131]

Due to limited data availability, we assessed food security trends in a modified sample population leading up to our study period. We also reviewed financial shocks, and federal as well as provincial-level assistance adjustments made just before and after implementation of the CCB. To our knowledge, there were no changes to provincial family policies, and none of the overall fiscal trends had the potential to influence food security on a national level as dramatically as CCB.[132-134] Even if fiscal trends were more influential than anticipated, we would not expect them to differentially impact food security among households with and without children.

Accounting for Confounding

Using four distinct groups to approximate two populations introduces additional variability to traditional cohort-based DID studies. Consequentially, it cannot be assumed that time invariant differences will cancel out[135] without statistical intervention. To achieve balance within our treated and control populations and further boost comparability between them, we constructed a directed acyclic graph (*Appendix D*) informed by prior research[115,136] to determine which factors may influence eligibility and/or uptake of CCB as well as food security: province, living in an urban vs. rural setting, household composition (including the number of children over and under six years of age), and sociodemographic variables. In the absence of household level data, we used respondent's immigration status and Black or Aboriginal racial identity to serve as proxies. Because we could not disentangle the CCB benefit amount from other income sources, including reported income in our models would have adjusted away the effects of CCB. Instead, we accounted for other components of socioeconomic status: reliance on wages or salaries for income and home ownership as indicators of financial security, maximum educational attainment as an indicator of social mobility, and receipt of any social assistance as an indicator of extreme economic disadvantage.

Statistical Analysis

IPTW: We employed modified inverse probability of treatment weights (IPTW)[137] to ensure that the composition of key characteristics within our treatment groups remained stable across the study period. To accomplish this, we first calculated propensity scores using household-weighted[138] logistic regressions, incorporating the aforementioned covariates for households with and without children, within each analytical subgroup. As well, the month participants were interviewed was included to balance potential micro-temporal variations that could influence food security reporting. "Unexposed" households were set as the reference for both models; IPTWs corresponded to the inverse of each household's probability of belonging to this group.[137] To gauge their success at promoting exchangeability, we assessed standardized mean and proportional differences for each covariate included in our models (**Table 3.1**). Differences greater than 0.2 indicate imbalance;[139] covariates for all households fell within this threshold. IPTWs ranges were similar among households with and without children, spanning from about 1.5 to 5, 1.5 to 6, and 1.5 to 8 among households reporting any income, the median income or less, and the LIM or less, respectively (Statistics Canada prohibits the release of exact minimums and maximums). We multiplied all IPTWs by their corresponding household-level survey weight to permit simultaneous weighting in our DID models.[140]

Regression Models: To calculate the DIDs, we ran multivariate, multinomial logistic regressions within each subpopulation. We applied the combination weights and adjusted for the same covariates included in our propensity models to account for potential residual confounding[141] and elements of between group variation. Instead of presenting the ratios of relative risk ratios produced by multinomial regressions, we ran post-estimation marginal effects to obtain more interpretable results, yielding the difference in the predicted probabilities of experiencing each food security category between households with and without children, before and after CCB. Standard errors were estimated using 1000 bootstrap replicate weights.

Missing Data: Approximately 5.5% of households were missing values for at least one covariate (N=2,431), with no discernable patterns or apparent relation to food security. Given that the missing data appeared to pose minimal bias, we ultimately ran complete case analyses.

This project was conducted using Stata 15 (College Station, TX) and approved by the Office of Research Ethics at the University of Toronto.

RESULTS

Parallel Trends

All food insecurity trends ran fairly parallel leading up to our study period, with some small fluctuations in marginal and severe food insecurity (**Figure 3.1**). We identified no significant differences in the changes in any category between treated and control groups, either by year or over time. Details can be found in *Appendix E*.

Full sample: descriptive statistics, predicted probabilities

The majority of our participants were Canadian born, home owners, reported wages or salaries as their main source of income, did not receive financial assistance or identify as black or aboriginal, and had at least some post-secondary education (**Table 3.2**). There was some variation in the distribution of covariates. Households with children had several indicators of higher socioeconomic status (higher prevalence of post-secondary education, home ownership, and reliance on wages or salaries for income; slightly lower prevalence of social assistance) and were more likely to be comprised of romantic partners.

In adjusted models, households with children reporting any income were less likely to be food secure (83.5% vs. 85.4%), but also less likely to be severely food insecure (3.6% vs. 4.0%), than those without children leading up to CCB (Table 3A). After implementation, households with and without children had higher probabilities of being food secure as well as marginally food insecure; moderate food insecurity remained essentially unchanged. Only households with children experienced a drop in likelihood of experiencing severe food insecurity (3.6% to 2.5%).

Analytical subgroups: predicted probabilities

The probability of experiencing food insecurity increased with economic vulnerability, regardless of CCB or presence of children in the household (**Table 3.3**). Levels of intensity increased as well. The likelihood of experiencing moderate or severe food insecurity was higher among households reporting the median income or less compared to households reporting any income, and highest among those reporting the LIM or less.

Overall, households with children appeared to fare better following CCB than those without (**Table 3.4**). The former experienced greater relative increases in food security, as well as marked reductions in severe food insecurity. Among households without children, the probability of severe food insecurity increased. Changes in moderate food insecurity were less consistent and pronounced between the two groups. Only households with children experienced increases in the probability of experiencing marginal food insecurity after CCB.

Difference-in-differences

Households with children reporting the median income or less and LIM or less experienced positive increases in food security compares to households without (2.1% and 2.3%, respectively) (**Table 3.5**). As well, there were largely insignificant increases in marginal food insecurity (excluding households reporting any income, whose probability significantly increased by 1.1% (95% CI: 0.0, 2.3) and decreases in moderate food insecurity. Differences in severe food insecurity were greater among all but the households reporting any income. Those reporting the LIM or less experienced the most dramatic declines (DID 4.7%, 95% CI: -8.6, -0.7).

18 vs. 10-item HFSSM

Restricting analyses to the 10-item scale did not substantially alter our results. We observed similar trends among households with and without children, before and after CCB. Increases in food security following CCB among households with children compared to those without were consistent across subpopulations and slightly larger. Reductions in severe food insecurity were slightly smaller. All findings are presented in *Appendix F*.

DISCUSSION

Using a DID approach, we identified improvements to overall food security status among Canadian households with children across the income spectrum following the implementation of CCB. Decreases in the probability of experiencing severe food insecurity were significant and more pronounced with declining economic circumstance, suggesting that CCB, and more specifically, increases to the country's child benefits, disproportionately benefited vulnerable households.

As long as CCB benefits are indexed to inflation,[38] we anticipate that these improvements will persist. A recent simulation study[142] explored several cost-neutral strategies to retarget existing CCB payments towards low and moderate income households, resulting in benefit increases from 8-50%. Such changes could contribute to more drastic reductions in the prevalence and/or severity of food insecurity. However, it seems unlikely that the policy as it is currently structured will spur additional long-term gains. The rises in marginal food insecurity, rather than food security, accompanying declines in more severe levels of food insecurity suggest that while existing benefit levels may enable households to better meet their basic needs, they may be insufficient to provide full protection against material deprivation.

Nevertheless, our findings are noteworthy. Severe food insecurity is associated with the greatest negative impacts on health.[102,105,107,108] In Canada, the long-term effects of children's exposure to severe food insecurity (measured as hunger) are well documented, including the subsequent development of serious mental health problems.[105,106] The deleterious impacts of extreme deprivation are also reflected in healthcare utilization and spending patterns. One study found that adults in severely food insecure households incurred an additional $1,124, $1,769, and $2,322 per year in health care costs relative to those in moderately food insecure, marginally food insecure, and food secure households, respectively.[113] Reductions in the severity of food insecurity are likely to be associated with profound health and financial gains.

Study Limitations and Strengths

This study should be interpreted with several limitations in mind. First, our analyses strictly captured aggregate changes over time, compromising our ability to make causal inferences. A longitudinal study tracking the same households would be better suited for isolating the potential impact of CCB by further reducing variability and the probability of confounding bias. Second, the pre-tax income measure precluded us from studying the effects of CCB within the three income-tiered benefit categories. We were able to gauge broad changes associated with CCB and identify differential effects across the economic spectrum, however, we could not identify if and how the program's structure altered food security. This is a crucial element for understanding and being able to thoughtfully improve upon CCB. One cannot identify subpopulations for which the assistance was (in)sufficient without knowing the level of assistance they received.

Third, by omitting five jurisdictions, we sacrificed some external generalizability in favor of maintaining internal validity. Additionally, the omission of households living on First Nations reserves from CCHS means that this highly vulnerable group has not been included in our analysis. The cost of living – and potential purchasing power of CCB – varies throughout the country. Therefore, our results cannot be interpreted as evidence of how CCB functioned nation-wide. Nevertheless, Ontario, the largest jurisdiction omitted, has a food insecurity rate that has historically resembled the Canadian average, and only 3% of the country's population lives in the other excluded jurisdictions. We believe it is unlikely that their exclusion meaningfully impacted our results. Fourth, intent-to-treat designs often provide more conservative estimates than other methods.[143] By including all households – some who were eligible for CCB but may not have received it, and some who may not have been eligible at all – it is possible that we diluted CCB's true treatment effects. Fifth, data limitations necessitated omitting three of the eight provinces in this study and 2014-2015 outcome comparisons from the parallel trends assessment. Though we captured the majority of our sample and years leading up to the study period, these exclusions may have biased our results and subsequent interpretation. Finally, our limited sample size compromised both our power and precision, particularly among the smallest and most economically vulnerable subgroup.

Despite these limitations, our methodologically rigorous, interdisciplinary approach to program evaluation has allowed this study to overcome many of the limitations inherent to analyses that utilize cross-sectional data. This study is the first to directly assess the potential impact of CCB on food security, and to our knowledge, one of the first to assess how a federal income transfer program may impact food security among families with children of all ages. Moreover, comparing outcomes associated with CCB to those associated with its predecessors (as opposed to the absence of programming) helped us to estimate its relative, and most policy-relevant impacts.

As high rates of food insecurity and conversations regarding cuts to social spending simultaneously persist, it is critical to understand the specifics of their interplay before acting upon either. By leveraging routine food security monitoring data to engage with this analysis, we have helped lay the groundwork for future assessments of similar population-level interventions.

CONCLUSION

Our findings contribute to the growing body of evidence suggesting that household food insecurity can be impacted by policy decisions yielding even modest changes to households' economic circumstances.[100,120-122] Mirroring results from the evaluation of Canada's previous non-income tested child benefit program,[120] we found that sensitivity was greatest at the bottom of the income spectrum, where the risk and repercussions of food insecurity are also most severe.

Elucidating the potency and true long-term impacts of CCB will require that more detailed, longitudinal data from recipients become available. Namely, consistent food security measurement across jurisdictions and the separation of market income from government transfers – and in turn, the prioritization of measuring food security as a policy outcome. However, this study speaks to the potential of income transfers to impact food insecurity, emphasizing the (positive or negative) role that changes in social protections might play.

FIGURE

Figure 3.1 Food security trends in select Canadian provinces, 2011-2014

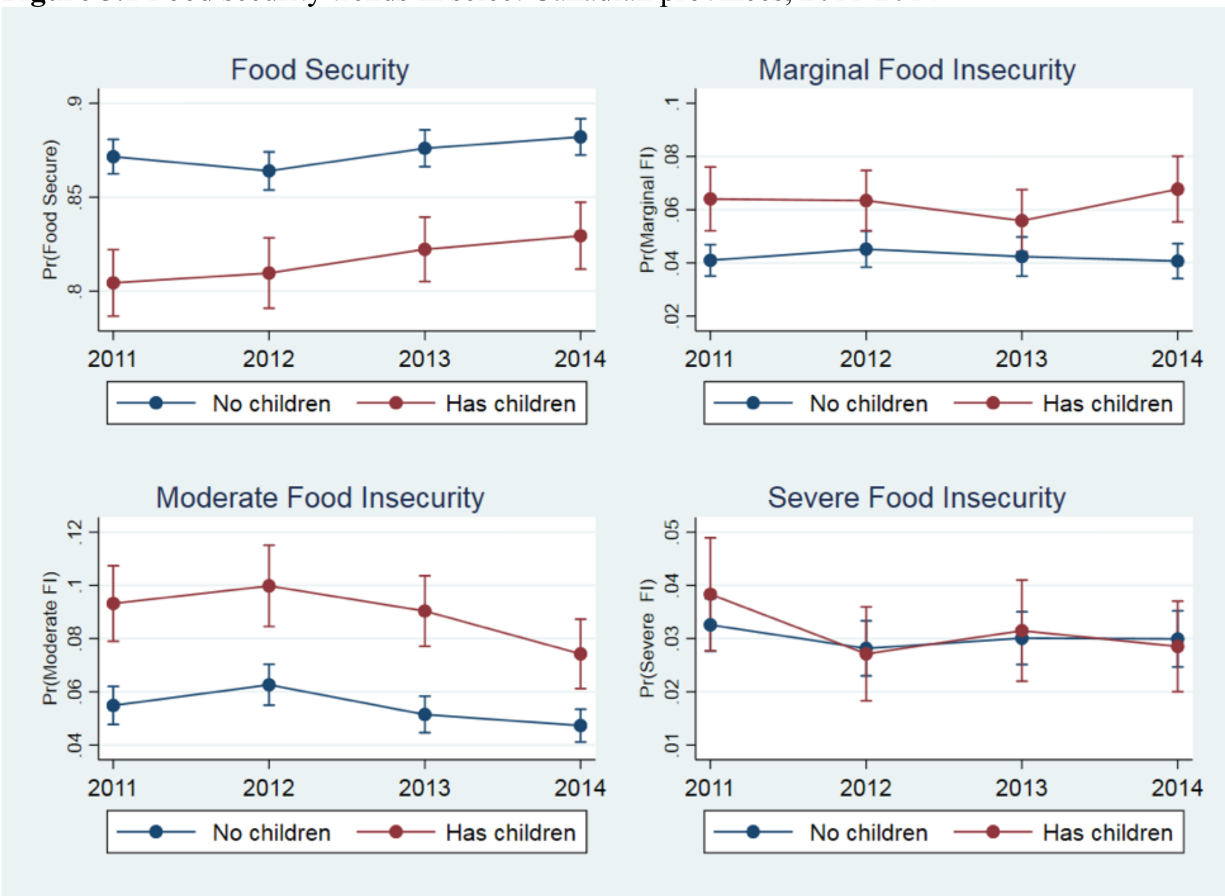


Table 3.1. Standardized mean and proportional differences of covariates among households with children (C) and without children (NC), within three subpopulations

	Any income		**≤Median income**		**≤LIM**	
	NC	C	NC	C	NC	C
IPTW weights						
Education	<0.1	<0.1	<0.1	<0.1	<0.15*	z<0.1
Household Composition	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
[Respondent] Black or Aboriginal	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
[Respondent] Immigrant	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Income from wages/salaries	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Owns home	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Received social assistance	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Province	<0.1	<0.1	<0.1	<0.1	<0.1	<0.15*
Children five or under	--	<0.1	--	<0.1	--	<0.1
Children six or older	--	<0.1	--	<0.1	--	<0.1
Month of interview	<0.15*	<0.1	<0.15*	<0.15*	<0.2*	<0.2*
Urban	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
IPTW weights combined with household-level survey weights						
Education	<0.1	<0.1	<0.1	<0.1	<0.15*	<0.1
Household Composition	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
[Respondent] Black or Aboriginal	<0.1	<0.1	<0.1	<0.1	<0.15*	<0.1
[Respondent] Immigrant	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Income from wages/salaries	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Owns home	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Received social assistance	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1
Province	<0.1	<0.1	<0.1	<0.1	<0.1	<0.15*
Children five or under	--	<0.1	--	<0.1	--	<0.1
Children six or older	--	<0.1	--	<0.1	--	<0.1
Month of interview	<0.15*	<0.1	<0.15*	<0.15*	<0.2*	<0.2*
Urban	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1

*At least one category within covariate has standardized proportion greater than 0.1

Table 3.2 Weighted household characteristics of a sample of CCHS respondents stratified by presence of children in the household, survey years 2015-2018

	Households without children (N^A =26,743)	Households with children (N^B =14,712)	Total (N^C =41,455)
Education			
High School or less	23.8%	14.7%	20.5%
Some post-secondary education	41.7%	40.7%	41.3%
College+	34.5%	44.6%	38.2%
Household Composition			
Single adult	41.3%	18.2%	32.8%
Single adult with other adults	9.3%	2.0%	6.7%
Partnered adult	47.1%	72.5%	56.4%
Partnered adult with other adults	1.9%	6.0%	3.4%
Others	0.4%	1.3%	0.7%
[Respondent] Black or Aboriginal	6.3%	9.0%	7.2%
[Respondent] Immigrant	17.6%	24.2%	20.0%
Income from wages/salary	88.0%	91.9%	89.5%
Owns home	64.1%	75.2%	68.2%
Received social assistance	15.5%	14.2%	15.0%
Province			
Prince Edward Island	0.7%	0.7%	0.7%
Nova Scotia	4.6%	4.1%	4.4%
New Brunswick	3.5%	3.5%	3.5%
Quebec	41.0%	39.1%	40.3%
Manitoba	5.5%	5.9%	5.7%
Saskatchewan	4.8%	5.7%	5.1%
Alberta	18.5%	20.3%	19.2%
British Columbia	21.4%	20.9%	21.2%
Lives in urban location	82.4%	81.1%	81.9%
Number of children <6 (mean, SD)	--	0.6 (0.8)	--
Number of children >5 (mean, SD)	--	1.2 (1.0)	--

[A] Estimating 15,500,000 households
[B] Estimating 8,500,000 households
[C] Estimating 24,00,000 households

Table 3.3 Crude and adjusted predicted probabilities of categorical food security among households with and without children, before and after the Canada Child Benefit (N=41,455[A])

	Households without children		Households with children	
	Pre-CCB	**Post-CCB**	**Pre-CCB**	**Post-CCB**
Unadjusted model[B]				
FS	85.9 (85.2, 86.6)	86.0 (84.8 87.1)	83.9 (82.8, 84.9)	84.3 (82.7, 85.9)
Ma FI	4.1 (3.7, 4.4)	3.8 (3.1, 4.4)	5.1 (4.6, 5.7)	5.4 (4.4, 6.3)
Mo FI	6.0 (5.5, 6.5)	6.1 (5.3, 6.9)	7.9 (7.1, 8.7)	8.0 (6.7, 9.3)
Sev FI	4.1 (3.7, 4.5)	4.1 (3.5, 4.7)	3.1 (2.6, 3.6)	2.3 (1.7, 3.0)
Adjusted model				
FS	85.4 (84.4, 86.4)	86.1 (85.2, 87.1)	83.5 (81.9, 85.1)	84.1 (82.6, 85.2)
Ma FI	4.6 (4.0, 5.2)	4.0 (3.2, 4.6)	4.2 (3.5, 4.9)	4.7 (3.9, 5.5)
Mo FI	6.0 (5.3, 6.6)	5.9 (5.2, 6.5)	8.7 (7.4, 10.3)	8.5 (7.4, 9.7)
Sev FI	4.0 (3.4, 4.6)	4.0 (3.4, 4.6)	3.6 (2.8, 4.4)	2.7 (2.0, 3.4)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure
[A] Estimating 24,000,000 households
[B] With household, but not IPTW, weights

Table 3.4 Adjusted predicted probabilities of categorical food security among two analytic samples of households with and without children, before and after the Canada Child Benefit

	Households without children		Households with children	
	Pre-CCB	**Post-CCB**	**Pre-CCB**	**Post-CCB**
Median income (N=16,205)[A]				
FS	74.3 (72.4, 76.2)	74.5 (72.6, 76.4)	72.8 (69.6,76.0)	75.1 (72.2, 78.0)
Ma FI	7.4 (6.2, 8.6)	6.5 (5.3, 7.7)	5.7 (4.4, 7.0)	6.1 (4.7, 7.4)
Mo FI	10.6 (9.4, 11.8)	10.9 (9.6, 12.2)	14.0 (11.4, 16.6)	13.8 (11.4, 16.6)
Sev FI	7.8 (6.7, 9.8)	8.1 (7.0, 9.1)	7.5 (5.8, 9.2)	5.1 (3.6, 6.5)
≤LIM (N=6,276)[B]				
FS	61.9 (58.6, 65.2)	61.8 (58.4, 65.2)	61.6 (57.4, 65.9)	63.8 (59.9, 67.7)
Ma FI	10.0 (7.6, 12.5)	8.2 (5.9, 10.4)	6.7 (5.0, 8.4)	7.9 (6.0, 9.8)
Mo FI	15.4 (13.0, 17.8)	16.7 (14.1, 19.2)	19.4 (15.8, 23.1)	20.0 (16.4, 23.7)
Sev FI	12.7 (10.5, 14.8)	13.4 (11.1, 15.6)	12.3 (9.2, 15.3)	8.2 (5.9, 10.6)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure
[A] Estimating 10,600,000 households
[B] Estimating 4,600,000 households

Table 3.5. Difference-in-differences in food security between households with and without children following the Canada Child Benefit

	DID estimate (95% CI)
Any income	
FS	-0.1 (-2.1, 1.8)
Ma FI	1.1 (0.0, 2.3)
Mo FI	-0.0 (-1.6, 1.4)
Sev FI	-1.0 (-2.0, 0.0)
<=Median income	
FS	2.1 (-1.9, 6.1)
Ma FI	1.3 (-0.8, 3.3)
Mo FI	-0.6 (-3.6, 2.4)
Sev FI	-2.8 (-5.0, -0.6)
<=LIM	
FS	2.3 (-3.6, 8.2)
Ma FI	3.1 (0.3, 6.5)
Mo FI	-0.7 (-5.8, 4.5)
Sev FI	-4.7 (-8.6, -0.7)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Conclusion

The first two aims of this dissertation sought to explore the potential long-term repercussions of childhood food insecurity on excess weight among a cohort of Black and White women and their children. We found significant increases in BMI that varied by race in adulthood, and either insignificant or lower odds of excess weight among offspring whose mothers' reported childhood food insecurity. The third aim assessed whether the implementation of the Canada Child Benefit reduced the prevalence of food insecurity among households with children. We identified significant declines in severe food insecurity that grew more substantial with increasingly socioeconomic vulnerability.

Paper 1 assessed average BMI differences by childhood food security status in young adulthood (age 18-20 years) and midlife (age 37-42 years), within and between Black and White racial strata. There appeared to be a direct association between the severity of childhood food insecurity and BMI among White women that intensified with age; by midlife, those reporting the most severe experiences of childhood food insecurity had the most substantial and significant increase in average BMI. However, the reverse was true for Black women. Though heavier on average, there were no significant differences by childhood food security status observed among Black participants in midlife; a significant association between severe childhood food insecurity and higher BMI identified in young adulthood abated, and women reporting severe childhood food insecurity had the lowest average BMI within this group. In conjunction with findings from other studies, we believe behavioral and metabolic changes stemming from childhood food insecurity may become increasingly potent among White women over time. However, among Black women, these impacts may be eclipsed by the collective stress and hardship of institutionalized and interpersonal racism. This analysis contributed to the growing body of literature that demonstrates the potency of childhood exposures throughout the life course, and sheds light on how it may vary by race. We hope future studies expound upon our findings by isolating and quantifying the influence of potential mechanisms along the causal pathway, considering them in the context of upstream factors to elucidate the impacts of food insecurity relative to other obesity risks.

Paper 2 investigated whether there was an association between maternal childhood food security status and odds of offspring overweight/obesity. We also tested for effect modification by child's age, child's gender, current household food security status, mother's race, and mother's weight status, which we believed might differential experiences of maternal childhood food insecurity and/or offspring weight status. Counterintuitively, we found a significant, inverse association between maternal moderate childhood food insecurity and offspring overweight/obesity risk that was strongest among food secure children, White children, and children between the age of 2-5, respectively. We believe that these findings may reflect a maternal reaction to shield children from their own adverse experiences, in turn "protecting" them from foods and behaviors that might increase obesity risk. Although non-conclusive, we believe their sentiment should be taken into account when crafting potential intervention strategies. Many mothers are likely aware of what is best or healthiest for their children; the availability of resources to provide that level of care may be more powerful in preventing obesity transmission.

Paper 3 explored the sensitivity of household food security status to increases in federal income transfers among three socioeconomic subpopulations of households with children in Canada: households reporting any income, the median income or less, or the Low Income Measure or less. Similar to national trends, we found that the prevalence and severity of food insecurity increased with economic vulnerability, and were both consistently higher among households with children compared to those without. However, they also experienced significantly greater drops in the likelihood of experiencing severe food insecurity following CCB; most dramatically among those reporting the LIM or less. These findings suggest that CCB may have contributed to significant declines in household food insecurity, disproportionately benefiting the most vulnerable families. Furthermore, they contribute to the growing body of evidence suggesting that household food insecurity can be impacted by policy decisions yielding even modest changes to households' economic circumstances. As rates of high food insecurity and conversations pertaining to cuts to social spending simultaneously persist in both Canada and the United States, it is critical to consider how their interplay may impact the health and wellbeing of their populations.

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Appendix A

Table A.1. NGHS participants' mean clinical BMI ratios, by race and childhood food security status in midlife (N=506)

		White women		**Black women**		**Black strata**
		N	**RMD (95% CI)**	**N**	**RMD (95% CI)**	
FS	-ref-	180/246	-ref-	163/259	1.11 (1.06, 1.17)	-ref-
Ma FI	1.05 (0.99, 1.11)	20/246	1.05 (0.95, 1.17)	49/259	1.16 (1.08, 1.24)	1.04 (0.98, 1.11)
Mo FI	1.03 (0.97, 1.09)	27/246	1.00 (0.93, 1.08)	21/259	1.18 (1.07, 1.30)	1.06 (0.97, 1.16)
Sev FI	1.00 (0.93, 1.08)	19/246	1.10 (0.99, 1.22)	26/259	1.04 (0.94, 1.15)	0.94 (0.86, 1.03)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Appendix B.

Past Food Insecurity: 7-item Scale

	Never	Rarely	Sometimes	Often
1. My family ate the same foods every day because there was not enough money or resources for other foods.	☐	☐	☐	☐
2. There were times of the month or year when my family ran low on food.	☐	☐	☐	☐
3. We had to divide very small amounts of meat among family members because there wasn't enough for everyone.	☐	☐	☐	☐
4. There were times when my parents/guardians did not have enough to eat.	☐	☐	☐	☐
5. There were times when I did not have enough to eat.	☐	☐	☐	☐
6. I worked as a child to earn money to help my family buy food.	☐	☐	☐	☐
7. Do you feel you need to give your child special foods that you didn't have as a child?	☐	☐	☐	☐

Appendix C

Table C.1: Tiered household income phase-outs for the Canada Child Benefit, 2016-2018*

Household income	One child	Two children	3+ children
$0-30,000	No phase out	No phase out	No phase out
$30,001-$65,000	6.8%**	13%	16%
$65,001+	3.1%***	5.5%	8%

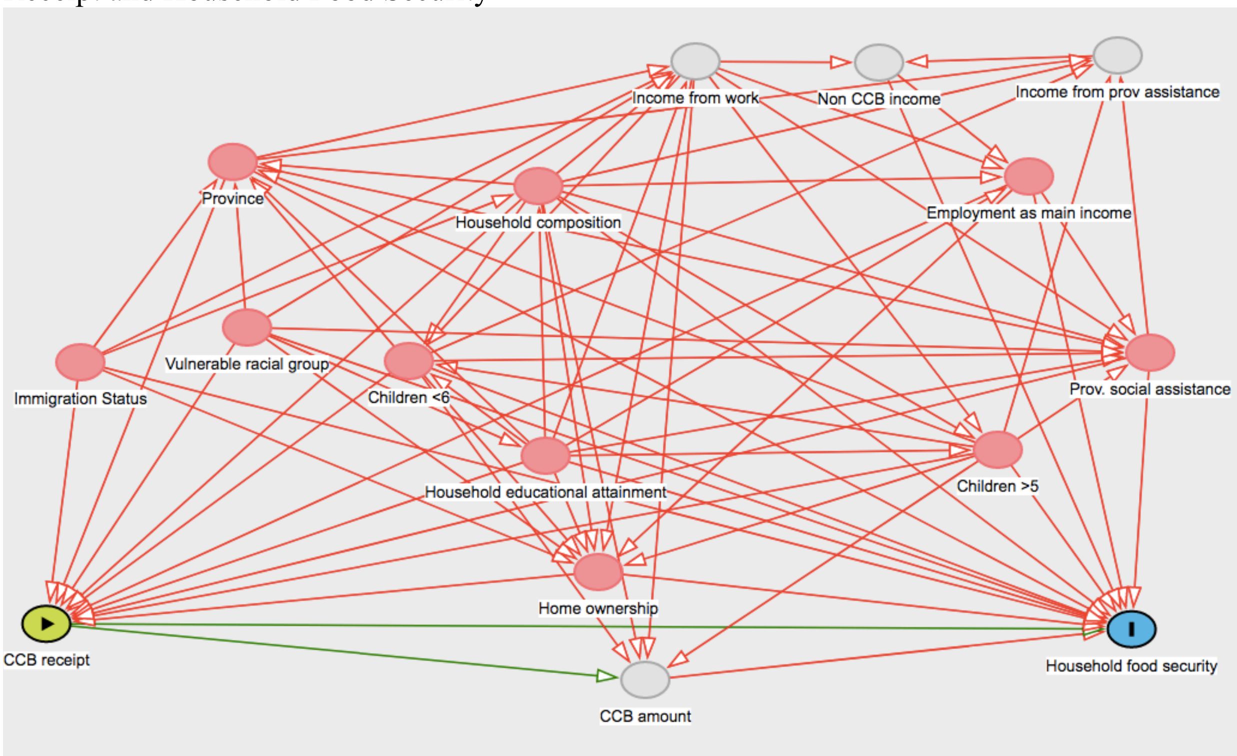
*Based on adjusted net income
**Every $100 of income in this tier has a $6.80 phase out. For example, if a household earns $40,000, then $10,000 will fall within the 6.8% phase out (10,000*0.068=$680 will be subtracted from overall benefit)
***Every $100 of income in this tier has a $3.10 phase out. For example, if you earn $90,000, then $35,000 will be phased out at 6.8% and $25,000 will be phased out at 3.1%)

Table C.2: Income Cut-offs for the Canada Child Benefit based on number and ages of children, for 2016-2018

One child <6	$188,437
One child >5	$157,187
Two children <6	$206,667
Two children, one <6	$189,123
Two children >5	$171,579
Three children <6	$221,875
Three children, two <6	$209,375
Three children, one <6	$196,875
Three children >5	$184,375
Four children <6	$249,737
Four children, three <6	$239,211
Four children, two <6	$228,684
Four children, one <6	$218,158
Four children >5	$207,631

Appendix D

Figure D.1. Directed Acyclic Graph depicting the relationship between Canada Child Benefit Receipt and Household Food Security



Appendix E

We adapted the methodology used in our primary analysis to evaluate whether there were significant, differential trends in each food security category among households with and without children, leading up to our study period (2011-2014). DIDs can be found in Table 7.

There were two significant differences between both assessments. First, only five of the eight provinces included in our analysis had HFSSM data available throughout this period (Prince Edward Island, Saskatchewan, Nova Scotia, New Brunswick, Quebec, and Alberta). Second, we were limited to using regression adjustment to account for potential confounding bias.

It is also worth noting that in 2015, CCHS adopted a new sampling frame. Statistics Canada has since issued an advisory about comparing recent (2015-present) data with cycles preceding this change. As such, we chose not to directly compare 2014 to 2015, and advise readers to considering both sets of findings in tandem with caution.

Table E.1. Difference-in-differences among food security categories between households with and without children among six provinces from 2011-2014 (N=60,756) [A]

	FS	**Ma FI**	**Mo FI**	**Sev FI**
Yearly DID (95% CI)				
2012 vs. 2011	1.3 (-1.6, 4.1)	-0.5 (-2.3, 1.3)	-0.1 (-2.4, 2.2)	-0.7 (-2.2, 0.9)
2013 vs. 2012	0.1 (-2.8, 2.9)	-0.5 (-2.3, 1.4)	0.2 (-2.0, 2.4)	0.2 (-1.2, 1.7)
2014 vs. 2013	0.1 (-2.6, 2.9)	1.4 (-0.6, 3.3)	-1.2 (-3.2, 0.8)	-0.3 (-1.8, 1.2)
Bi-annual DID (95% CI)				
2013 vs. 2011	1.3 (-1.4, 4.1)	-1.0 (-2.8, 0.9)	0.1 (-2.1, 2.2)	-0.4 (-2.0, 1.1)
2014 vs. 2012	0.2 (-2.7, 3.1)	0.9 (-1.0, 2.8)	-1.0 (-3.2, 1.2)	-0.0 (-1.5, 1.4)
Overall DID (95% CI)				
2014 vs. 2011	1.5 (-1.3, 4.2)	0.4 (-1.5, 2.3)	-1.1 (-3.2, 1.0)	-0.7 (2.2, 0.8)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure
[A] Estimating 7,529,000 households

Appendix F

Table F.1. Adjusted predicted probabilities of categorical food security among three analytic samples of CCHS households, before and after the Canada Child Benefit (using 10-item scale)

	Households without children		**Households with children**	
	Pre-CCB	Post-CCB	Pre-CCB	Post-CCB
Total population (N=41,455)				
FS	85.7 (84.7, 86.7)	86.4 (85.4, 87.3)	84.4 (82.8, 86.0)	85.2 (83.7, 86.7)
Ma FI	4.4 (3.8, 5.1)	3.9 (3.3, 4.4)	4.0 (3.3, 4.8)	4.0 (3.4, 4.7)
Mo FI	5.9 (5.3, 6.5)	5.8 (5.2, 6.5)	8.0 (6.8, 9.3)	8.0 (6.19, 9.2)
Sev FI	4.0 (3.4, 4.5)	4.0 (3.4, 4.5)	3.6 (2.8, 4.4)	2.7 (2.0, 3.5)
≤Median income (N=18,191)				
FS	74.9 (73.0, 76.7)	75.0 (73.1, 76.9)	74.1 (71.0, 77.3)	76.6 (73.7, 79.4)
Ma FI	7.0 (5.8, 8.2)	6.2 (5.0, 7.3)	5.5 (4.0, 7.0)	5.3 (4.1, 6.6)
Mo FI	10.5 (9.3, 11.7)	10.9 (9.6, 12.2)	12.9 (10.5, 15.3)	12.9 (10.6, 15.2)
Sev FI	7.6 (6.6, 8.7)	7.9 (6.9, 9.0)	7.5 (5.8, 9.3)	5.2 (3.7, 6.7)
≤LIM income (N=7,579)				
FS	62.9 (59.6, 66.1)	62.7 (59.4, 66.0)	63.4 (59.1, 67.7)	66.3 (62.5, 70.2)
Ma FI	9.6 (7.1, 12.0)	7.7 (5.6, 9.7)	6.1 (4.4, 7.7)	6.5 (4.9, 8.1)
Mo FI	15.1 (12.7, 17.5)	16.5 (13.9, 19.0)	18.3 (14.8, 21.9)	18.8 (15.2, 22.3)
Sev FI	12.5 (10.4, 14.6)	13.2 (11.0, 15.5)	12.2 (9.1, 15.3)	8.4 (6.0, 10.9)

FS: Food secure, Ma FI: marginally food insecure, Mo FI: moderately food insecure, Sev FI: severely food insecure

Table F.2. Adjusted effects of CCB on categorical food insecurity among four analytical subgroups (using 10-item scale)

	DiD estimate (95% CI)
Total population (N=41,455)	
FS	0.2 (-1.8, 2.0)
Ma FI	0.6 (-0.5, 1.7)
Mo FI	0.1 (-1.4, 1.6)
Sev FI	-0.8 (-1.9, 0.2)
Median income (N=18,191)	
FS	2.3 (-1.7, 6.3)
Ma FI	0.7 (-1.3, 2.7)
Mo FI	-0.4 (-3.3, 2.6)
Sev FI	-2.6 (-4.9, -0.4)
≤LIM income (N=7,579)	
FS	3.1 (-2.7, 4.1)
Ma FI	2.4 (-0.8, 5.5)
Mo FI	-0.9 (-6.0, 4.1)
Sev FI	-4.5 (-8.6, -0.5)

FS: Food secure, Ma FI: marginally food insecure,
Mo FI: moderately food insecure, Sev FI: severely food insecure