

FOOD INSECURITY AND DISEASE

Prevalence, Policy, and Politics



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Edited by

Areej Hassan, MD, MPH



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Introduction

We know that food insecurity and disease are inextricably linked. The articles selected for this compendium reinforce that message by specifically linking food insecurity to various forms of chronic disease, including HIV/AIDS and obesity, as well as mental health issues. The research in the fifth section of this book then goes a step further by asking, “What next?” In other words, how can we shape politics and policy to address this urgent international crisis?

The quality of the research gathered here is incredibly high. The authors have done much to advance our understanding of this issue—and they have provided us with a solid foundation on which to build well-informed clinical practice, further research, and effective future policy.

—Areej Hassan, MD

According to the USDA, food security means access by all people at all times to enough food for an active, healthy life. We begin our compendium with the USDA’s definitions of food security and insecurity.

Because little is known about food insecurity in people with mental health conditions, the authors of chapter 2 investigated relationships among food insecurity, nutrient intakes, and psychological functioning in adults with mood disorders. Data from a study of adults randomly selected from the membership list of the Mood Disorder Association of British Columbia ($n = 97$), Canada, were analyzed. Food insecurity status was based on validated screening questions asking if in the past 12 months did the participant, due to a lack of money, worry about or not have enough food to eat. Nutrient intakes were derived from 3-day food records and compared to the Dietary Reference Intakes (DRIs). Psychological functioning measures included Global Assessment of Functioning, Hamilton Depression scale, and Young Mania Rating Scale. Using binomial tests of two proportions, Mann–Whitney U tests, and Poisson regression authors examined: (1) food insecurity prevalence between the study respondents and a general population sample from the British Columbia Nutrition Survey (BCNS; $n = 1,823$); (2) differences in nutrient intakes based on food insecurity status; and (3) associations of food insecurity and psychological functioning using bivariate and Poisson regression statistics. In comparison to the general population (BCNS), food insecurity was significantly more prevalent in the adults

with mood disorders (7.3% in BCNS vs 36.1%; $p < 0.001$). Respondents who were food-insecure had lower median intakes of carbohydrates and vitamin C ($p < 0.05$). In addition, a higher proportion of those reporting food insecurity had protein, folate, and zinc intakes below the DRI benchmark of potential inadequacy ($p < 0.05$). There was significant association between food insecurity and mania symptoms (adjusted prevalence ratio = 2.37, 95% CI 1.49–3.75, $p < 0.05$). The authors found that food insecurity is associated with both nutritional and psychological health in adults with mood disorders. Investigation of interventions aimed at food security and income can help establish its role in enhancing mental health.

There are compelling theoretical and empirical reasons that link household food insecurity to mental distress in the setting where both problems are common. However, little is known about their association during pregnancy in Ethiopia. A cross-sectional study is reported in chapter 3 that was conducted to examine the association of household food insecurity with mental distress during pregnancy. Six hundred and forty-two pregnant women were recruited from 11 health centers and one hospital. Probability proportional to size (PPS) and consecutive sampling techniques were employed to recruit study subjects until the desired sample size was obtained. The Self Reporting Questionnaire (SRQ-20) was used to measure mental distress and a 9-item Household Food Insecurity Access Scale was used to measure food security status. Descriptive and inferential statistics were computed accordingly. Multivariate logistic regression was used to estimate the effect of food insecurity on mental distress. Fifty-eight of the respondents (9 %) were moderately food insecure and 144 of the respondents (22.4 %) had mental distress. Food insecurity was also associated with mental distress. Pregnant women living in food insecure households were 4 times more likely to have mental distress than their counterparts (COR = 3.77, 95% CI: 2.17, 6.55). After controlling for confounders, a multivariate logistic regression model supported a link between food insecurity and mental distress (AOR = 4.15, 95% CI: 1.67, 10.32). The study found a significant association between food insecurity and mental distress. However, the mechanism by which food insecurity is associated with mental distress is not clear. Further investigation is therefore needed to understand either how food insecurity during pregnancy leads to mental distress or whether mental distress is a contributing factor in the development of food insecurity.

Understanding how food insecurity among women gives rise to differential patterning in HIV risks is critical for policy and programming in resource-limited settings. This is particularly the case in Brazil, which has undergone

successive changes in the gender and socio-geographic composition of its complex epidemic over the past three decades. The authors of chapter 4 used data from a national survey of Brazilian women to estimate the relationship between food insecurity and HIV risk. They used data on 12,684 sexually active women from a national survey conducted in Brazil in 2006–2007. Self-reported outcomes were (a) consistent condom use, defined as using a condom at each occasion of sexual intercourse in the previous 12 mo; (b) recent condom use, less stringently defined as using a condom with the most recent sexual partner; and (c) itchy vaginal discharge in the previous 30 d, possibly indicating presence of a sexually transmitted infection. The primary explanatory variable of interest was food insecurity, measured using the culturally adapted and validated *Escala Brasileira de Segurança Alimentar*. In multivariable logistic regression models, severe food insecurity with hunger was associated with a reduced odds of consistent condom use in the past 12 mo (adjusted odds ratio [AOR]=0.67; 95% CI, 0.48–0.92) and condom use at last sexual intercourse (AOR=0.75; 95% CI, 0.57–0.98). Self-reported itchy vaginal discharge was associated with all categories of food insecurity (with AORs ranging from 1.46 to 1.94). In absolute terms, the effect sizes were large in magnitude across all outcomes. Underweight and/or lack of control in sexual relations did not appear to mediate the observed associations. Severe food insecurity with hunger was associated with reduced odds of condom use and increased odds of itchy vaginal discharge, which is potentially indicative of sexually transmitted infection, among sexually active women in Brazil. Interventions targeting food insecurity may have beneficial implications for HIV prevention in resource-limited settings.

Food insecurity (FI) is the lack of physical, social, and economic access to sufficient food for dietary needs and food preferences. The authors of chapter 5 examined the association between FI and women's uptake of services to prevent mother-to-child HIV transmission (MTCT) in Zimbabwe. They analyzed cross-sectional data collected in 2012 from women living in five of ten provinces. Eligible women were ≥ 16 years old, biological mothers of infants born 9–18 months before the interview, and were randomly selected using multi-stage cluster sampling. Women and infants were tested for HIV and interviewed about health service utilization during pregnancy, delivery, and post-partum. The authors assessed FI in the past four weeks using a subset of questions from the Household Food Insecurity Access Scale and classified women as living in food secure, moderately food insecure, or severely food insecure households. The weighted population included 8,790 women. Completion of all key steps in the PMTCT cascade was reported by 49%, 45%, and 38% of women in food secure,

moderately food insecure, and severely food insecure households, respectively (adjusted prevalence ratio (PRa) = 0.95, 95% confidence interval (CI): 0.90, 1.00 (moderate FI vs. food secure), PRa = 0.86, 95% CI: 0.79, 0.94 (severe FI vs. food secure)). Food insecurity was not associated with maternal or infant receipt of ART/ARV prophylaxis. However, in the unadjusted analysis, among HIV-exposed infants, 13.3% of those born to women who reported severe household food insecurity were HIV-infected compared to 8.2% of infants whose mothers reported food secure households (PR = 1.62, 95% CI: 1.04, 2.52). After adjustment for covariates, this association was attenuated (PRa = 1.42, 95% CI: 0.89, 2.26). There was no association between moderate food insecurity and MTCT in unadjusted or adjusted analyses (PRa = 0.68, 95% CI: 0.43, 1.08). Among women with a recent birth, food insecurity is inversely associated with service utilization in the PMTCT cascade and severe household food insecurity may be positively associated with MTCT. These preliminary findings support the assessment of FI in antenatal care and integrated food and nutrition programs for pregnant women to improve maternal and child health.

Food insecurity and poor nutrition are key barriers to anti-retroviral therapy (ART) adherence. Culturally-appropriate and sustainable interventions that provide nutrition counseling for people on ART and of diverse nutritional statuses are needed, particularly given rising rates of overweight and obesity among people living with HIV (PLHIV). As part of scale-up of a nutritional counseling intervention, the authors of chapter 6 recruited and trained 17 peer counselors from 14 government-run HIV clinics in Honduras to deliver nutritional counseling to ART patients using a highly interactive curriculum that was developed after extensive formative research on locally available foods and dietary patterns among PLHIV. All participants received the intervention; at baseline and 2 month follow-up, assessments included: 1) interviewer-administered, in-person surveys to collect data on household food insecurity (15-item scale), nutritional knowledge (13-item scale), dietary intake and diversity (number of meals and type and number of food groups consumed in past 24 h); and 2) anthropometric measures (body mass index or BMI, mid-upper arm and waist circumferences). The authors used multivariable linear regression analysis to examine changes pre-post in food insecurity and the various nutritional outcomes while controlling for baseline characteristics and clinic-level clustering. Of 482 participants at baseline, the authors had complete follow-up data on 356 (74%), of which 62% were women, median age was 39, 34% reported having paid work, 52% had completed primary school, and 34% were overweight or obese. In multivariate analyses adjusting for gender, age, household size, work status, and education, the

authors found that between baseline and follow-up, household food insecurity decreased significantly among all participants ($\beta = -0.47$, $p < .05$) and among those with children under 18 ($\beta = -1.16$, $p < .01$), while nutritional knowledge and dietary intake and diversity also significantly improved, ($\beta = 0.88$, $p < .001$; $\beta = 0.30$, $p < .001$; and $\beta = 0.15$, $p < .001$, respectively). Nutritional status (BMI, mid-arm and waist circumferences) showed no significant changes, but the brief follow-up period may not have been sufficient to detect changes. A peer-delivered nutritional counseling intervention for PLHIV was associated with improvements in dietary quality and reduced food insecurity among a population of diverse nutritional statuses. Future research should examine if such an intervention can improve adherence among people on ART.

Little is known about the potential impact of food insecurity on mortality among people living with HIV/AIDS. The authors of chapter 7 examined the potential relationship between food insecurity and all-cause mortality among HIV-positive injection drug users (IDU) initiating antiretroviral therapy (ART) across British Columbia (BC). Cross-sectional measurement of food security status was taken at participant ART initiation. Participants were prospectively followed from June 1998 to September 2011 within the fully subsidized ART program. Cox proportional hazard models were used to ascertain the association between food insecurity and mortality, controlling for potential confounders. Among 254 IDU, 181 (71.3%) were food insecure and 108 (42.5%) were hungry. After 13.3 years of median follow-up, 105 (41.3%) participants died. In multivariate analyses, food insecurity remained significantly associated with mortality (adjusted hazard ratio [AHR] = 1.95, 95% CI: 1.07–3.53), after adjusting for potential confounders. HIV-positive IDU reporting food insecurity were almost twice as likely to die, compared to food secure IDU. Further research is required to understand how and why food insecurity is associated with excess mortality in this population. Public health organizations should evaluate the possible role of food supplementation and socio-structural supports for IDU within harm reduction and HIV treatment programs.

Despite advances in treatment of people living with HIV, morbidity and mortality remains unacceptably high in sub-Saharan Africa, largely due to parallel epidemics of poverty and food insecurity. The authors of chapter 8 conducted a pilot cluster randomized controlled trial (RCT) of a multisectoral agricultural and microfinance intervention (entitled *Shamba Maisha*) designed to improve food security, household wealth, HIV clinical outcomes and women's empowerment. The intervention was carried out at two HIV clinics in Kenya, one randomized to the intervention arm and one to the control arm. HIV-infected

patients >18 years, on antiretroviral therapy, with moderate/severe food insecurity and/or body mass index (BMI) <18.5, and access to land and surface water were eligible for enrollment. The intervention included: 1) a microfinance loan (~\$150) to purchase the farming commodities, 2) a micro-irrigation pump, seeds, and fertilizer, and 3) trainings in sustainable agricultural practices and financial literacy. Enrollment of 140 participants took four months, and the screening-to-enrollment ratio was similar between arms. The authors followed participants for 12 months and conducted structured questionnaires. They also conducted a process evaluation with participants and stakeholders 3–5 months after study start and at study end. Baseline results revealed that participants at the two sites were similar in age, gender and marital status. A greater proportion of participants at the intervention site had a low BMI in comparison to participants at the control site (18% vs. 7%, $p = 0.054$). While median CD4 count was similar between arms, a greater proportion of participants enrolled at the intervention arm had a detectable HIV viral load compared with control participants (49% vs. 28%, respectively, $p < 0.010$). Process evaluation findings suggested that *Shamba Maisha* had high acceptability in recruitment, delivered strong agricultural and financial training, and led to labor saving due to use of the water pump. Implementation challenges included participant concerns about repaying loans, agricultural challenges due to weather patterns, and a challenging partnership with the microfinance institution. The authors expect the results from this pilot study to provide useful data on the impacts of livelihood interventions and will help in the design of a definitive cluster RCT.

The authors of chapter 9 aim to explore how food insecurity affects individuals' ability to manage their diabetes, as narrated by participants living in a large, culturally diverse urban centre. To this end, the authors underwent a qualitative study comprising of in-depth interviews, using a semistructured interview guide. Participants were recruited from the local community, three community health centres, and a community-based diabetes education centre servicing a low-income population in Toronto, Ontario, Canada. Twenty-one English-speaking adults with a diagnosis of diabetes and having experienced food insecurity in the past year (based on three screening questions) participated in the study. Using six phases of analysis, the authors used qualitative, deductive thematic analysis to transcribe, code, and analyze participant interviews. Three themes emerged from the authors' analysis of participants' experiences of living with food insecurity and diabetes: (1) barriers to accessing and preparing food, (2) social isolation, and (3) enhancing agency and resilience. Food insecurity appears to negatively impact diabetes self-management. Healthcare professionals need to

be cognizant of resources, skills, and supports appropriate for people with diabetes affected by food insecurity. Study findings suggest foci for enhancing diabetes self-management support.

Food insecurity among Mexican-origin and Hispanic households is a critical nutritional health issue of national importance. At the same time, nutrition-related health conditions, such as obesity and type 2 diabetes, are increasing in Mexican-origin youth. Risk factors for obesity and type 2 diabetes are more common in Mexican-origin children and include increased intakes of energy-dense and nutrient-poor foods. Chapter 10 assessed the relationship between children's experience of food insecurity and nutrient intake from food and beverages among Mexican-origin children (age 6-11 y) who resided in Texas border colonias. Baseline data from 50 Mexican-origin children were collected in the home by trained promotora-researchers. All survey (demographics and nine-item child food security measure) and 24-hour dietary recall data were collected in Spanish. Dietary data were collected in person on three occasions using a multiple-pass approach; nutrient intakes were calculated with NDS-R software. Separate multiple regression models were individually fitted for total energy, protein, dietary fiber, calcium, vitamin D, potassium, sodium, Vitamin C, and percentage of calories from fat and added sugars. Thirty-two children (64%) reported low or very low food security. Few children met the recommendations for calcium, dietary fiber, and sodium; and none for potassium or vitamin D. Weekend intake was lower than weekday for calcium, vitamin D, potassium, and vitamin C; and higher for percent of calories from fat. Three-day average dietary intakes of total calories, protein, and percent of calories from added sugars increased with declining food security status. Very low food security was associated with greater intakes of total energy, calcium, and percentage of calories from fat and added sugar. Chapter 10 not only emphasizes the alarming rates of food insecurity for this Hispanic subgroup, but describes the associations for food insecurity and diet among this sample of Mexican-origin children. Child-reported food insecurity situations could serve as a screen for nutrition problems in children. Further, the National School Lunch and School Breakfast Programs, which play a major beneficial role in children's weekday intakes, may not be enough to keep pace with the nutritional needs of low and very low food secure Mexican-origin children.

Interventions that cultivate sustainable food systems to promote health, prevent obesity, and improve food security have the potential for many large-scale and long-lasting benefits including improvements in social, environmental, health, and economic outcomes. The authors of chapter 11 briefly summarize

findings from previous research examining associations between obesity and food insecurity and discuss the need for greater synergy between food insecurity initiatives and national obesity prevention public health goals in the United States. The common ground between these two nutrition-related public health issues is explored, and the transformation needed in research and advocacy communities around the shared goal of improving population health through individual, environmental, and policy level changes to promote healthy sustainable food systems is discussed. The authors of chapter 11 propose an ecological framework to simultaneously consider food insecurity and obesity that identifies levers for change to promote sustainable food systems to improve food security and prevent obesity.

The author of chapter 12 argues that understanding hunger and malnutrition requires an examination of what systems and institutions hold power over food. The concept of “food security” captures the notion of hunger not as a deficit of calories, but as a violation of a broader set of social, economic, and physical conditions. Gender is key to food insecurity and malnourishment, because women and girls are disproportionately disempowered through current processes and politics of food’s production, consumption, and distribution. La Via Campesina has advocated for food sovereignty, through which communities have the right to define their own food and agriculture policy. Women’s rights are central elements to food sovereignty. The author of chapter 12 suggests the role of the food industry demands attention within the food system, where power is concentrated in the hands of a few corporations.

Chapter 13 explores the power of large food corporations over the global food system. The authors of chapter 13 begin with the notion that global food systems are not meeting the world’s dietary needs. About one billion people are hungry, while two billion people are overweight. India, for example, is experiencing rises in both: since 1995 an additional 65 million people are malnourished, and one in five adults is now overweight. This coexistence of food insecurity and obesity may seem like a paradox, but over- and undernutrition reflect two facets of malnutrition. The authors of chapter 13 believe that underlying both is a common factor: food systems are not driven to deliver optimal human diets but to maximize profits.

Author Notes

Chapter 2

Authors' Contributions

KMD conducted the study as part of her doctoral studies and was supervised by BJK. KMD drafted the manuscript and BJK helped with revisions of the manuscript. Both authors read and approved the final manuscript.

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Compliance with Ethical Guidelines

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000.

Competing Interests

The authors declare that they have no competing interests.

Informed Consent

Informed consent was obtained from all participants included in the study.

Chapter 3

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We declare that we have no any competing interests.

Authors' Contributions

The analysis is conceived and performed and drafted by M G.J and MN, MA, AL, RH, FL. Both TB and PK assisted the analysis and interpretation of the data. MT, MT, EK, TG, HS, NW, YT participate during protocol development, designing of the study and monitored the data collection. All authors critically reviewed the manuscript. M G. J and MN, RH, TB & PK also reviewed the manuscript after reviewers' comments. All Authors have read and approved the final version of the manuscript. M G. J is responsible for manuscript submission.

Chapter 4**Author Contributions**

Conceived and designed the experiments: ACT KJH. Performed the experiments: ACT. Analyzed the data: ACT. Contributed reagents/materials/analysis tools: ACT. Wrote the first draft of the manuscript: ACT KJH. Contributed to the writing of the manuscript: ACT KJH SDW. ICMJE criteria for authorship read and met: ACT KJH SDW. Agree with manuscript results and conclusions: ACT KJH SDW. Assisted in interpretation of the data: ACT KJH SDW. Revised the manuscript for important intellectual content: ACT KJH SDW.

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SDW has previously been affiliated with Physicians for Human Rights, an organization that advocates for the protection of internationally guaranteed rights and/or prosecution of those who violate human rights. All authors have declared that no financial conflicts of interest exist.

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Authors' Contributions

SM RB, NP, and FC collaboratively designed the impact evaluation which was the source of data for this analysis. SM and RB conducted the data analysis, which was iteratively refined after discussion with all authors. SM drafted the initial manuscript and all authors participated in reviewing the draft for intellectual content and assisting with revisions. All authors approved the final version of the manuscript.

Chapter 6

Acknowledgments

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Competing Interests

The authors have no competing interests to declare.

Authors' Contributions

HM developed the peer nutritional counseling intervention and trained the peer counselors. KPD, HM, and KP conceptualized and designed the present study to assess impacts of the intervention. HM, HF, and BR led field implementation.

KPD, BH, and MF analyzed the data. KPD, BH, MF, and HM drafted the paper; KP and HF reviewed the paper and provided critical comment. All authors read and approved the final manuscript.

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Author Contributions

Contributed specialist knowledge and critical review/feedback on manuscript drafts: SDW JSGM RSH. Conceived and designed the experiments: AA RSH. Analyzed the data: AA KC YC. Wrote the paper: AA.

Chapter 8

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Authors' Contributions

Conceived and designed the experiments: CRC, SDW, EAB. Performed the experiments: EW, RLS. Analyzed the data: FW, SS, CRC, SDW, RLS, AMH, RR, KS, SLD. Wrote the paper: CRC, SW, RLS, EW, AH. Contributed to the writing of the manuscript: CRC, SDW, RLS, EW, EAB, LMB. All authors read and approved the final manuscript.

Chapter 9

Disclosure

The funders had no role in the design or conduct of the study; in the collection, analysis, and interpretation of the data; or in the preparation or approval of the paper.

Disclaimer

All authors, external and internal, had full access to all of the data (including statistical reports and tables) in the study and can take responsibility for the integrity of the data and the accuracy of the data analysis.

Conflict of Interests

There is no potential conflict of interests.

Authors' Contribution

Enza Gucciardi and Margaret DeMelo conceived the study. Enza Gucciardi, Justine Chan, and Margaret DeMelo were involved in designing the study and developing the methods. Justine Chan and Enza Gucciardi obtained funding. Justine Chan coordinated the study and conducted the individual interviews. Justine Chan, Margaret DeMelo, Enza Gucciardi, and Jacqui Gingras read transcripts, came to a consensus on the analytical framework, and contributed to the analysis. Justine Chan drafted the paper. All authors contributed to the interpretation of the analysis and critically revised the paper. Justine Chan is the guarantor.

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Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

JRS designed the study, and worked on the development of the instrument and the protocol for collection of data. JRS, CN, CMJ, and WRD wrote the first draft of the paper. JRS, CN, CMJ, and WRD read and approved the final manuscript.

Chapter 11

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Chapter 12

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Author Contributions

Wrote the first draft of the manuscript: RP. Contributed to the writing of the manuscript: RP. ICMJE criteria for authorship read and met: RP. Agree with manuscript results and conclusions: RP.

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Chapter 13

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Analyzed the data: DS. Wrote the first draft of the manuscript: DS. Contributed to the writing of the manuscript: DS MN. ICMJE criteria for authorship read and met: DS MN. Agree with manuscript results and conclusions: DS MN.

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PART I

Defining Food Security and Insecurity



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Definitions of Food Security

United States Department of Agriculture

1.1 RANGES OF FOOD SECURITY AND FOOD INSECURITY

In 2006, USDA introduced new language to describe ranges of severity of food insecurity. USDA made these changes in response to recommendations by an expert panel convened at USDA's request by the Committee on National Statistics (CNSTAT) of the National Academies. Even though new labels were introduced, the methods used to assess households' food security remained unchanged, so statistics for 2005 and later years are directly comparable with those for earlier years for the corresponding categories.

1.1.1 USDA'S Labels Describe Ranges of Food Security

1.1.1.1 *Food Security*

- **High food security** (old label=Food security): no reported indications of food-access problems or limitations.
- **Marginal food security** (old label=Food security): one or two reported indications—typically of anxiety over food sufficiency or shortage of food in the house. Little or no indication of changes in diets or food intake.

1.1.1.2 *Food Insecurity*

- **Low food security** (old label=Food insecurity without hunger): reports of reduced quality, variety, or desirability of diet. Little or no indication of reduced food intake.
- **Very low food security** (old label=Food insecurity with hunger): Reports of multiple indications of disrupted eating patterns and reduced food intake.

1.2 CNSTAT REVIEW AND RECOMMENDATIONS

USDA requested the review by CNSTAT to ensure that the measurement methods USDA uses to assess households' access—or lack of access—to adequate food and the language used to describe those conditions are conceptually and operationally sound and that they convey useful and relevant information to policy officials and the public. The panel convened by CNSTAT to conduct this study included economists, sociologists, nutritionists, statisticians, and other researchers. One of the central issues the CNSTAT panel addressed was whether the concepts and definitions underlying the measurement methods—especially the concept and definition of hunger and the relationship between hunger and food insecurity—were appropriate for the policy context in which food security statistics are used.

1.2.1 The CNSTAT Panel

- Recommended that USDA continue to measure and monitor food insecurity regularly in a household survey.
- Affirmed the appropriateness of the general methodology currently used to measure food insecurity.
- Suggested several ways in which the methodology might be refined (contingent on confirmatory research). ERS has recently published *Assessing Potential Technical Enhancements to the U.S. Household Food Security Measures* and is continuing to conduct research on these issues.

The CNSTAT panel also recommended that USDA make a clear and explicit distinction between food insecurity and hunger.

- Food insecurity—the condition assessed in the food security survey and represented in USDA food security reports—is a household-level economic and social condition of limited or uncertain access to adequate food.
- Hunger is an individual-level physiological condition that may result from food insecurity.

The word “hunger,” the panel stated in its final report, “...should refer to a potential consequence of food insecurity that, because of prolonged, involuntary lack of food, results in discomfort, illness, weakness, or pain that goes beyond the usual uneasy sensation.” To measure hunger in this sense would require collection of more detailed and extensive information on physiological experiences of individual household members than could be accomplished effectively in the context of the CPS. The panel recommended, therefore, that new methods be developed to measure hunger and that a national assessment of hunger be conducted using an appropriate survey of individuals rather than a survey of households.

The CNSTAT panel also recommended that USDA consider alternative labels to convey the severity of food insecurity without using the word “hunger,” since hunger is not adequately assessed in the food security survey. USDA concurred with this recommendation and, accordingly, introduced the new labels “low food security” and “very low food security” in 2006.

1.3 CHARACTERISTICS OF HOUSEHOLDS WITH VERY LOW FOOD SECURITY

Conditions reported by households with very low food security are compared with those reported by food-secure households and by households with low (but not very low) food security in the following graph:

The defining characteristic of very low food security is that, at times during the year, the food intake of household members is reduced and their normal eating patterns are disrupted because the household lacks money and other resources for food. Very low food security can be characterized in terms of the conditions that households in this category typically report in the annual food security survey.

- 98 percent reported having worried that their food would run out before they got money to buy more.

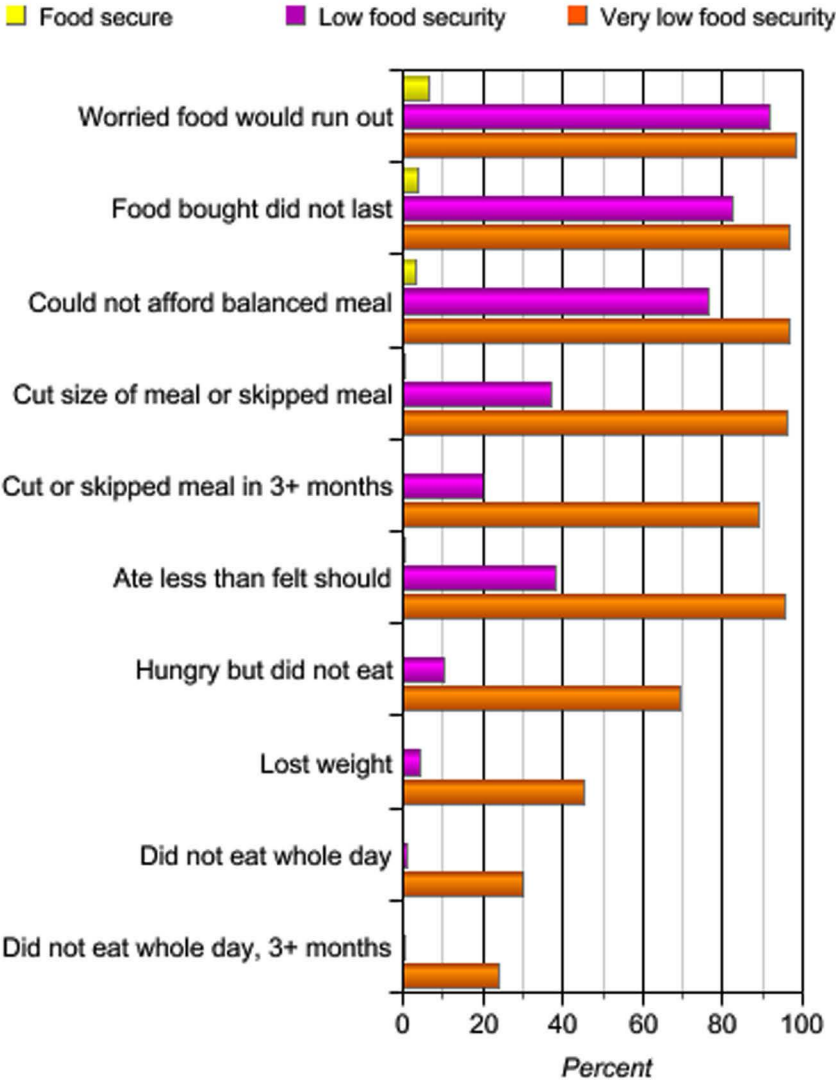


FIGURE 1.1 Percentage of households reporting indicators of adult food insecurity, by food security status, 2014.

Source: Calculated by ERS using data from the December 2014 Current Population Survey Food Security Supplement.

- 97 percent reported that the food they bought just did not last, and they did not have money to get more.
- 97 percent reported that they could not afford to eat balanced meals.
- 96 percent reported that an adult had cut the size of meals or skipped meals because there was not enough money for food.
- 89 percent reported that this had occurred in 3 or more months.
- 96 percent of respondents reported that they had eaten less than they felt they should because there was not enough money for food.
- 69 percent of respondents reported that they had been hungry but did not eat because they could not afford enough food.
- 45 percent of respondents reported having lost weight because they did not have enough money for food.
- 30 percent reported that an adult did not eat for a whole day because there was not enough money for food.
- 24 percent reported that this had occurred in 3 or more months.

All households without children that were classified as having very low food security reported at least six of these conditions, and 69 percent reported seven or more. Food-insecure conditions in households with children followed a similar pattern.

1.4 GLOBAL FOOD SECURITY

ERS provides quantitative and qualitative research and analysis on food security issues in developing countries, focusing on food security measurement and the key factors affecting food production and household access.

The annual ERS International Food Security Assessment is the only report to provide a 10-year projection of food security indicators in 76 low- and middle-income countries.

In recent years, the ERS International Food Security Assessments have estimated that between 500 and 700 million people in the 76 countries studied are food insecure. The estimate for 2015 is 475 million food-insecure people (food-insecure people are those consuming less than the nutritional target of about 2,100 calories per day). However, food security conditions vary from year to year because of changes in local food production and the financial capacity of countries to purchase food in global markets. Despite progress, Sub-Saharan Africa continues to account for the bulk of the food-insecure people in the countries assessed, followed by Asia and then Latin America and the Caribbean.

1.5 GLOSSARY

A **distribution gap** measures the difference between projected food consumption and the amount of food needed to increase consumption in food-deficit income groups within individual countries to meet nutritional requirements. Inadequate economic access to food is the major cause of chronic undernutrition in developing countries and is related to the level of income. In the ERS global food security model, the total projected amount of available food is allocated among different income groups using income distribution data.

A **nutrition gap** is estimated to measure food insecurity. This gap represents the difference between projected food supplies and the food needed to support per capita nutritional standards at the national level.

A **status quo gap** is estimated to measure changes in food security. This gap represents the difference between projected food supplies and the food needed to maintain per capita consumption of the most recent 3-year period.

PART II

Food Insecurity and Mental Health



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Food Insecurity in Adults with Mood Disorders: Prevalence Estimates and Associations with Nutritional and Psychological Health

Karen M. Davidson and Bonnie J. Kaplan

2.1 BACKGROUND

Among health researchers, policy makers, practitioners, and decision makers, there are concerns about the growing global and ethical issue of food insecurity [1], defined as the limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable food in socially acceptable ways [2]. The impact of food insecurity on mental health is significant and may be attributed to its associations with suboptimal diet [3–5], and psychological issues such as depression, eating disorders, and impaired cognition [6–9]. Of the few investigations that have examined food insecurity in populations with confirmed diagnosis of a mental health condition, results have indicated an association with food insufficiency [10] and that patients in a psychiatric emergency unit who lacked food security had higher levels of psychological distress compared to food-secure individuals [11]. In a previous study of the determinants of food intakes in a sample of adults with confirmed

mood disorders conducted by the authors [12], a high prevalence of inadequate intakes of several micronutrients (e.g., folate, vitamin B12, iron, zinc) was found. As part of this investigation, the authors also included food insecurity screening questions and measures of psychological symptoms, as it was speculated that food access would be associated with both dietary intake and mental function in this population. To further understanding of food insecurity in specific mental health populations, we used data from the study of adults with mood disorders to answer the following research questions: (1) what is the prevalence of food insecurity compared to a general population sample?; and (2) is food insecurity associated with poorer nutrient intakes and psychological function? It was hypothesized that in this sample of adults with mood disorders, food insecurity would be: (1) significantly more prevalent than in the general population; (2) associated with suboptimal nutrient intakes based on defined standards; and (3) associated with poorer psychological functioning.

2.2 METHODS

2.2.1 Sample

The data were from a cross-sectional nutrition survey of adults (>18 years) with clinically defined mood disorders (Structured Clinical Interview for DSM-IV-TR Axis I Disorders or SCID; [13]) who lived in the lower mainland of British Columbia; 146 individuals were randomly selected from the membership list of the Mood Disorder Association of British Columbia and invited to participate. Of the 146 randomly selected members, 26 were deemed ineligible and 23 refused to participate. Eleven of the 23 individuals who declined participation completed a non-response questionnaire, and statistical comparisons showed no significant differences compared to the respondents based on a variety of lifestyle habits (e.g., smoking, multivitamin use).

As part of the recruitment process, all individuals received phone follow-up from research staff to determine their interest and eligibility. Full details of recruitment, data collection, quality control, and overall nutrient intake results have been published previously [12]. This study adhered to guidelines in the Declaration of Helsinki and was approved by the University of Calgary's Conjoint Health Research Ethics Board. Sufficiency of statistical power (minimum 80%) to conduct the analysis was based on: (1) the hypothesis, food insecurity would be associated with lower nutrient intakes; (2) results from a Canadian study on

food insecurity and nutrient intakes reporting mean intakes of folate of 424 and 378 micrograms for food-secure and food-insecure groups, respectively, with a common standard deviation of 18.5 [14]; and (3) an alpha level of 0.05 [15].

2.1.2 Measurements

2.1.2.1 Dependent Variable

2.1.2.1.1 Food Insecurity

Food insecurity status was determined as having an affirmative response to at least one of the two screening questions:

1. In the past 12 months did you worry that there would not be enough to eat because of lack of money? (Question description: Worry about food access).
2. In the past 12 months did you not have enough food to eat because of lack of money? (Question description: Compromised diet).

These two screening questions, which have previously been used in Statistics Canada national surveys [16], were also used in the British Columbia Nutrition Survey and allowed for direct comparisons of food insecurity between the sample and the general population. In the Canadian survey and in our study, a third question was also used: “In the past 12 months, did you or anyone in your household not have enough food to eat because of a lack of money?”. All of our study respondents who responded affirmatively to question two also indicated “yes” to the third question. Due to this redundancy in responses, the third question was not included in the analysis.

2.1.2.2 Independent Variables

2.1.2.2.1 Psychological Functioning and Symptoms

Psychological, social, and occupational functioning was based on scores of the Global Assessment of Functioning Scale (GAF) [17]. Current symptoms of depression and mania were measured based on the Hamilton Depression Scale (Ham-D) [18], and Young Mania Rating Scale (YMRS) [19].

2.1.2.2.2 *Diet*

Nutrient intakes were derived from 3-day food records (two weekdays and one weekend day; non-consecutive) according to standard protocols [20]. The dietary variables included intakes of energy, macronutrients, and selected micronutrients (i.e., vitamins B6, B9, B12, and C, plus the trace minerals iron, and zinc) that function in cognition, and were analyzed using Food Processor SQL with the Canadian nutrient file [21].

2.1.3 **Covariates**

Covariates included in the analysis were body mass index (BMI; kg/m²; continuous variable) measured according to standard protocols used in national and provincial nutrition surveys [20], diagnosis of depressive or bipolar disorder based on the SCID (dichotomous), following a therapeutic (diet for a medical condition) diet (dichotomous), sociodemographic factors including age (continuous), gender (male/female), in a relationship or not (dichotomous), and income (dichotomized as low versus adequate, based on Canadian government standards).

2.1.3.1 *Data Analysis*

To test the first hypothesis, prevalence estimates of food insecurity (i.e., affirmative response to at least one of the two food insecurity screening questions) and low income were compared (using binomial tests of two proportions) to regional data available from the 1999 British Columbia Nutrition Survey (BCNS; $n = 1,823$) that contained the same income and food insecurity measures [20]. The BCNS was conducted by the British Columbia Ministry of Health Services, Health Canada, and the University of British Columbia. It randomly sampled British Columbians aged from 19 to 84 years. Most of the BCNS participants were married (65.2%), did not hold a university degree (85.5%), and had income levels above the poverty cut-off (74.8%).

To examine the second hypothesis, differences in nutrient intakes between respondents who were either food-insecure or secure were compared using Mann–Whitney U tests or binomial tests of two proportions based on the Dietary Reference Intakes [22]. Specifically, the proportion of the sample above and below the Estimated Average Requirements (EAR; to estimate prevalence of possible nutrient inadequacy) or within and above the Adequate Macronutrient

Distribution Ranges (AMDR; to estimate suboptimal or excess macronutrient intake) were analyzed. To test the third hypothesis, bivariate relationships between food insecurity and the psychological measures were analyzed using the Mann–Whitney U test and crude prevalence ratios. Cut-offs used to categorize the mental health measures included scores of 7 or less for the Ham-D [18] and 12 or less for the YMRS [19] which indicate that symptoms are currently absent. A cut-off of 60 for the GAF was used; scores less than this indicate more severe mental illness [23].

The final steps of the analysis involved conducting Poisson regression with robust variance to examine relationships between food insecurity and psychological functioning while adjusting for age, sex, relationship status, and income. This particular method was chosen as it is considered the most viable model option when analyzing cross-sectional data [24]. It provides adjusted prevalence ratios that are interpreted as the ratio of the proportion of the persons with the outcome (e.g., low GAF scores) over the proportion with the exposure (e.g., food insecurity). To test whether the Poisson model form fit the data, the goodness-of-fit Chi-squared test was applied. All data analyses were performed using Stata 10.0 [25].

2.3 RESULTS

2.3.1 Description of Sample

Similar to the general population sample studied in the BCNS, most respondents ($n = 97$) were females ($n = 69$; 71.1%). Unlike the BCNS, most did not have a university degree ($n = 76$; 78.4%) and were not in a relationship (61.9%). Approximately half of the sample (49.0%) had government defined low-income levels (Statistics Canada, 2013). Most (67.0%) had body mass indices greater than 24.9 kg/m² and 19.0% indicated they were following a specific diet for medical reasons. Based on the SCID, 58 (59.8%) met criteria for bipolar disorder and 39 (40.2%) for depressive disorder. More than 85% of the participants were taking psychiatric medications.

2.3.2 Comparison of Prevalence Estimates of Food Insecurity

As hypothesized, the sample of adults with mood disorders had a higher proportion of individuals (36%) experiencing food insecurity ($p < 0.001$) compared to

TABLE 2.1 Indicators of low income and food insecurity compared to regional survey data.

Characteristic	Low-income status		Worry about food access ^a		Compromised diet ^b	
	Study	BCNS	Study	BCNS	Study	BCNS
	(n = 97)	(n = 1,823)	(n = 97)	(n = 1,823)	(n = 97)	(n = 1,823)
Prevalence estimates (%) with 95% confidence intervals for income and food insecurity						
Income and food insecurity	40.2 (30.4–50.7)*	25.2 (23.2–27.3)	36.1 (26.6 to 46.5)**	7.3 (6.1–8.6)	19.6 (12.2–28.9)**	3.4 (2.6–4.3)

* p < 0.05, ** p < 0.0001.

^a Question: in the past 12 months did you worry that there would not be enough to eat because of lack of money?

^b Question: in the past 12 months did you not have enough food to eat because of lack of money?

the general population sample (BCNS) (Table 2.1). The proportion of individuals reporting low-income status was also higher in adults with mood disorders ($p < 0.05$).

2.3.3 Food Insecurity and Nutrient Intakes

The respondents who reported food insecurity had lower median carbohydrate and vitamin C intakes (Table 2.2). The assessment of nutrient intakes based on the EARs indicated that those reporting food insecurity had higher proportions of inadequate protein, folate and zinc intakes ($p < 0.05$). The food-insecure group also had a higher proportion of participants with excess total fat intakes as measured by the AMDR ($p < 0.05$).

2.3.4 Food Insecurity and Psychological Functioning

Based on the bivariate analysis, some associations were found between food insecurity and psychological functioning when measured as continuous variables (Table 2.3). Ham-D and YMRS scores were significantly higher ($p < 0.05$) in participants with compromised diet (i.e., answered affirmatively to the food insecurity screening question “In the past 12 months did you not have enough food to eat because of lack of money”). In addition, higher depression scores were found in those reporting low income ($p < 0.05$).

Crude prevalence ratios (PRs) of food insecurity and the psychological measures (dichotomized based on their defined cut-off scores) showed significant association between food insecurity and mania symptoms (Table 2.4). When Poisson regression was applied, the ratio of the proportion of respondents with high YMRS scores over the proportion with food insecurity was 2.37 (95% CI 1.49–3.75, $p < 0.001$). Low income was also consistently associated with worse scores on all psychological measures (adjusted PRs ranged from 2.68 to 2.88, $p < 0.05$). The variables in the final three Poisson regression models included the psychological measures (i.e., GAF, YMRS, Ham-D, respectively) age, sex, and income. The goodness-of-fit Chi-squared test results were not significant for all models (goodness-of-fit 51.34 to 55.01, p 's $> \chi^2(92) = 1.00$) suggesting that the Poisson model form fit the data.

TABLE 2.2 Comparisons of nutrient intakes by food security status

Measurement	Nutrient intakes according to food insecurity status ^a (median, IQR ^b)		Nutrient intakes compared to Dietary Reference Intakes ^c and by food insecurity status ^a	
	Food insecure (n = 36)	Food secure (n = 61)	Food insecure (n = 36)	Food secure (n = 61)
Energy and macronutrients			% > AMDR ^d (95% CI)	
Energy (kilocalories)	2,406 (1,907; 2,875)	2,541 (1,802; 3,182)	–	–
Protein (% of calories)	14.0 (10.1; 18.4)	13.7 (9.4; 20.1)	5.5 (0.7–18.7)	0
Carbohydrates (% of calories)	47.8 (41.3; 57.3)*	52.9 (48.5; 59.8)	0.2 (0.1–19.5)*	11.4 (4.7–22.2)
Fibre (g)	21.5 (13.7; 29.4)	24.3 (15.3; 30.2)	–	–
Fats (% of calories)	35.4 (29.2; 45.0)*	34.2 (25.9; 38.9)	55.6 (38.1–72.1)*	29.5 (18.5–42.6)
			% < EAR ^e (95% CI)	
Protein (g/kg)	–	–	19.4 (6.5–32.4)*	4.9 (0.5–10.3)
Vitamins				
Vitamin B ₆ or pyridoxine (mg)	1.5 (1.0; 2.0)	1.5 (1.2; 2.2)	30.6 (16.3–48.1)	21.3 (11.9–33.7)
Vitamin B ₉ or folate (dietary folate equivalents) ^f	74.2 (39.7; 204.4)	114.5 (55.0; 225.4)	83.3 (67.2–93.6)*	52.5 (39.3–65.4)
Vitamin B ₁₂ or cobalamin (µg)	3.3 (1.9; 4.6)	3.5 (1.9; 5.1)	27.8 (14.2–45.2)	26.2 (15.8–39.1)
Vitamin C (mg)	80.5 (51.8; 180.7)*	128.8 (70.2; 216.7)	27.8 (14.2–45.2)	21.3 (11.9–33.7)

TABLE 2.2 (Continued)

Measurement	Nutrient intakes according to food insecurity status ^a (median, IQR ^b)		Nutrient intakes compared to Dietary Reference Intakes ^c and by food insecurity status ^a	
	Food insecure (n = 36)	Food secure (n = 61)	Food insecure (n = 36)	Food secure (n = 61)
Trace minerals				
Iron (mg)	14.4 (10.2; 18.3)	16.0 (12.0; 23.8)	13.9 (4.7–29.5)	6.6 (1.8–15.9)
Zinc (mg)	8.9 (5.8; 11.8)	8.8 (6.4; 12.8)	52.8 (35.5–69.6)*	31.1 (19.9–42.3)

* $p < 0.05$.

^aFood-insecure or secure based on respondents who answered yes to either of the following questions: (1) in the past 12 months did you worry that there would not be enough to eat because of lack of money; or (2) in the past 12 months did you not have enough food to eat because of lack of; food-secure based on respondents who answered no to both questions.

^bInterquartile range.

^cReference values that are quantitative estimates of nutrient intakes to be used for planning and assessing diets for healthy people.

^dAdequate macronutrient distribution ranges.

^eEstimated average requirement.

^fDietary folate equivalents (DFE): values that adjust for the differences in absorption of food folate and synthetic folic acid; 1 mcg of DFE = 0.6 mcg of folic acid from fortified food or as a supplement taken with a meal = 1 mcg food folate; 0.5 mcg of folic acid from a supplement taken on an empty stomach.

TABLE 2.3 Indicators of low income and food insecurity by psychological measures in adults with mood disorders ($n = 97$)

Psychological measure	Median and interquartile range					
	Low-income status		Worry about food access ^a		Compromised diet ^b	
	Yes (n = 39)	No (n = 58)	Yes (n = 35)	No (n = 62)	Yes (n = 19)	No (n = 78)
Global Assessment of Functioning	60 (51; 70)	65 (55; 75)	10 (3; 16)	9 (4; 14)	3 (1; 5)	3 (1; 4)
Hamilton Depression Scale	60 (51; 65)*	65 (60; 75)	9 (4; 16)	9 (4; 14)	3 (2; 7)*	2 (1; 4)
Young Mania Rating Scale	58 (43; 68)	65 (55; 75)	10 (3; 19)	9 (4; 14)	4 (2; 7)*	2 (1; 4)

* $p < 0.05$.

^a Question: in the past 12 months did you worry that there would not be enough to eat because of lack of money?

^b Question: in the past 12 months did you not have enough food to eat because of lack of money?

TABLE 2.4 Crude and adjusted prevalence ratios of food insecurity^a, psychological, and income measures

Psychological measure	Crude prevalence ratio	Adjusted prevalence ratio ^b (95% confidence interval, p value)	
		Food insecurity	Low income
GAF (<60)	1.49 (0.97–2.31, p = 0.072)	1.42 (0.88–2.28, p = 0.148)	2.68 (1.53–4.71, p = 0.001)
YMRS (>12)	4.72 (1.36–16.24, p = 0.006)	2.37 (1.49–3.75, p = 0.000)	2.71 (1.59–4.63, p = 0.000)
Ham-D (>7)	1.02 (0.71–1.48, p = 0.880)	0.94 (0.59–1.49, p = 0.783)	2.88 (1.64–5.06, p = 0.000)

^a Answered yes to question 1 or 2: Question 1: In the past 12 months did you worry that there would not be enough to eat because of lack of money?; and Question 2: In the past 12 months did you not have enough food to eat because of lack of money?

^b Prevalence ratios from final models that included food insecurity, age, sex, and income; income is included in table as the adjusted prevalence ratios were significant.

2.4 DISCUSSION

The results of this study indicated that food insecurity was more prevalent in adults with mood disorders when compared to a general population. Sample respondents who reported food insecurity had significantly lower intakes of carbohydrates and vitamin C. A higher proportion of the adults with mood disorders had potentially inadequate intakes of protein, folate, and zinc. Finally, food insecurity was consistently associated with worsened mania symptoms in adults with mood disorders.

This is the first study to report the relationships between food insecurity and selected nutrients in adults with mood disorders. As shown in other studies of food insecurity in different populations [14, 26–28], there is higher risk of inadequate intakes of essential nutrients which can have profound effects on mental health. Research conducted in this sample of adults with mood disorders has shown positive correlations between nutrient intakes and psychological function [29]. There are multiple interconnected ways in which food insecurity could contribute to poorer nutritional and psychological health, including through nutrient deficiencies and/or the body’s physiological response to the immense stress from not having the resources to feed oneself and/or one’s family [30–32]. When people experience food insecurity, they may be forced to

consume food in socially unacceptable ways [33] which may affect psychological function directly or indirectly by altering nutrient intakes and metabolism. For example, reduced blood folate levels (that may be a result of compromised dietary folate intake due to food insecurity) may impair one-carbon metabolism, which has been implicated in the pathogenesis of psychiatric symptoms [34]. While previous studies have shown links between food insecurity and psychological symptoms such as depression, anxiety, and suicide ideation [6, 7, 28, 35, 36], our results are the first to show association with mania symptoms. One mechanism underlying this relationship may be due to suboptimal blood levels of vitamin C caused by either lower intakes and/or increased breakdown due to stress. With lower blood levels of vitamin C, disequilibrium between ascorbic acid and vanadium metabolism may occur and result in mania symptoms [37].

The consistent association between low-income status and worse scores on the psychological measures is not surprising as other studies have shown links with depression and low income [38]. However, to our knowledge, this study is the first to report associations with YMRS and GAF scores. While food insecurity is an independent determinant of health [39], cross-sectional surveys have also shown it is strongly linked with another health determinant, inadequate income [16, 40–42]. Unfortunately, the cross-sectional nature of these investigations and our study cannot determine the temporality of the relationships among food insecurity, low income, and mental health. However, longitudinal studies have shown that associations between food insecurity and depression are bidirectional [30, 43].

For several reasons, the results of this study should be interpreted with caution. Limitations include the modest sample size and that the food insecurity screening questions may not discriminate varying degrees of food access. However, previous studies indicate that short form measurement tools are appropriate to determine the subjective experiences of food insufficiency [44]. Measurement error between food insecurity and psychological functioning may be present as the two may be correlated (e.g., people in depressed mood states might report increased food insecurity regardless of their true status) and thereby yield a spuriously stronger positive association. However, the multivariate analysis did not show an association between food insecurity and Ham-D scores. Finally, most of the sample was taking psychiatric medications which may impact on food-related behaviours (e.g., increase appetite) [45] and therefore, increase food insecurity.

2.5 CONCLUSIONS

Food insecurity is an important determinant of health and significant public health and social issue [39, 40]. This study extends the current body of food insecurity knowledge by providing prevalence estimates and reported associations with poorer nutrient intakes and psychological functioning in a sample of adults with mood disorders. While program and policy developments that strengthen food security would reduce health and social inequities [41, 42], it may also be speculated that such interventions may enhance the nutritional and psychological well-being of those with mood disorders. Future investigations should focus on interventions aimed at improving food security to establish its role in enhancing mental health.

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Household Food Insecurity and Mental Distress Among Pregnant Women in Southwestern Ethiopia: A Cross Sectional Study Design

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3.1 BACKGROUND

Mental distress is becoming one of the major contributors to the global burden of diseases in developing countries [1, 2]. Mental distress is defined as a collection of mental problems that may not fall into standard diagnostic criteria and are characterized by symptoms of sleeplessness, exhaustion, irritability, poor memory, difficulty in concentrating, and somatic complaints [3].

Numerous epidemiologic studies have revealed that maternal distress during pregnancy is a public health concern in Sub Saharan African [4–8]. It has been

associated with low infant birth weight, impaired postnatal growth, increased frequency of infant diarrhea [9, 10], under nutrition, stunted growth, and poorer cognitive development [11, 12]. Previous study done in Ethiopia also showed that maternal distress was associated with child growth and low birth weight [10, 13].

If public health measures aim to improve the mental health status of pregnant women, there must be empirical data revealing the social, behavioral, economic and cultural factors associated with mental distress [14–17]. Among these, food insecurity is one of the determinants that are known to increase risk for mental distress [5, 18–21]. Food insecurity is defined as either the lack of nutritionally adequate and safe food or a limited ability to acquire acceptable food in socially acceptable ways [22]. It is a process that may start with household members being worried about not being able to access food followed by sacrificing the quality of their diet and then eventually reducing the amount of calories consumed. This usually occurs when regular access to adequate and nutritious food is limited [23, 24].

Food insecurity has been identified as a public health issue for women living in low-income households which results in poorer health outcomes [25]. For example, food insecurity is associated with decreased self-rated health status among adults and children [18, 26–28], depression and anxiety in mothers [29] reduced micronutrient intake, decreased fruit and vegetable consumption [30, 31], overweight [32], poor child physical growth [25, 33] low birth weight & elevated prenatal depressive symptoms [34]. The association between maternal depression and food insecurity has been also reported [5, 29–32]. But, few studies have examined the association between mental distress and food insecurity among pregnant women [35].

In Ethiopia both mental illness and food insecurity are reported. While previous research has shown an association between mental health and food insecurity among adults, non-pregnant women and children [7, 10, 13, 28, 36, 37], there is scant literature studying their relationship during pregnancy in Ethiopia. This study tried to answer the following two questions: One, what is the magnitude of both mental distress and food insecurity among pregnant women? Two is there an association between food insecurity and mental distress among pregnant women? Thus, the purpose of this study was to document the magnitude of food insecurity and mental distress and to examine their association during pregnancy. These findings can be used for program planners and researcher to further study the link between the two in southwestern Ethiopia.

3.2 METHODS

3.2.1 Study Setting

A facility-based cross-sectional study was conducted in Jimma Zone, one of the 20 administrative zones in Oromia Regional State, southwest Ethiopia. According to the Central Statistical Authority [38] 2.7 million people live in Jimma Zone on an area of 15,569 km² with a population density of 159.69 persons per km². Of these, 1.23 million are women. An estimated 31,050 women become pregnant every year and antenatal care coverage in the zone is 64.3 percent. There are three hospitals and 84 primary health centers in Jimma zone where pregnant mothers can receive antenatal care services. There are 12 public health facilities affiliated with Jimma university within the radius of 70 km for community based education program, research and services. Between the months of June and August 2013, a total of 2,987 pregnant women were on antenatal care (ANC) follow up at the 12 health facilities selected for this study [39].

3.2.2 Sample Size and Sampling

A single population proportion formula was used to estimate 660 pregnant women to be included in the sample. Assumptions for calculating the sample size were the degree of confidence interval (95%; $Z_{1-\alpha/2} = 1.96$), the estimated magnitude of mental distress among pregnant women ($P = 50\%$), a 4% degree of precision, and a non-response rate of 10%. A total of 11 health centers and one hospital were selected to sample the study subjects. These facilities were chosen purposefully based on their previous affiliation with the Jimma University Community Based Education Training Program (CBTP). Probability proportional to size sampling (PPS) techniques was employed to assign the number of pregnant women to be interviewed from each selected health center and hospital. All pregnant women coming for ANC services during the data collection period were taken as the source population for the study. Finally, a consecutive sampling technique was used to identify the study subjects from each of the health facilities until the desired sample size was obtained. Seriously ill pregnant women were excluded from the study and referred to the respective hospital.

3.2.3 Tools and Measurements

The instruments used for data collection were adapted from earlier studies and WHO guidelines [30, 40–48] and translated from English into the two most commonly spoken languages in the study setting (Afan Oromo and Amharic) by two fluent linguists (from the university Language and Literature Department). Each translation was then translated back by another person (linguists from the English Department) to ensure its consistency. Before the actual survey, the final translated questionnaires were pre tested on 5% of the sample at two different health institutions (one urban and the other rural) so that coherence, wording, sequencing and consistencies of all questions were amended accordingly. The result of this pretest was not included in the main analyses. Two days of intensive training on how to approaches the clients, interview techniques, ethical consideration and how to refer any mothers that needed help. Finally, exit interviews were conducted by trained data collectors at each of the 12 health facilities immediately after the mothers had received their ANC services. Field supervisors and the research team supervised the data collection process. Supervisors also checked the consistency of data before submission to the data manager. Ethical clearance was obtained from the Jimma University (JU) ethical review board. The participants were asked for their oral consent after the purpose of the study was clearly communicated. Confidentiality was ensured for each study participants.

3.2.4 Questionnaires to Measure Mental Distress

Mental distress was measured using The Self Reporting Questionnaire (SRQ-20). The SRQ-20 is a screening instrument developed by the World Health Organization (WHO) to assess the level of symptoms of overall mental distress one month preceding the survey [42]. Scores range from 0 to 20, with higher scores representing more severe mental distress. The SRQ has been used in several previous studies exploring the relationship between maternal psychological wellbeing and infant health [42, 46]. In developing countries, cutoff scores of ≥ 6 , 7, 8, 4 and 10 have been used for identifying cases of mental distress [40, 42, 46, 48]. However, in this study we report the proportion of women scoring $\text{SRQ} \geq 7$ or greater to indicate mental distress. The SRQ-20 has been validated in Ethiopia for measuring mental distress among rural pregnant women and the recommended cutoff points greater or equal to 7 have specificity of 62% and sensitivity of 68.4% [40]. If the scoring was < 7 , we coded “0” for no mental

distress and if it was greater or equals to 7, we coded “1” to indicate presence of mental distress.

3.2.5 Questionnaire to Measure Household Food Insecurity Access Scale

Household food insecurity access was measured using items from the validated Household Food Insecurity Access Scale (HFIAS) that was specifically developed for use in developing countries [41, 43–45]. The HFIAS consists of 9 items specific to an experience of food insecurity occurring within the previous four weeks. Each respondent indicated whether they had encountered the following due to lack of food or money to buy food in the last one month: (1) worried about running out of food, (2) lack of preferred food, (3) the respondent or another adult had limited access to a variety of foods due to a lack of resources (4) forced to eat un preferred food due to lack of resources, (5) eating smaller portions, (6) skipping meals, (7) the household ran out of food, (8) going to sleep hungry, and (9) going 24 hours without food. Endorsed items are then clarified with reported estimates of the frequency of food insecurity (rarely, sometimes, and often). Scores range from 0 to 27 where higher scores reflect more severe food insecurity and lower scores represent less food insecurity. To determine the status of food insecurity the average HFIAS score (dividing the sum of Household score by number of household in the sample) was computed and then household food insecurity access prevalence (HFIAP) categories (food secure, mild, moderately and severely food insecure) was generated. But, since none of the mothers reported mild and severely food insecure households, HFIAP was only categorized in to two conditions [44].

3.2.6 Data Management and Analysis

The data were entered, cleaned, and analyzed using STATA version 12 for Microsoft Windows. Descriptive statistics, bivariate and multivariate logistic regression analyses were computed to examine the relationship between the explanatory variables and mental distress. Assuming a linear relationship between independent and dependent variables, the binary form of the dependent variable was coded as “1” for mental distress and “0” for not distressed. First binary logistic regression analyses were conducted between each and separate explanatory variables with the outcome of our interest (mental distress) (Model I) and

reported using crude Odds Ratios. Finally, all significant variables($P < 0.05$) during the bivariate analyses were chosen for multivariate logistic regression modeling using forward selection method to explore the association of food insecurity with mental distress by controlling for other confounding variables such as age, occupation, monthly income, and ownership of agricultural land (Model II). Adjusted odds ratios (AOR) and their 95% confidence intervals (CI) were presented as indicators of strength of association. A p-value of 0.05 or less was used to determine the cut-off points for statistical significance.

3.3 RESULTS

3.3.1 Socio Demographic Characteristics

A total of 642 pregnant women agreed to participate in the study resulting in a response rate of 97.3%. The mean ($\pm$ SD) age of the mother was 25.5($\pm$ 4.9). The majority of the women (67.1%) were between the ages of 20 and 29 years old. A total of 91% of them were married. Just over half of them were from urban areas (58.7%) and most (69.6%) of them were Muslim by religion. About one quarter of the women were illiterate (26.8%). Half of the women had completed primary school or were able to read and write (26.6% and 23.5% respectively). The mean ($\pm$ SD) household size was 3.9 ($\pm$ 1.6) (Table 1).

TABLE 3.1 Socio demographic characteristics of respondents in Jimma Zone, southwest Ethiopia, 2013.

Variables	Categories	Number	Percentage
Residence	Urban	377	58.7
	Rural	265	41.3
Household size	≤ 4	435	67.8
	> 4	207	32.2
Age of respondents	15-24	277	43.2
	25-34	318	49.5
	≥ 35	47	7.3
Occupation	Farmer	172	26.8
	Gov. employee	107	16.7
	Merchant	83	12.9
	Daily laborer	66	10.3
	Others ^a	214	33.3

TABLE 3.1 (Continued)

Variables	Categories	Number	Percentage
Marital status	Married	584	91.0
	Others ^b	58	9.0
Ethnicity	Oromo	494	76.9
	Dawuro	32	5.0
	Amhara	75	11.7
	Others ^c	41	6.4
Religion	Muslim	447	69.6
	Orthodox	141	22.0
	Others ^d	54	8.4
Educational status	Illiterate	172	26.8
	Read and write	151	23.5
	Primary school	171	26.6
	Secondary school	60	9.3
	College & above	88	13.7
Number of children <5	0	234	36.4
	1	395	61.5
Food insecurity status	2	13	2.0
	Food secure	584	91.0
	Food insecure	58	9.0

^aStudents, housewife, maid workers, ^bsingle, widowed, divorced. ^cWolaita, Kullo,Tigray, Yam,
^dCatholics, protestant

3.3.2 Socioeconomic and Household Wealth

Just over one quarter of the women reported a household monthly income less than 1,000 Ethiopian Birr (ETB). One hundred seventy-two (26.8%) of women were involved in farming, and 274 (42.7%) of women owned agricultural land. Three hundred forty-six (53.9%) of the respondents did not have electricity and 65 (10.1%) of the respondents did not have the use of a latrine. Most respondents (89.1%) used firewood or other agricultural products as fuel for cooking. Water was provided by access to pipe water or tap water in 61.1% of the households while 39% depend on spring, river or well water. While most had a radio (72%) and a cell phone (77.3%) in the home, other household items such as television, land line phones and refrigerators were uncommon (30.2%, 6.2% and 11.8% respectively) (Table 2).

TABLE 3.2 Socioeconomic and household wealth of respondents, southwest Ethiopia, 2013.

Household effects	Category	Number	Percentage
Electricity	Yes	296	46.1
	No	346	53.9
Television	Yes	194	30.2
	No	448	69.8
Radio	Yes	462	72.0
	No	180	28.0
Telephone- fixed	Yes	40	6.2
	No	602	93.8
Mobile telephone	Yes	496	77.3
	No	146	22.7
Refrigerator	Yes	76	11.8
	No	566	88.2
Own agricultural Land	Yes	274	42.7
	No	368	57.3
Latrine	Yes	577	89.9
	No	65	10.1
Type of fuel	Electricity	18	2.8
	Wood & Agri crops.	572	89.1
	Charcoal	48	7.5
Source of water supply	Others (e.g.kerosene)	4	0.8
	Pipe water	195	30.4
	Tap water	197	30.7
	spring	202	31.5
	Dig well	23	3.6
	Protected river water	25	3.9
Family-monthly income ^e	≤500	70	10.9
	500-999	106	16.5
	≥1000	466	72.6
Transportation			
Bicycle	Yes	40	6.2
	No	602	93.8

TABLE 3.2 (Continued)

Household effects	Category	Number	Percentage
Animal drawn cart	Yes	34	5.3
Bajaj ^f	No	608	94.7
	Yes	13	2.0
	No	629	98.0
	Yes	7	1.1
Car	No	635	98.9

^eNational currency in Birr, 3/27/2014 exchange rate 1 US Dollar = 19.37 Birr, 1 Euro = 27.627 Birr ^fBajaj is a three wheel drive motor bike owned by household used for transportation.

3.3.3 Prevalence of Household Food Insecurity and Mental Distress

Internal consistency of the Household Food Insecurity Access Scale was strong (Cronbach’s alpha=0.96). The reliability coefficient (Cronbach’s Alpha) for the SRQ-20 was 0.858, showing very good internal consistency of the items. Fifty-eight (9%) of the respondents were living in food insecure households and twenty-two percent of the pregnant women had mental distress (22.4%). The prevalence of mental distress was higher among pregnant women living in a food insecure environment (48.3%) when compared to those living in food secured households (19.9%).

3.3.4 Association between Food Insecurity and Mental Distress

Table 3 reports the association between food insecurity and mental distress. Pregnant women living in urban areas were more likely to have mental distress when compared to their rural counter parts (COR=3.01, 95% CI=1.19, 7.60). Lower monthly income (≤500 ETB) was associated with mental distress (COR=1.94, 95% CI=1.12, 3.35). Pregnant women living in food insecure households were more likely to have mental distress (COR=3.77, 95% CI=2.17, 6.55). Multivariate logistic regression modeling analysis using the forward selection method was used to investigate the independent association of food insecurity with mental distress. The result showed that pregnant women living in a food insecure household were 4.15 times more likely to have

mental distress (AOR=4.15, 95% CI=1.67, 10.32). In addition, this study reveals mental distress is also associated with a family history of mental illness (AOR= 5.85, 95% CI=2.23, 15.34) and intimate partner violence (AOR= 3.20, 95% CI= 1.43, 7.13).

TABLE 3.3 Factors associated with mental distress among pregnant women in Jimma Zone, southwest Ethiopia, 2013

Variables	Categories	COR(95% CI)	AOR(95% CI)
Residence	Urban	1. 74(1.17,2.58)	3.01(1.19,7.60)
	Rural	1	1
HH size	>4	0.80 (0.53,1.20)	2.26(1.25,4.19)
	≤4	1	1
Age	≥35	1.82(0.69,4.77)	3.44(0.91,12.96)
	30-34	1.44(0.62,3.35)	2.22(0.71,6.91)
	25-29	1.49(0.67,3.27)	1.67(0.58,4.81)
	20-24	1.26(0.57,2.77)	1.53(0.55,4.30)
	15-19	1	1
Occupation	Gove. employee	0.81(0.40,1.62)	0.33(0.09,1.26)
	Merchant	1.82(0.95,3.46)	1.04(0.31,3.50)
	Daily laborer	2.51(1.29,4.85)	1.03(0.26,3.94)
	Others	2.14(1.29,3.55)	1.65(0.62,4.41)
	Farmer	1	1
Monthly income	≤500	1.94(1.12,3.35)	0.76(0.32,1.82)
	501-999	1.35(0.83,2.21)	0.96(0.44,2.07)
	≥1000	1	1
Marital status	In Marriage	0.37(0.21,0.64)	0.05(0.01,0.33)
	Not in marriage	1	1
Land ownership	Yes	0.71(0.47,1.08)	1.23(0.68,2.22)
	No	1	1
Previous Hx of IPV	Yes	3.92(2.38,6.46)	3.20(1.43,7.13)
	No	1	1

TABLE 3.3 (Continued)

Variables	Categories	COR(95% CI)	AOR(95% CI)
Current Hx of IPV	Yes	1.95(1.10,3.48)	0.48(0.17,1.31)
	No	1	1
Food insecurity	Food insecure	3.77(2.17,6.55)	4.15(1.67,10.32)
	Food secure	1	1
FamHx of mental disorder	Yes	3.90(2.10,7.28)	5.85(2.23,15.34)
	No	1	1
Currently chewed khat	Yes	1.35(0.86,2.12)	2.25(1.05,4.83)
	No	1	1

COR- Crude Odds Ratios, AOR- Adjusted Odds Ratio, IPV-Intimate Partner Violence.

3.4 DISCUSSION

This is a multi-center, facility-based cross sectional study conducted to determine the magnitude of food insecurity and its correlates with mental distress during pregnancy among women following antenatal care. Previously, there was limited information related to common mental distress among pregnant women in this study setting. Moreover, findings from previous studies on the general adult community, adolescents and children [14, 18, 27, 29, 33]. To the best of our knowledge, there has been limited study of antenatal mental distress in Ethiopia; one study that measured the prevalence of postnatal maternal and paternal symptoms among adult women revealed rates of 37% for anxiety and 19.9% for depression respectively [7, 10, 11]. Therefore, the present study addresses the information gap regarding the prevalence of food insecurity and its correlate with mental distress among pregnant women and therefore expands the scientific literature in this area.

In this study the current prevalence of food insecurity was 9% and mental distress was 22.4%. The magnitude of household food insecurity in this study was very small when compared with a similar previous study [36, 37]. Dibaba et al., 2013 noted that 41% of women in that study reported food insecurity [7]. There are three possible reasons that might explain this observed difference. The first reason is the difference in the versions of the HFIAS used as a measure of food insecurity. We used 9 items and other studies have used a 6-item measurement scale. The second reason is the difference in study design. The other

studies used a cohort and community-based cross sectional sampling as well as a different study population (i.e. the other studies used pregnant women in a community based design and a female adolescent population). This study focused on pregnant women in a facility-based design. The other difference might be due to the seasonal effect on household food insecurity status, i.e. there are times when most households run out of food and food insecurity tends to be high during those seasons.

The magnitude of mental distress was 22.4% in the present study, which is approximately consistent with a previous study conducted in Ethiopian communities in which about 22.7% of those subjects reported mental distress [15, 49, 50]. A similar study in southwest Ethiopia reported the magnitude of antenatal depression as 19.9%, which is within the range of findings reported from Sub-Saharan Africa and other developing countries [15, 16, 32, 43]. However, the rate of mental distress in the present study is higher than the 11.7% of adults prevalence reported from Addis Ababa [14], the 12% from southern Ethiopia [49], and the 17% rate reported from Butajira, south-central Ethiopia [13] and it was also very high when compared to the reported 12% prevalence of prenatal depression in developed countries [51]. The difference in prevalence may be due to the tools used to measure the psychological morbidity or the cut-off points used. Some of these studies used higher/lower cut-off points to measure SRQ. The difference in prevalence might also be due to a difference in the study populations. Pregnant women are challenged by different physiologic and psychological stressors [7, 52–55], and the differential presence of hormones during pregnancies might contribute to the reported distress [56]. However, the high prevalence of maternal depression in poor countries may be related to women's exposure to several depression-related risk factors [52–54]. For instance, in settings of socio-economic adversity, there is substantial evidence for a relationship between intimate partner violence, lack of social support as well as poverty, and maternal mental distress during their pregnancies [57–60]. This study also reports that pregnant women who experienced intimate partner violence have significantly associated maternal distress. This is consistent with studies from other developing regions where intimate partner violence during pregnancy was reported to be significantly associated with poor mental health symptoms [54, 55]. The present study also revealed that urban pregnant women were more likely to report mental distress compared to their rural counterparts. The pressure associated with urban living where there is high economic vulnerability and poor mental health status might explain this. For example, a study conducted in rural Malawi utilizing the SRQ-20 showed that social circumstances and type

of employment among women influenced psychological conditions and their expression [61]. The authors recommend that further studies be conducted in order to explore the relationship between urbanization and mental distress.

The present study showed a significant association between food insecurity and mental distress. The magnitude of food mental distress was higher (48.3%) among pregnant women living in a food insecure household compared with those from food secure households (19.9%). Other studies have also indicated that the effects of food insecurity extend beyond the nutritional effects [10, 11, 18, 62]. This is consistent with other studies documenting a close association between food insecurity and mental distress [5–7, 18, 20, 22, 30] that showed food insecurity to be associated with depressive symptoms. The mechanism by which food insecurity leads to mental distress is difficult to determine using a cross sectional design. Nonetheless, available evidence suggests that there are biological pathways and psycho social pathways where food insecurity leads to mental distress [52]. In general, despite differences in study subject characteristics and different cut-off points used to define mental distress and food insecurity, our study findings is in general agreement with previous reports of research completed in Ethiopia [7, 36, 53]. The present study has some methodological strength. There was a high response rate; the study was also facilities-based, which helped us include study participants with varied socio economic and cultural backgrounds. This study could also give an insight for policy makers and program planners to device appropriate strategies for prevention of food insecurity and mental health. However, there are also some study limitations. First, given that this is a cross-sectional study, it is not possible to establish causal relationships. The cross-sectional nature of our data did not enable us to show the direction of the association between household food insecurity and mental distress. Therefore, prospective longitudinal studies are needed in the study setting among pregnant women to understand better the bidirectional relationship. Secondly, mental distress is based on self-report and thus is subject to non-systematic errors in recall and systematic non-disclosure. Both types of errors may have led to some misclassification in our study. Thirdly, study findings may not be generalized to the broader pregnant population since our study was limited to only women presenting to the ANC at health care facilities. In a country such as Ethiopia, where a significant proportion of pregnant women do not have antenatal follow-up, the findings of the present study cannot be generalized to the broader population of pregnant women in the community. There are also other exogenous variables responsible for mental distress but these were not assessed by this study. Other studies may

be required to understand different factors responsible for the cause of mental distress among pregnant women at the individual, community and societal level. In addition, lack of qualitative data to further explore their relationship is the major limitation to this study. More importantly, while this study reflects the public health importance of food security and mental distress, to quantify the prevalence of mental distress we used a cut off ≥ 7 ; there are different cut offs used by other researchers. We chose our particular cut-off because previous validation studies in Ethiopia using this cut point yielded an optimum SRQ cut-off score to determine the case for mental distress with 68.4% sensitivity and 62% specificity. In addition, studying at health facilities may have skewed the responses to affirmative responses for attempts to elicit help, rather than a manifestation of emotional distress [40].

3.5 CONCLUSION

This study found a 9% prevalence of food insecurity and a 22.4% prevalence of mental distress among pregnant women. The prevalence of mental distress is reported to be 48.3% and 19.9% among food insecure and food secure households respectively. Moreover, the results showed that there was an association between food insecurity and mental distress. However, the mechanism by which food insecurity is associated with mental health was not clearly known. Thus, further study is recommended to determine if food insecurity during pregnancy produces mental distress or whether mental distress is a contributing factor in the development of food insecurity. Future research should also investigate the impact of food insecurity and mental distress on pregnancy outcomes, fetal & child growth and development.

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PART III

Food Insecurity and HIV



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Is Food Insecurity Associated with HIV Risk? Cross-Sectional Evidence from Sexually Active Women in Brazil

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4.1 INTRODUCTION

Since the early stages of the HIV epidemic, social science researchers have described how unequal gender relations and gendered structural constraints facilitate the spread of HIV among women [1], particularly among women in sub-Saharan Africa [2]–[5]. A series of newer studies have highlighted food insecurity as a central variable shaping women’s risks of HIV exposure. Although women often occupy a primary role in household food production in sub-Saharan Africa, gender bias in the distribution of resources within the household places them at elevated risk for food insecurity compared with men [6],[7]. Qualitative research suggests that inadequate or uncertain access to food exerts an undue influence on women’s decisions to engage in transactional sex or unprotected sex [8] or enter commercial sex work [9]. In a population-based study of women in Botswana and Swaziland, food insufficiency was associated with risky sexual behaviors including inconsistent condom use, even

after statistical adjustment for education and household income [10],[11], and subsequent studies have replicated these findings in different settings in sub-Saharan Africa [12],[13].

Less is known about power relations, food insecurity, and sexual risk in Brazil, which has undergone successive changes in the gender and socio-geographic composition of its complex epidemic over the past three decades. Although the overall HIV incidence rate stabilized in the 1990s, this trend was driven primarily by reductions in new cases among men [14]. The number of new heterosexually transmitted infections among women has continued to increase, especially among women of reproductive age [14],[15]. Population-based data in Brazil suggest that knowledge about HIV prevention practices is well disseminated, but less than one-half of the population reports consistent condom use or condom use at last sexual intercourse (with a far greater proportion of men reporting condom use compared to women) [16],[17]. These differences are worrisome given that condom promotion has been given primary emphasis in Brazilian HIV prevention programming and policy [18] and that cities where the epidemic is most concentrated are generally characterized by the greatest inequalities between men and women [19]. Although some observers have hypothesized that unequal power relations between men and women in Brazil may explain the observed differences in condom use [16],[20],[21], little empirical work has been done to confirm this hypothesis [22].

At the country level, Brazil has achieved a very low score on the United Nations Development Programme's Gender Inequality Index relative to other countries that are considered to be advanced with regards to human development [23], and textbooks and didactic teaching tend to reinforce gender-based stereotypes [24]. Although increasingly gender-equitable legislation has been adopted in Brazil, such as mandatory joint titling of land to couples, landownership by men still exceeds that of women by a ratio of 8:1 [25]. In addition, violence against women is highly prevalent, particularly in the north and north-east regions of the country [26]. During times of economic adversity, women and girls living in resource-limited settings may experience worse nutritional and health outcomes than men and boys living in the same households [27]–[29]. These outcomes are relevant to the current context, given that Brazilian men exercise considerable decision-making dominance at the household level [30] and favor their sons in the distribution of resources within the household [31]–[33].

A significant methodological weakness of earlier studies linking food insecurity to HIV risk has been their reliance on non-validated measures of food

insecurity and a lack of objective measures of nutritional risk [34], as well as failure to consider the specific mechanisms linking food insecurity to HIV risk reduction behaviors. To address these shortcomings, we analyzed data from a large, geographically diverse sample of women in Brazil to determine whether food insecurity is associated with condom use and/or symptoms of sexually transmitted infection, and to discern the mechanisms underlying these associations.

4.2 METHODS

4.2.1 Ethical Review

The data collection procedures for the 2006 Pesquisa Nacional de Demografia e Saúde da Criança e da Mulher (PNDS) were approved by the ICF Macro Institutional Review Board as well as by the Research Ethics Committee of the Sexually Transmitted Diseases/AIDS Reference and Training Center of the Health Secretariat of São Paulo state. All participants provided oral informed consent. Additional details on staff training, pretesting, and other survey procedures are detailed in the PNDS final report [35]. The specific analysis of PNDS data presented in this paper was reviewed by the Harvard School of Public Health Office of Human Research Administration and deemed exempt from full review because it was based on anonymous public-use data with no identifiable information on participants.

4.2.2 Data Source

The data for this study were drawn from the PNDS, a national study implemented by the Ministério da Saúde from March 11, 2006, to March 5, 2007, with technical assistance from ICF Macro and the US Agency for International Development. The PNDS employed a probabilistic, complex sampling design, and it was designed to be nationally representative of all women of reproductive age (i.e., 15–49 y). Of 17,411 eligible women selected, 15,575 were successfully interviewed, for a response rate of 89.5%. Data on the primary outcomes of interest were obtained only from women who were sexually active. Therefore, the analyses reported in this paper were restricted to women who reported sexual activity with a man in the previous 12 mo.

4.2.3 Conceptual Framework and Statistical Analysis

The conceptual framework guiding our analysis, adapted from previously published work [36], is depicted in Figure 1. Our primary focus was to explain HIV risk. Accordingly, the primary outcomes of interest in our analysis were (a) consistent condom use, defined as using a condom at each occasion of sexual intercourse in the previous 12 mo; (b) recent condom use, less stringently defined as using a condom with the most recent sexual partner; and (c) self-report of an itchy vaginal discharge in the previous 30 d, possibly indicating presence of a sexually transmitted infection. The primary explanatory variable of interest was household food insecurity, defined as “access by all people at all times to enough food for an active, healthy life” ([37], p. 1560). To measure food insecurity, we used the Escala Brasileira de Segurança Alimentar (EBIA) [38],[39], a culturally adapted, Portuguese version of the US Household Food Security Survey Module [40]. Both the US and Brazilian scales differentiate between households with and without children in assessing the degree of food insecurity. The 18-item EBIA scale employs a recall period of 3 mo (compared to 12 mo for the US version) and has demonstrated good internal consistency as well as content, convergent, and internal validity [38],[39]. Using the previously validated algorithm [38],[39], we assigned participants into one of four categories: food secure, food insecure without hunger, moderately food insecure with hunger, and severely food insecure with hunger.

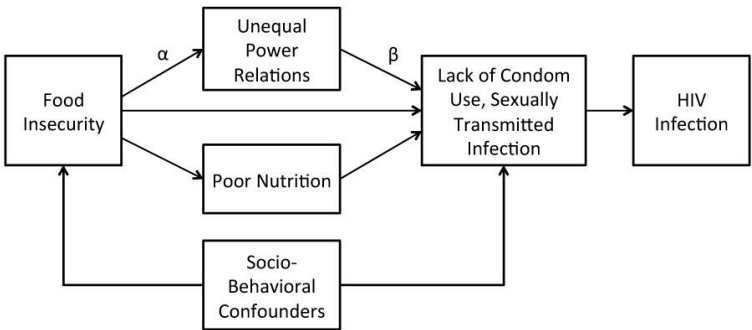


FIGURE 4.1 Conceptual framework linking food insecurity to HIV risk. The pathways between food insecurity and HIV risk may be direct or indirect. The indirect effects are mediated through unequal power relations and/or poor nutrition. For each hypothesized mediator, the indirect effect of the exposure on the outcomes (lack of condom use and sexually transmitted infection) is computed as the product of $\alpha \times \beta$. Other socio-behavioral variables may confound the observed association between food insecurity and HIV risk.

In our conceptual framework, food insecurity may have a direct effect on women's HIV risk, or the effect may be mediated through intervening variables that can also serve as programming or policy levers. In this analysis, we considered two specific mediators, poor nutrition and/or unequal power relations. Food insecurity may undermine women's ability to negotiate for condom use through its effects on nutritional risk and chronic energy deficiency. Previous research has also linked food insecurity to lack of control in sexual relations and to forced sex [10],[11]. In order to investigate these hypotheses, we operationalized chronic energy deficiency as a binary variable equal to one if the participant was underweight (defined as a body mass index $<18.5 \text{ kg/m}^2$ [41]), zero otherwise. As a proxy for unequal power relations, we constructed a variable based on the participant's responses to questions about whether she felt it would be acceptable for a woman to refuse sexual intercourse with her husband or partner in five hypothetical scenarios [42]: if she knew he had a sexually transmitted disease, if she knew that he was having sexual intercourse with other women, if she had given birth to a child recently, if she was tired, or if she did not want to have sexual intercourse. Women who responded "no" to all five scenarios were (stringently) categorized as lacking control in sexual relations.

All analyses were conducted using the Stata statistical software package (version 12.0, StataCorp). To estimate the association between food insecurity and the outcomes of interest, we fit multivariable logistic regression models to the data, with cluster-correlated robust estimates of variance [43]–[45]. This modeling approach appropriately recognizes that variables measured at the level of the primary sampling unit have a smaller effective sample size and corrects the standard errors for potentially correlated observations between participants who live in the same primary sampling unit. We did not use the sampling weights provided by ICF Macro because this analysis was restricted to sexually active women only, and sampling weights were not provided for analyses restricted to this sub-sample of the population.

As depicted in the conceptual framework, socio-behavioral variables may confound the association between food insecurity and sexual risk. In our regression analyses, we therefore adjusted for potential confounding by the following socio-behavioral variables: age, racial/ethnic group (white [*branca*], black [*preta*], mixed [*parda*], Asian [*amarela*], or indigenous [*indigena*]), urban residence, macro-region of the country (north, northeast, southeast, south, or center-west), domestic partnership status (legally or formally married, not married but living with a partner in a consensual union, never married, separated, divorced, or widowed), Catholic religion, news reading frequency (reads the

news daily, nearly every day, once per week, less than once per month, does not read), within-country quintiles of household asset wealth [46], and current use of cigarettes.

If simple linear regression models had been used in this analysis, we could have estimated the association between sexual risk and the hypothesized mediator adjusted for food insecurity (depicted as β in the conceptual framework), and then estimated the association between the food insecurity and the hypothesized mediator (α). The indirect effect of food insecurity on sexual risk, i.e., the portion of the effect of food insecurity on sexual risk that is due to the mediating variables of interest, could be computed as the product $\alpha \times \beta$ [47], and the asymptotic variance would be computed using the multivariate delta method [48]. In the context of logistic regression, however, parameter rescaling tends to increase the apparent magnitude of the estimated regression coefficient and counters the effect of including the (potential) socio-behavioral confounders, as noted above. We therefore implemented a previously published algorithm [49],[50] to rescale the parameter estimates in order to decompose the total effect of food insecurity into its indirect and direct effects.

We also investigated whether the effect of food insecurity on the outcomes of interest varied according to domestic partnership status or fertility preferences. Fertility preferences were measured with a binary variable equal to one if the woman expressed a preference for no further childbearing and zero if the woman was undecided or expressed a preference to have more children. To assess potential effect modification, we included both the main effect terms and the interaction terms (with food insecurity) in the regression models and then used Wald-type F-tests to determine whether these variables modified the associations between food insecurity and the outcomes of interest. These interaction tests were based on our hypothesis that the adverse effects of food insecurity on condom use may be strongest among women who have a stronger preference for condom use, i.e., women who do not desire to bear more children or women who are not currently in a domestic partnership.

4.3 RESULTS

Of the 15,575 women interviewed for the study, 12,684 (81.4%) reported sexual activity with a man in the previous 12 mo and were therefore included in this analysis. The distributions of food insecurity scores were similar for women who were sexually active and women who were not: the mean EBIA scores were similar ($t=0.18$; $p=0.86$), and the percentages of women assigned to the different

categories of food insecurity were also similar ($\chi^2=1.02$; $p=0.80$). Consistent condom use was reported by 2,210 women (18.0%), condom use at last sexual intercourse was reported by 3,172 women (25.7%), and itchy vaginal discharge was reported by 1,337 women (10.8%). Summary statistics are presented in Table 1. On the EBIA, most women were categorized as food secure (9,343 [73.7%]), while 1,762 women (13.9%) were categorized as food insecure without hunger, 783 (6.2%) were categorized as moderately food insecure with hunger, and 473 (3.7%) were categorized as severely food insecure with hunger. The Cronbach’s α for the EBIA was 0.91, indicating a high degree of internal consistency.

TABLE 4.1 Summary statistics

Variable	All Participants (n = 12,684)	Food Security Category		χ^2 Test Statistica
		Food Secure, Food Insecure without Hunger, or Moderately Food Insecure with Hunger (n = 12,211)	Severely Food Insecure with Hunger (n = 473)	
Age	32 (24–40)	32 (24–39)	34 (27–41)	20.6***
Race				90.4***
White (branca)	4,824 (39.4%)	4,725 (40.1%)	99 (21.2%)	
Black (preta)	1,210 (9.9%)	1,150 (9.8%)	60 (12.9%)	
Mixed (parda)	5,607 (45.8%)	55,334 (45.3%)	273 (58.6%)	
Asian (amarela)	342 (2.8%)	334 (2.8%)	8 (1.7%)	
Indigenous (indigena)	265 (2.2%)	239 (2.0%)	26 (5.6%)	
Urban residence	8,713 (70.5%)	8,432 (70.9%)	281 (59.4%)	29.0***
Macro-region				241.8***
North	2,126 (17.2%)	1,940 (16.3%)	186 (39.3%)	
Northeast	2,352 (19.0%)	2,218 (18.7%)	134 (28.3%)	
Southeast	2,627 (21.3%)	2,567 (21.6%)	160 (12.7%)	
South	2,713 (22.0%)	2,675 (22.5%)	38 (8.0%)	
Center-west	2,543 (20.6%)	2,488 (20.9%)	55 (11.6%)	
Domestic partnership status				68.1***
Other	2,779 (22.5%)	2,673 (22.5%)	106 (22.4%)	
Cohabiting	4,181 (33.8%)	3,944 (33.2%)	237 (50.1%)	

TABLE 4.1 (Continued)

Variable	All Participants (n = 12,684)	Food Security Category		χ^2 Test Statistica
		Food Secure, Food Insecure without Hunger, or Moderately Food Insecure with Hunger (n = 12,211)	Severely Food Insecure with Hunger (n = 473)	
Married	5,401 (43.7%)	5,271 (44.3%)	130 (27.5%)	0.13 167.5***
Catholic religion	10,248 (82.9%)	9,853 (82.9%)	395 (83.5%)	
Frequency of reading the news				
Does not read	4,468 (36.2%)	4,174 (35.1%)	294 (62.2%)	550.5***
Less than once a month	2,363 (19.1%)	2,274 (19.1%)	89 (18.8%)	
At least once a week	2,773 (22.5%)	2,715 (22.9%)	58 (12.3%)	
Nearly every day	1,546 (12.5%)	1,527 (12.9%)	19 (4.0%)	
Daily	1,201 (9.7%)	1,188 (10.0%)	13 (2.8%)	
Household asset wealth index				
Most poor	2,501 (20.3%)	2,200 (18.7%)	281 (59.8%)	28.7***
Very poor	2,514 (20.4%)	2,398 (20.2%)	116 (24.7%)	
Poor	2,372 (19.2%)	2,319 (19.6%)	53 (11.3%)	
Less poor	2,517 (20.4%)	2,498 (21.1%)	19 (4.0%)	
Least poor	2,426 (19.7%)	2,425 (20.5%)	1 (0.2%)	
Smokes cigarettes	1,881 (15.2%)	1,768 (14.9%)	113 (23.9%)	

All data are number (percent), except for age, which is median (interquartile range).
*Represents the result of a non-parametric K-sample test on the equality of medians with continuity correction (for continuous variables) or Pearson's chi-squared test (for categorical variables).
***Statistical significance at the level of $p < 0.001$.
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In multivariable analyses, severe food insecurity with hunger was associated with a statistically significant reduced odds of consistent condom use (adjusted odds ratio [AOR]=0.67; 95% CI, 0.48–0.92) and condom use at last sexual intercourse (AOR=0.84; 95% CI, 0.81–0.86) (Table 2). The estimated odds ratios for food insecurity categories of lesser severity did not have statistically significant associations with the condom use outcomes, whereas all categories of food insecurity were associated with increased odds of reporting symptoms

TABLE 4.2 Associations between food insecurity and sexual risk outcomes.

Variable	Consistent Condom Use in the Past 12 mo		Condom Use at Last Sexual Intercourse		Itchy Vaginal Discharge in the Past 30 d	
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Food insecurity category						
Food secure	Ref	Ref	Ref	Ref	Ref	Ref
Food insecure without hunger	0.85 (0.74–0.99)	0.94 (0.79–1.10)	0.93 (0.82–1.04)	1.00 (0.87–1.14)	1.61 (1.37–1.89)	1.46 (1.24–1.73)
Moderately food insecure with hunger	0.88 (0.73–1.07)	1.00 (0.81–1.24)	0.86 (0.73–1.02)	0.95 (0.78–1.15)	1.94 (1.58–2.37)	1.78 (1.44–2.22)
Severely food insecure with hunger	0.54 (0.40–0.72)	0.67 (0.48–0.92)	0.60 (0.47–0.77)	0.75 (0.57–0.98)	2.16 (1.67–2.79)	1.94 (1.47–2.56)
Age (in 5-y blocks)	0.77 (0.75–0.79)	0.87 (0.90–0.96)	0.75 (0.73–0.77)	0.84 (0.81–0.86)	0.95 (0.93–0.98)	0.95 (0.92–0.98)
Race						
White	1.09 (0.98–1.22)	1.10 (0.97–1.24)	0.97 (0.88–1.07)	0.96 (0.86–1.08)	0.81 (0.72–0.92)	0.95 (0.83–1.10)
Black	1.09 (0.92–1.28)	1.06 (0.88–1.26)	1.03 (0.89–1.19)	0.97 (0.83–1.14)	0.96 (0.79–1.18)	0.98 (0.80–1.21)
Mixed	Ref	Ref	Ref	Ref	Ref	Ref
Asian	1.24 (0.95–1.63)	0.96 (0.71–1.30)	1.19 (0.93–1.53)	0.92 (0.68–1.24)	0.82 (0.56–1.21)	0.88 (0.58–1.33)
Indigenous	1.22 (0.87–1.70)	1.14 (0.83–1.57)	1.15 (0.84–1.57)	1.09 (0.80–1.49)	0.82 (0.53–1.27)	0.73 (0.45–1.18)
Urban residence	1.75 (1.54–1.99)	1.14 (1.00–1.30)	1.89 (1.69–2.12)	1.31 (1.15–1.49)	0.78 (0.69–0.88)	0.94 (0.82–1.08)
Macro-region						
North	Ref	Ref	Ref	Ref	Ref	Ref
Northeast	0.78 (0.65–0.94)	0.85 (0.71–1.02)	0.94 (0.80–1.12)	1.06 (0.89–1.25)	0.68 (0.56–0.83)	0.69 (0.56–0.84)
Southeast	0.87 (0.73–1.03)	0.77 (0.64–0.92)	0.86 (0.73–1.02)	0.85 (0.71–1.01)	0.70 (0.58–0.85)	0.87 (0.72–1.07)
South	0.84 (0.70–1.00)	0.75 (0.62–0.91)	0.87 (0.73–1.02)	0.87 (0.73–1.05)	0.71 (0.59–0.86)	0.91 (0.74–1.12)
Center-west	0.81 (0.68–0.97)	0.76 (0.63–0.91)	0.86 (0.73–1.02)	0.86 (0.72–1.02)	0.77 (0.65–0.93)	0.90 (0.75–1.08)

TABLE 4.2 (Continued)

Variable	Condom Use in the Past 12 mo		Condom Use at Last Sexual Intercourse		Itchy Vaginal Discharge in the Past 30 d	
	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)	OR (95% CI)	AOR (95% CI)
Domestic partnership status						
Other	Ref	Ref	Ref	Ref	Ref	Ref
Cohabiting	0.16 (0.15–0.19)	0.20 (0.18–0.23)	0.18 (0.16–0.20)	0.22 (0.19–0.25)	1.39 (1.20–1.63)	1.23 (1.05–1.44)
Married	0.15 (0.13–0.17)	0.19 (0.17–0.22)	0.14 (0.12–0.16)	0.19 (0.17–0.22)	1.12 (0.96–1.31)	1.16 (0.98–1.37)
Catholic religion	0.87 (0.77–0.97)	1.00 (0.88–1.14)	0.88 (0.79–0.98)	1.04 (0.92–1.17)	0.93 (0.80–1.08)	0.94 (0.81–1.10)
Frequency of reading the news						
Does not read	Ref	Ref	Ref	Ref	Ref	Ref
Less than once a month	1.60 (1.40–1.84)	1.34 (1.16–1.55)	1.54 (1.37–1.74)	1.29 (1.14–1.47)	0.92 (0.79–1.07)	0.91 (0.77–1.06)
At least once a week	1.91 (1.67–2.17)	1.38 (1.20–1.60)	1.86 (1.66–2.09)	1.39 (1.22–1.58)	0.71 (0.60–0.82)	0.78 (0.66–0.91)
Nearly every day	2.47 (2.13–2.86)	1.61 (1.36–1.91)	2.41 (2.11–2.75)	1.64 (1.41–1.91)	0.59 (0.49–0.73)	0.74 (0.60–0.91)
Daily	2.57 (2.19–3.01)	1.61 (1.33–1.94)	2.51 (2.17–2.90)	1.67 (1.41–1.98)	0.51 (0.40–0.64)	0.64 (0.50–0.84)
Household asset wealth index						
Most poor	Ref	Ref	Ref	Ref	Ref	Ref
Very poor	1.46 (1.23–1.72)	1.39 (1.15–1.68)	1.44 (1.26–1.66)	1.41 (1.20–1.66)	0.88 (0.75–1.05)	1.01 (0.84–1.22)
Poor	1.46 (1.26–1.71)	1.36 (1.13–1.65)	1.39 (1.21–1.60)	1.33 (1.12–1.57)	0.79 (0.66–0.94)	1.02 (0.83–1.25)
Less poor	1.61 (1.36–1.90)	1.46 (1.20–1.78)	1.46 (1.26–1.68)	1.39 (1.18–1.65)	0.80 (0.67–0.95)	1.11 (0.90–1.37)
Least poor	2.05 (1.74–2.42)	1.50 (1.21–1.86)	1.83 (1.59–2.11)	1.43 (1.18–1.73)	0.45 (0.37–0.55)	0.73 (0.56–0.94)
Smokes cigarettes	0.96 (0.85–1.09)	0.93 (0.81–1.07)	0.88 (0.79–0.99)	0.84 (0.74–0.96)	0.90 (0.77–1.05)	0.84 (0.71–0.98)

Bold indicates statistical significance at the level of $p < 0.05$.

OR, odds ratio; Ref, reference.

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of itchy vaginal discharge. These estimated associations were also large in magnitude: evaluated at the mean of the other covariates, changing food security status from food secure to severely food insecure with hunger resulted in a change of the predicted probability of consistent condom use from 15.0% to 10.5%, while the predicted probability of self-reported itchy vaginal discharge changed from 9.2% to 16.4%. A number of other important patterns were also evident. There was little evidence of racial/ethnic differences. Condom use and self-reported itchy vaginal discharge were more likely among women in the north and north-east regions of the country, which have been less affected by the HIV epidemic and have experienced a slower rise in HIV incidence [14]. Consistent with previous work [51], greater reading frequency was associated with greater odds of condom use and reduced odds of self-reported itchy vaginal discharge.

In the mediation analyses, neither underweight nor lack of control in sexual relations proved to be substantive mediators of the relationship between food insecurity and the outcomes of interest (Table 3). Across the outcomes of interest, when these hypothesized mediators were included in the multivariable regression models, the estimated AOR for severe food insecurity changed minimally and even shifted away from the null. In addition, we assessed effect modification by domestic partnership status and fertility preferences. No statistically significant effect modification was observed for any of the outcomes, although severe food insecurity appeared to have the strongest association with condom use and symptoms of sexually transmitted infection among women who prefer more children.

4.4 DISCUSSION

Using data on 12,684 sexually active women sampled from diverse geographic regions of Brazil, we found that condom use was infrequent and that severe food insecurity with hunger was associated with reduced odds of condom use and increased odds of self-reported itchy vaginal discharge, possibly indicating presence of a sexually transmitted infection. These estimated associations were statistically significant, large in magnitude, and robust to statistical adjustment for known confounders. Given the infrequency of condom use among Brazilian women, a finding echoed by previous studies [16]–[18], and the centrality of condom promotion to Brazil's HIV prevention strategy, our findings have important implications for policy and programming for HIV prevention.

TABLE 4.3 Mediation and effect modification analyses.

Variable	Consistent Condom Use in the Past 12 mo	Condom Use at Last Sexual Intercourse	Itchy Vaginal Discharge in the Past 30d
Mediation analysis			
Unadjusted effect of severe food insecurity with hunger	OR = 0.55 (95% CI, 0.41–0.74)	OR = 0.62 (95% CI, 0.48–0.79)	OR = 1.89 (95% CI, 1.47–2.43)
Adjusted effect ^a	AOR = 0.68 (95% CI, 0.49–0.94)	AOR = 0.76 (95% CI, 0.57–0.99)	AOR = 1.52 (95% CI, 1.16–2.01)
Adjusted effect, accounting for underweight ^a	AOR = 0.68 (95% CI, 0.49–0.94)	AOR = 0.75 (95% CI, 0.57–0.99)	AOR = 1.53 (95% CI, 1.17–2.01)
Percentage of total effect due to underweight	–0.9%	–2.7%	–0.8%
Adjusted effect, accounting for lack of control in sexual relations ^a	AOR = 0.67 (95% CI, 0.49–0.93)	AOR = 0.76 (95% CI, 0.58–0.99)	AOR = 1.59 (95% CI, 1.21–2.08)
Percentage of total effect due to lack of control in sexual relations	–2.9%	–2.4%	–1.5%
Effect modification analysis			
By domestic partnership status			
Among non-partnered women	AOR = 0.68 (95% CI, 0.43–1.07)	AOR = 0.71 (95% CI, 0.47–1.08)	AOR = 2.46 (95% CI, 1.41–4.30)
Among cohabiting women	AOR = 0.69 (95% CI, 0.39–1.21)	AOR = 0.75 (95% CI, 0.50–1.13)	AOR = 1.60 (95% CI, 1.07–2.39)
Among married women	AOR = 0.44 (95% CI, 0.16–1.23)	AOR = 0.79 (95% CI, 0.41–1.53)	AOR = 2.22 (95% CI, 1.34–3.67)
Wald-type F-test (<i>p</i> -value)	5.49 (0.48)	3.46 (0.75)	6.60 (0.36)

TABLE 4.3 (Continued)

Variable	Consistent Condom Use in the Past 12 mo	Condom Use at Last Sexual Intercourse	Itchy Vaginal Discharge in the Past 30d
By fertility preference			
Among women who prefer no more children	AOR = 0.73 (95% CI, 0.46–1.16)	AOR = 0.76 (95% CI, 0.52–1.10)	AOR = 1.81 (95% CI, 1.14–2.88)
Among women who prefer more children/ undecided	AOR = 0.54 (95% CI, 0.34–0.87)	AOR = 0.65 (95% CI, 0.43–0.98)	AOR = 2.03 (95% CI, 1.46–2.82)
Wald-type F-test (<i>p</i> -value)	0.20 (0.90)	0.67 (0.72)	0.36 (0.83)

^aRegression estimates adjusted for age, race, urban residence, macro-region, domestic partnership status, Catholic religion, news reading frequency, household asset wealth, and cigarette use. Bold indicates statistical significance at the level of $p < 0.05$.

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It is well known that the social and economic marginalization of women constrains their ability to engage in HIV risk reduction behaviors [1]–[5]. Newer research has specifically identified food insecurity as a critical variable influencing women's risks of sexual violence [11] and exposure to HIV [10],[12],[13]. In these studies, however, food insecurity was measured using just one [10]–[12] or two [13] questions about food insufficiency. Food insecurity is a complex, multidimensional phenomenon characterized not only by insufficient food intake, but also by poor diet quality, disrupted eating patterns, and anxiety and uncertainty about access [52]. The single-question item incorporated into the US National Center for Health Statistics' Third National Health and Nutrition Examination Survey has demonstrated poor sensitivity for identifying food insecure households [53]. What is new about our analysis is our use of a well-developed, culturally adapted 18-item food insecurity scale that measures the entire range of human experience with food insecurity, from food security to severe food insecurity with hunger [38],[39].

We investigated two hypothesized mediators, underweight and lack of control in sexual relations, but these variables did not yield a substantive degree of mediation. This suggests that the observed association is due to a direct effect of food insecurity on sexual risk, or that it is due to mediation by unmeasured variables such as depression and other negative affect states [54] or condom use self-efficacy [55],[56]. In addition, measurement error in the variable for lack of control in sexual relations may have undermined our ability to adequately test for evidence of mediation. We did not have access to better developed measurements, such as the sexual relationship power scale [57]. However, even if the precise mechanism of action remains unknown, if the observed association is causal then food security interventions could still have beneficial effects on women's sexual risk, irrespective of the mechanism of action.

Our findings about food insecurity and sexual risk add to the burgeoning research base that highlights the importance of food insecurity as a variable of central importance in HIV prevention efforts [58],[59]. In Brazil, the specific targeting of high-risk women through food supplementation or livelihood interventions may help to equalize gender-based intra-household bargaining power differentials. Specifically, microfinance-based interventions have been promoted for reducing HIV risk [60],[61]. However, in Brazil, women have not been the traditional focus of microfinance initiatives as in other countries like India and Bangladesh [62].

Several limitations must be considered in interpreting our findings. First, we did not use the sampling weights provided by ICF Macro. Our analysis was

restricted to sexually active women, a sub-sample for which sampling weights were not provided, and application of the weights for national representativeness could lead to unpredictable biases. This would not necessarily be considered as a source of potential bias, however, given that we do not attempt to generalize our findings to the population of Brazilian women of reproductive age. The large sample size does make our analysis to our knowledge the largest study of its kind to date, suggesting broad applicability across diverse socio-demographic groups in an emerging economy.

Second, measurement error in the outcomes of interest could bias our estimates in unpredictable ways. Although condom use at last sexual intercourse may be erroneously measured [63], consistent condom use signifies a greater degree of commitment and intention and is less subject to errors in reporting [64]. In addition, itchy vaginal discharge may be symptomatic of other conditions that are not sexually transmitted (e.g., genital/vulvovaginal candidiasis). In a meta-analysis of symptoms and signs of chlamydial infection and gonorrhea among women, the specificity of vaginal itching and vaginal discharge ranged from 65% to 79%, depending on the study setting [65]. Random measurement error in the dependent variable would have biased our estimates towards the null and resulted in more conservative estimates of association, however. In order for systematic measurement error in the dependent variable to bias our estimates away from the null, the systematic measurement error would need to be somehow related to the exposure of interest (food insecurity). Studies of food insecurity and HIV risk clearly warrant the collection of biomarker data, but these data are more difficult to obtain compared to measures of self-report. Because of the stigma attached to HIV, household surveys that incorporate HIV testing have typically experienced a 10%–20% lower response rate to HIV testing than to the household survey modules [66].

Third, study participants' mental health was not assessed. A cross-sectional study of women living in Goa, India, demonstrated that complaints of vaginal discharge were associated with both hunger and non-psychotic psychiatric morbidity [67],[68]. The study authors interpreted the latter finding as indicative of vaginal discharge as a bodily idiom of distress. Non-psychotic psychiatric morbidity could be potentially considered an unmeasured confounder with regards to our analysis. However, in light of prior studies linking food insecurity to depression and other markers of psychological distress [69]–[72], we believe that including such a variable in our regression models (if it had been available) would have resulted in over-adjustment by conditioning on part of the effect of interest.

Fourth, the observed associations between food insecurity and the outcomes could also be explained by unmeasured confounding. Our multivariable models included statistical adjustment for key variables known to confound the relationship between food insecurity and sexual risk (e.g., educational attainment and economic status) but may have omitted others. Most notably, we were unable to distinguish between consistent condom use with regular partners versus consistent condom use with casual partners [73]. There may have been differential patterning of food insecurity and condom use by partner type [74], given the highly negative meanings that may be attached to condom use in the context of marital relationships or regular sexual partnerships [1],[75]. Because casual or transactional partnerships are more likely to be economically motivated and characterized by greater frequency of HIV transmission risk behaviors [76],[77], failure to account for the type of partner could have confounded our estimates of the association between food insecurity and sexual risk. However, in our data we found no evidence of effect modification by domestic partnership status, and we would expect domestic partnership to be correlated (however weakly) with a lower propensity to have casual sexual partners.

Fifth, both the exposure and outcomes of interest were based on participant self-report. If study participants who provided responses consistent with more severe levels of food insecurity were also more likely to under-report condom use or over-report itchy vaginal discharge, this could have biased our estimates away from the null.

Sixth, the direction of causality is generically uncertain with data of a cross-sectional nature. However, the estimated associations presented in our analysis are strong, increasing with the intensity of the exposure, consistent with previously published research conducted in independent samples [10],[12],[13], plausible, and coherent with our socio-cultural understanding of the Brazilian context. Together these elements suggest our conservative interpretation of the data is correct [78], but longitudinal or experimental study designs in future work would help to strengthen claims of causality.

In summary, this study presents evidence from sexually active women living in Brazil that food insecurity is associated with reduced use of condoms during sexual intercourse. If the estimated association is causal, our findings suggest that interventions targeting food insecurity may have beneficial implications for HIV prevention. Individual-level cognitive and/or behavioral interventions targeting HIV risk avoidance or risk reduction behaviors are likely to be less than optimally effective if these structural factors are not also taken into account.

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Food Insecurity is a Barrier to Prevention of Mother-to-Child HIV Transmission Services in Zimbabwe: A Cross-Sectional Study

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5.1 BACKGROUND

It is widely recognized that attrition from the prevention of mother-to-child HIV transmission (PMTCT) cascade is a significant obstacle to achieving UNAIDS' and the World Health Organization (WHO)'s goal to eliminate mother-to-child transmission by 2015 [1-4]. The PMTCT cascade is a series of services that HIV-positive pregnant women and their infants need to receive in order to prevent HIV transmission, including antenatal care (ANC), HIV testing, and antiretroviral therapy (ART) or antiretroviral (ARV) prophylaxis [5]. However, 49% of HIV-infected pregnant women in sub-Saharan Africa are lost between ANC registration and delivery and miss some or all essential PMTCT services [6]. Furthermore, high rates of loss to follow-up among women initiating ART

under 'Option B+', [7] WHO's PMTCT strategy whereby all pregnant and breastfeeding women receive lifelong ART, [8] has renewed emphasis on the importance of reducing barriers to uptake of PMTCT services.

In many settings, economic factors are cited as barriers to ANC and PMTCT services, [9,10] including facility-based delivery, [11] initiation of ART and ARV prophylaxis, and retention in HIV care [12]. Here we focus on one aspect of socioeconomic position: food security. People are considered food secure when they have adequate physical, social, and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life [13]. Food insecurity is increasingly recognized as exacerbating the HIV/AIDS epidemic by increasing engagement in HIV-related risk behaviors, [14-17] and among people living with HIV, undermining ART adherence and retention in care [18-20]. However, few studies have examined the relationship between food insecurity and utilization of PMTCT services and MTCT [19,20].

There are several pathways through which food insecurity might affect women's use of health services and increase vertical HIV transmission [21]. First, food insecurity might result in avoidance or delay of maternal health services because of its overlap with socioeconomic position [22,23] and the real or perceived costs of ANC, facility delivery, and/or HIV prevention and care services. Second, food insecurity is associated with undernutrition, which among HIV-infected women is associated with preterm delivery, low birth weight, and MTCT [24-26]. In addition, food insecure HIV-infected women may be less likely to adhere to ART/ARV prophylaxis, [27] and they may exclusively breast-feed their infants for shorter periods of time, heightening the risk of onward transmission as they resort to mixed feeding [28,29]. Lastly, food insecurity may influence women's receipt of PMTCT services through mental health pathways related to the anxiety and stress associated with real or perceived hunger [30,31]. Stress and depression, in turn, may affect service utilization and obstetric and child health outcomes [32,33]. Together, these compelling pathways support the hypothesis that food insecurity may undermine global efforts to achieve elimination of mother-to-child HIV transmission.

We examined the relationship between food security and PMTCT in Zimbabwe, where a generalized HIV epidemic coexists with food insecurity, hunger, and undernutrition. Thirty-three percent of Zimbabwe's population is undernourished, [34] and the 2013 Global Hunger Index was 16.5, indicating serious levels of hunger [35]. Moreover, 12% of pregnant women are HIV-positive [36]. The objectives of our analyses were to: 1) determine the

prevalence of food insecurity among women with a recent birth; 2) explore whether food insecurity is associated with receipt of PMTCT-related services; and 3) examine the association between food insecurity and MTCT.

5.2 METHODS

5.2.1 Study Population

We analyzed data from a 2012 cross-sectional survey of mother/caregiver-infant pairs conducted as part of the impact evaluation of Zimbabwe's Accelerated National PMTCT Program [5,37]. The survey targeted women who were ≥ 16 years old and biological mothers or caregivers of infants (alive or deceased) born 9–18 months earlier in order to capture MTCT during pregnancy, delivery and breastfeeding. The primary outcomes of the impact evaluation were MTCT and HIV-free infant survival. Because the analyses presented in this paper use data from the 2012 survey, which were the baseline data for the parent impact evaluation, we describe the association between food security and engagement in PMTCT services before the Ministry of Health and Child Care's (MoHCC) implementation of PMTCT strategy 'Option A'. We restricted the sample of 9,018 mothers and caregivers to 8,662 biological mothers and their eligible infants by excluding 356 (3.9%) caregiver/infant pairs.

5.2.2 Sampling Strategy and Data Collection

The two-stage sampling strategy has been previously described [37,38]. Five provinces (Harare, Mashonaland West, Mashonaland Central, Manicaland, and Matabeleland South) were purposefully selected to include Zimbabwe's capital, rural communities with higher and lower HIV prevalence, and both Shona and Ndebele ethnic groups. In the first stage, we randomly selected 157 catchment areas from 699 health facilities offering PMTCT services, proportionate to the number of facilities per district. In the second stage, in each catchment area, a pre-determined proportion of eligible infants was randomly sampled, depending on the size of the catchment area. Potentially eligible infants and their mothers/caregivers were identified by pooling information from: 1) community health workers, 2) immunization registers from both sampled and nearby health facilities, and 3) peer referral. Together, this approach efficiently identified eligible participants without screening all households and captured mother-infant pairs

who did not utilize any health services and those who accessed care outside of their area of residence. Mothers providing written informed consent completed an anonymous interviewer-administered survey about maternal and household demographics, health services accessed during pregnancy and after delivery, and behaviors germane to MTCT (e.g., breastfeeding).

5.2.3 Food Security Status

Household food security was determined with a subset of questions from the Household Food Insecurity Access Scale (HFIAS) [30]. Due to interview time constraints, we selected three questions for inclusion, one from each domain of food access of the HFIAS: 1) anxiety and uncertainty about household food supply; 2) insufficient quality, including food variety and preferences; and 3) insufficient food intake and its physical consequences [30,39]. Women were asked how often, in the last 4 weeks, they worried that their household would not have enough food (anxiety/uncertainty), how often they were not able to eat preferred foods because of lack of resources (insufficient quality), and whether anyone in the household went to bed hungry (insufficient intake).

Based on the distribution of these responses, consideration of the recommendations for categorizing responses to the full HFIAS, and examination of other food security scales [40], we determined an algorithm to classify households into three mutually exclusive groups: food secure, moderately food insecure, and severely food insecure. Severe food insecurity was defined as ≥ 1 household member going to bed hungry (even if infrequently or rarely) or “often” worrying (more than 10 times in the last month) about food access or food quality. Households were classified as having moderate food insecurity if they “sometimes” (3–10 times in the last month) worried about food access or quality. Food secure households experienced either none of the food insecurity conditions or they only rarely worried about food access or quality. We assumed that household food security status in the previous 4 weeks was strongly correlated with what food security status would have been during pregnancy, 9–18 months prior. We excluded seven women without food security information from the analysis.

5.2.4 Assessment of HIV Status

Living mothers and infants provided blood spot samples for HIV testing, which were air-dried onto filter papers and stored at room temperature until biweekly

transport to the laboratory. Maternal samples were tested for HIV-1 antibody using AniLabsystems EIA kit (AniLabsystems Ltd, OyToilette 3, FIN-01720, Vantaa, Finland) with positive specimens confirmed using Enzygnost Anti-HIV 1/2 Plus ELISA (Dade Behring, Marburg, Germany) and discrepant results resolved by Western Blot. Samples from HIV-exposed infants and infants of mothers with unavailable samples were tested for HIV with DNA polymerase chain reaction (Roche Amplicor HIV-1 DNA Test, version 1.5). Results were available for 97.8% and 97.2% of women and HIV-exposed infants, respectively. Women were able to receive their HIV test results at the local health facility up to 3 months after the survey using a card with a barcode of their unique identification number.

5.2.5 Data Analyses

We first compared socio-demographic characteristics and service utilization stratified by food security status. We examined the following maternal health services: ANC (any and the WHO-recommended ≥ 4 visits [41]), gestational age in weeks at ANC registration (WHO recommends the first visit should occur in first trimester [41]), HIV testing during ANC or labor and delivery (or prior knowledge of HIV-positive serostatus), facility-based delivery, and postnatal visit attendance (6–8 weeks postpartum). Among HIV-infected women, we examined reported use of maternal and infant ART/ARV prophylaxis, infant co-trimoxazole prophylaxis, exclusive breastfeeding (≥ 1 month), and MTCT, stratified by food security status. We also examined a combined category indicating “completion” of the cascade including the following key services: ≥ 4 ANC visits, HIV testing, facility-based delivery, postnatal visit attendance, and among HIV-infected women, report of maternal and infant ART or ARV prophylaxis and co-trimoxazole prophylaxis. Missing values of PMTCT services were $< 1\%$; in those few cases, women were classified as not having received the service.

We conducted an exploratory analysis to describe the association between food security and completion of the PMTCT cascade and MTCT using Poisson regression models. With cross-sectional data, the exponentiated parameter estimates represent prevalence ratios (PR) [42–44]. The fully adjusted models contain all covariates specified a priori for inclusion (see below) and key services or behaviors not hypothesized to lie on the causal pathway between food insecurity and the outcome. Covariates with variance inflation factors > 10 (indicating

multicollinearity) were examined for correlation with food security status and if necessary, excluded [45]. We present PRs and 95% confidence intervals (CI) computed with linearized standard errors to account for the sample design.

Several covariates, which likely preceded pregnancy, were considered for inclusion in models as potential confounders: province, mother's age, religion, tribe, being married or having a regular sexual partner, mother's highest educational level, household size, lifetime births, and the building materials of the best building on the homestead. Additionally, we created a household asset index, divided into quartiles, using principal component analysis with a polychoric correlation matrix [46-48]. We also included a variable to indicate the infant's age in months at the time of the survey (or age the infant would have been, if deceased), indicative of the time elapsed between the pregnancy and the interview to account for recall bias. No more than 1% of any covariate was missing. All analyses were conducted with STATA 12 (College Station, Texas) and were weighted to account for the varying sampling fraction by catchment area and 1.1% survey non-response.

5.2.6 Human Subjects Protection

The Medical Research Council of Zimbabwe and the ethical review boards at the University of California, Berkeley and University College London approved this study.

5.3 RESULTS

5.3.1 Participant Characteristics

The weighted population included 8,790 eligible mothers (based on 8,655 observations). The average age of women was 26.7 years, 93% were married or had a regular sexual partner, and they had an average of 2.7 lifetime births (Table 1). Overall, 4,305 (49%) women reported living in food secure households, 2,906 (33%) were living in moderately food insecure households, and 1,578 (18%) were living in severely food insecure households. Women living in moderately or severely food insecure households were less likely to be from Harare, less likely to have a husband or main partner (92% vs. 94%), had less education, fewer assets, and larger household sizes (5.3 vs. 5.0 members). Of

the women with HIV test results, 1,075 (12.4%) were HIV-infected; including 9.8%, 12.4%, and 19.4% of women living in food secure, moderately food insecure, and severely food insecure households, respectively ($p < 0.01$).

TABLE 5.1 Sociodemographic characteristics of participants, Zimbabwe, 2012; Women were ≥ 16 years old and mothers of infants (alive or deceased) born 9–18 months prior to the interview^a

Characteristic	Total (N = 8,790)	Household food security status ^b		
		Food secure (n = 4,305)	Moderate food insecurity (n = 2,906)	Severe food insecurity (n = 1,578)
	N (%)	N (%)	N (%)	N (%)
Province				
Harare	1,529 (17.4)	930 (21.6)	439 (15.1)	160 (10.1)
Manicaland	3,564 (40.6)	1,449 (33.7)	1,366 (47.0)	749 (47.5)
Mashonaland Central	1,503 (17.1)	818 (19.0)	504 (17.3)	181 (11.5)
Mashonaland West	1,339 (15.2)	713 (16.6)	413 (14.2)	214 (13.6)
Matabeleland South	855 (9.7)	396 (9.2)	184 (6.3)	275 (17.4)
Age, years (mean, SE)	26.7 (0.09)	26.2 (0.12)	27.0 (0.12)	27.4 (0.21)
Married or has a regular sexual partner	8,152 (92.7)	4,028 (93.6)	2,691 (92.6)	1,432 (90.8)
Education, highest completed				
No education	274 (3.1)	99 (2.3)	123 (4.2)	52 (3.3)
Primary school (Standard 7)	2,458 (28.0)	966 (22.4)	854 (29.4)	638 (40.4)
Some secondary school	2,469 (28.1)	1,120 (26.0)	855 (29.4)	494 (31.3)
“O” Level or more (Grade 11)	3,589 (40.8)	2,120 (49.3)	1,073 (36.9)	396 (25.1)
Ethnicity				
Shona	7,341 (83.5)	3,646 (84.7)	2,516 (86.6)	1,179 (74.7)
Ndebele	586 (6.7)	297 (6.9)	116 (4.0)	172 (10.9)
Kalanga/Other	862 (9.8)	361 (8.4)	274 (9.4)	227 (14.4)
Household size (mean, SE)	5.2 (0.05)	5.0 (0.06)	5.2 (0.05)	5.5 (0.08)
Asset Index (quartile)				
1st (lowest)	2,463 (28.0)	862 (20.0)	874 (30.1)	726 (46.0)
2nd	1,624 (18.5)	748 (17.4)	559 (19.2)	317 (20.1)
3rd	2,022 (23.0)	1,016 (23.6)	687 (23.6)	320 (20.3)
4th (highest)	2,681 (30.5)	1,679 (39.0)	786 (27.1)	216 (13.7)

TABLE 5.1 (Continued)

Characteristic	Total (N = 8,790)	Household food security status ^b		
		Food secure (n = 4,305)	Moderate food insecurity (n = 2,906)	Severe food insecurity (n = 1,578)
		N (%)	N (%)	N (%)
Lifetime births (mean, SE)	2.7 (0.04)	2.4 (0.04)	2.8 (0.04)	3.1 (0.06)
Infant alive	8,726 (99.3)	4,278 (99.4)	2,882 (99.2)	1,565 (99.2)
Infant's age, months (mean, SE) ^c	13.7 (0.04)	13.6 (0.05)	13.7 (0.07)	13.6 (0.08)
Mother HIV-infected	1,075 (12.4)	414 (9.8)	358 (12.4)	304 (19.4)

SE: Linearized standard error.

^aWeighted counts and proportions presented in the table. Numbers may not sum to column totals due to missing data. Percentages may not add to 100 due to rounding.

^bFood security determined from a subset of questions from the Household Food Insecurity Access Scale (HFIAS) [30].

^cAge of infants who were alive as well as the age deceased infants would have been at the time of the survey.

5.3.2 Food Insecurity and Receipt of Maternal Health Services

Food insecurity was inversely associated with use of ANC services, with 95%, 94%, and 92% of women from food secure, moderately food insecure, and severely food insecure households reporting attendance at ≥ 1 ANC visit, respectively ($p < 0.01$, Table 2), although food insecurity was not associated with ≥ 4 ANC visits nor the timing of the first ANC visit. Compared to women from food secure households, women from moderately or severely food insecure households were significantly less likely to know their HIV status during pregnancy or labor and delivery, were significantly less likely to deliver in a health facility, and were less likely to report attending the postnatal visit. Overall, completion of all key steps in the PMTCT cascade was reported by 49% of women from food secure households, 45% of women from moderately food insecure households, and 38% of women from severely food insecure households (adjusted $PR_a = 0.95$, 95% CI: 0.90-1.00 (moderate food insecurity vs. food secure), $PR_a = 0.86$, 95% CI: 0.79, 0.94 (severe food insecurity vs. food secure), adjusted Wald test $p < 0.01$, Table 3). There was no association between food insecurity and completion of the cascade when the analysis was restricted to HIV-infected women.

TABLE 5.2 Food security status and receipt of services in the PMTCT cascade, Zimbabwe, 2012^a

Service	Total (N = 8,790)	Household food security status ^b		
		Food secure (n = 4,305)	Moderate food insecurity (n = 2,906)	Severe food insecurity (n = 1,578)
	N (%)	N (%)	N (%)	N (%)
Antenatal care (ANC)				
Any	8,287 (94.2)	4,091 (95.0)	2,737 (94.3)	1,450 (92.0)**
≥4 visits	5,627 (64.5)	2,801 (65.6)	1,855 (64.3)	971 (62.2)
Gestational age (months) at booking (mean, SE)	5.1 (0.06)	5.1 (0.08)	5.1 (0.06)	5.0 (0.08)
Tested for HIV infection in ANC or labor and delivery (L&D) or knew HIV-infected	8,117 (92.4)	4,043 (93.9)	2,689 (92.5)	1,385 (87.8)**
Health facility delivery	6,747 (76.8)	3,469 (80.6)	2,199 (75.7)	1,079 (68.4)**
Postnatal visit attendance	8,109 (92.4)	4,040 (93.9)	2,647 (91.3)	1,422 (90.1)**
If HIV-infected (n = 1,075):				
Received ART or ARVs	639 (59.5)	242 (58.6)	215 (60.2)	182 (59.9)
Infant prophylaxis	673 (62.9)	250 (61.1)	227 (63.4)	196 (64.7)
Co-trimoxazole prophylaxis	475 (44.2)	184 (44.6)	166 (46.5)	124 (40.9)
Exclusive breastfeeding (ever)	959 (95.3)	364 (95.9)	314 (92.0)	281 (98.3)**
Infant infected	93 (9.0)	33 (8.2)	22 (6.2)	39 (13.3)**
Received all key maternal health services^c	4,027 (45.8)	2,121 (49.3)	1,301 (44.8)	605 (38.3)**
HIV-infected women	299 (27.8)	111 (26.7)	107 (30.0)	82 (26.8)
HIV-uninfected women	3,727 (49.1)	2,011 (52.8)	1,194 (47.4)	523 (41.5)**

SE: Linearized standard error.

Design-based chi-squared p-value: *p < 0.05, **p < 0.01.

^aWeighted counts and proportions presented in the table. Numbers may not sum to column totals due to missing data. Percentages may not add to 100 due to rounding.

^bFood security determined from the responses to a subset of questions from the Household Food Insecurity Access Scale (HFIAS) [30].

^cCompleted at least 4 ANC visits, was tested for HIV infection or already knew HIV-positive serostatus, delivered infant in a health facility, and attended the postnatal visit. Among HIV-infected women, must also have reported maternal and infant ART or ARV prophylaxis and receipt of infant co-trimoxazole prophylaxis.

TABLE 5.3 Association between household food security and completion of services in the PMTCT cascade and MTCT, Zimbabwe, 2012

Household food security status	All women: completion of key PMTCT services ^a				HIV-infected women: MTCT ^b			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	PR	95% CI	PR	95% CI	PR	95% CI	PR	95% CI
Food secure	1	—	1	—	1	—	1	—
Moderate food insecurity	0.91	(0.86, 0.96)**	0.95	(0.90, 1.01)	0.75	(0.46, 1.24)	0.68	(0.43, 1.08)
Severe food insecurity	0.78	(0.70, 0.86)**	0.86	(0.79, 0.94)**	1.62	(1.04, 2.52)*	1.42	(0.89, 2.26)

PR: prevalence ratio; CI: confidence interval.

P-value: * $p < 0.05$, ** $p < 0.01$.

^aRegression model of a weighted sample of 8,655 women. Outcome: combined variable indicating at least 4 ANC visits, tested for HIV infection or already knew HIV-positive serostatus, delivered infant in a health facility, attended the postnatal visit, and among HIV-infected women, report of maternal and infant ART or ARV prophylaxis and receipt of infant co-trimoxazole prophylaxis. Adjusted model includes province, maternal age, whether the woman has a husband or regular partner, education, tribe, religion, household size, building material of the best structure, an asset index created using principal component analysis, and whether the infant was alive at the time of the survey.

^bRegression model of a weighted sample of 1,058 HIV-infected women who had infants with HIV test results. Adjusted model includes province, maternal age, whether the woman has a husband or regular partner, education, tribe, religion, household size, building material of the best structure, an asset index created using principal component analysis, and whether the infant was alive at the time of the survey.

5.3.3 Food Insecurity and MTCT

Food insecurity was not associated with maternal or infant receipt of ART/ARV prophylaxis. However, women living in severely food insecure households were the most likely to have ever exclusively breastfed their infant (98%, vs. 96% of women in food secure and 92% of women in moderately food insecure households, $p < 0.01$). Of HIV-exposed infants, 13.3% of infants from severely food insecure households were HIV-infected compared to 8.2% of infants from food secure households ($PR = 1.62$, 95% CI: 1.04, 2.52, Tables 2 & 3). After adjustment for covariates, this association was attenuated ($PR_a = 1.42$, 95% CI: 0.89, 2.26). There was no increased likelihood of MTCT among women from moderately food insecure households in unadjusted or adjusted analyses ($PR_a = 0.68$, 95% CI: 0.43, 1.08).

5.4 DISCUSSION

In this analysis of women with a recent birth in Zimbabwe, we found that more than half reported living in moderate or severely food insecure households in the month prior to the survey. Compared to women from food secure households, women from food insecure households were more likely to be HIV-infected. Consistent with previous qualitative studies, [49] we found that food insecurity may be an important barrier to uptake of some PMTCT services: in unadjusted analyses, food insecurity was inversely associated with ANC, knowing one's HIV status, facility-based delivery, and postnatal visit attendance. When services were examined together, and after adjustment for covariates, women who reported severe food insecurity were 14% less likely to complete all recommended maternal and infant health services for PMTCT compared to food secure women. Although the effect sizes are modest and absolute differences are small, these findings suggest that among a subgroup of pregnant women, severe food insecurity is an important barrier to some maternal health services.

Among HIV-infected women, we unexpectedly found that there was no association between food insecurity and completion of the PMTCT cascade. This might be due to the small sample size, women's motivation to protect their infant from HIV infection, or nutritional support provided during pregnancy and postpartum that partially mitigates household food insecurity. However, women from severely food insecure households were 42% more likely to have an HIV-infected infant compared to women from food secure households, although this finding was not statistically significant after adjustment for covariates. Although

food security's association with vertical transmission has been speculated, [21,50] this analysis is the first, to our knowledge, to provide empirical data supporting this hypothesis. We must nevertheless interpret these findings with caution because a strong 'dose-response' relationship between food insecurity and MTCT was not observed, as women in moderately food insecure households had the lowest proportions of exclusive breastfeeding and MTCT.

Although we found that food insecurity was associated with ever attending ANC, we found no association between food insecurity and attending the WHO-recommended ≥ 4 ANC visits or the timing of ANC registration. There are several potential explanations for this finding. In facilities that charge a fee, the fees often cover the bundle of services from ANC booking through the 6-week postnatal visit. Thus, once engaged in ANC, women may be retained in the cascade and continue to receive ANC care and deliver at the health facility. Women who don't attend ANC may therefore also be more likely to deliver at home and miss the postnatal visit. Although this study found only small but statistically significant reductions in utilization of each service among women who reported being moderately or severely food insecure, losses from the cascade are additive, as was demonstrated by a cohort study in Cameroon, Côte d'Ivoire, South Africa, and Zambia, where unremarkable levels of attrition of HIV-infected mothers from individual steps in the cascade coupled with poor adherence resulted in 49% of HIV-exposed infants not being protected by a prophylactic ARV regimen [51].

An unanswered question is the pathway(s) through which food insecurity might impede service utilization. It is possible that food insecurity in this analysis is simply a proxy for poverty, and our findings are reflective of the difficult choices food insecure women must make between food (and other goods and services) and the costs associated with health care, including transport and fees. Certainly, food insecurity is highly correlated with socioeconomic position [22,23] and has been shown to be the strongest measure of socio-economic position associated with HIV and HSV-2 risk among young women in Zimbabwe, potentially due to engagement in risk behavior to obtain food or other essential goods and services [52]. This might be the most likely explanation for the inverse association we identified between food insecurity and ANC and other services that require or are perceived to require payment. Although Zimbabwe is moving toward elimination of user fees for maternal and child health services, some facilities still charge a fee that may be cost-prohibitive.

However, this economic explanation does not fully explain the finding that severe food insecurity was not associated with receipt of maternal and infant

ART/ARVs, but may nevertheless be associated with MTCT, although the width of the confidence limits suggests substantial uncertainty in this association. One explanation might be that although both food secure and insecure women and infants were equally likely to receive ART/ARV prophylaxis, women who were food insecure were less likely to adhere to treatment. Food insecurity is known to reduce ART adherence in non-pregnant populations, [27] although this study is not able to test this hypothesis. Another possible explanation is more complex: severe food insecurity increases MTCT risk due to cumulative loss of women from the cascade coupled with an increased risk of MTCT associated with undernutrition [25,26] and the possible increased propensity for mixed feeding [28]. This study was unable to explore more complex patterns of breastfeeding (such as duration of exclusive breastfeeding) to support or refute this hypothesis, and our simple measure of exclusive breastfeeding (ever) found that nearly all women exclusively breastfed at some point. Furthermore, this secondary data analysis used cross-sectional data from a study that was not designed to specifically examine this question, so we do not have prospective data nor information on several causal intermediates, including nutritional indicators such as women's body mass index (BMI) and micronutrient status, to examine these pathways. Nonetheless, these data provide both compelling empirical evidence about these hypothesized relationships and also reveal important gaps for future research.

An important issue when considering these findings is the measurement of food security [53,54]. In this study, household food security was measured in the 4 weeks prior to the survey, a common reference period used by other scales [30,55,56] in order to balance the tradeoffs between recall bias (which favors a shorter recall period) and 'telescoping errors' (a phenomenon associated with short recall periods whereby events outside of the recall window are erroneously reported) [57,58]. We made the essential temporality assumption that a household's recent food security status was highly correlated with its food security status during the woman's pregnancy, 9–18 months prior. The validity of this assumption is unknown; it depends on how much household food access changed over time and season, which was not measured in the survey. Nevertheless, this issue could be overcome in future prospective studies by conducting a simple food security assessment at ANC registration to identify food insecure women who are at risk of both undernutrition and of missing key PMTCT services.

Another key measurement issue is that food security was measured using only part of the HFIAS, a validated scale, which adds some uncertainty to the

classification of food security. Nevertheless, our inclusion of a question from each dimension of food access [30] in addition to the correlation between our parameterization of food security and other dimensions of household socioeconomic position increases confidence in our classification scheme. A strength of our measurement of food security is that women themselves reported household food security status, the individuals who are typically responsible for a household's food supply and meal preparation in Zimbabwe. This is also important because food insecurity at the individual level may be prevalent even in wealthier households due to unequal intra-household allocation of food, which, for example, can result in women eating last or having less access to fats, protein, or micronutrient-rich foods [59-61]. Nevertheless, as with all measures of food insecurity, food security may be subject to underreporting because of its sensitive nature [62].

Our analysis has other important limitations. We used cross-sectional data and therefore cannot make inferences about causation. Further, women self-reported receipt of healthcare services. Moreover, although our data are representative of the communities from which the sample was selected, they are not representative of all regions in Zimbabwe, and it is possible that the relationship between food insecurity and service utilization are different in other parts of the country. In addition, although our strategy to create a sampling frame of 9–18 month old infants in the community was comprehensive, it is possible that some mother-infant pairs were missed. Lastly, women's and infant's HIV status was measured at the time of the survey, 9–18 months postpartum. Although we have assumed that women who were HIV-infected at the time of the survey were also HIV-infected during their pregnancy, it is possible that a small proportion were infected during pregnancy or postpartum. Likewise, infants who were still breastfeeding at the time of the survey remained at risk of MTCT, so we may not have captured all possible infant infections.

5.5 CONCLUSIONS

This analysis is the first to our knowledge to examine the association between food insecurity and receipt of services in the PMTCT cascade. Our findings suggest that severe food insecurity may impede the receipt of some services among pregnant and postpartum women and may influence MTCT; these relationships will need to be confirmed by other prospective observational studies. In addition, the growing body of studies that examine the effect of food and cash

transfers as a mechanism to mitigate food insecurity and improve HIV-related outcomes [63,64] will also contribute to understanding these relationships, including whether food assistance programs have unexpected spillover benefits on maternal and child health. Regardless of its effect on MTCT, the high prevalence of food insecurity among women with a recent birth in Zimbabwe provides additional support for integrated food and nutrition programs for pregnant women.

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A Pre-Post Pilot Study of Peer Nutritional Counseling and Food Insecurity and Nutritional Outcomes among Antiretroviral Therapy Patients in Honduras

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6.1 BACKGROUND

Food insecurity, defined as “the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways” [1], and its resultant adverse effects on nutritional status represent important negative influences on HIV outcomes in low-resource settings [2–5]. Studies have found that food insecurity is associated with poor adherence to anti-retroviral therapy (ART) in both resource-poor regions [4, 6–8], as well as among vulnerable populations in resource-rich settings [9–12]. Because of the link among food insecurity, poor nutritional status, and adverse HIV outcomes, the World Health Organization (WHO) recommends that

interventions to promote initiation of and adherence to ART include attention to a sufficient and balanced diet [13]. Research as to how to provide a healthy diet among PLHIV has identified several approaches: nutrition supplementation (e.g., specialized foods) with or without nutritional education/counseling; safety nets such as food, cash transfer or vouchers; and livelihood interventions such as small scale agriculture, livestock or sewing [14]. These interventions—especially those providing food assistance—have been found to promote positive effects on nutrition status, quality of life, retention in care, adherence to treatment, and household food security among PLHIV [14, 15]. However, recent research has highlighted that nutrition education and counseling remain weak components of nutritional interventions for PLHIV [14].

Integrating nutrition education and counseling into ART treatment programs is constrained by human capital considerations. Most reported studies of nutritional counseling interventions for PLHIV have relied on professional staff [16–20] and this type of support is limited in low-resource settings. Trained community health workers represent a possible solution. Not only can such an approach contain the cost of delivering nutritional support, but it also offers the linguistic, cultural, and community-building skills to establish rapport with PLHIV. There has been some research into this means of supporting PLHIV: e.g., peer health workers in several countries have been found to be effective in reducing stigma, improving retention in care, and improving quality and outcomes of HIV care [21–26]. However, we are unaware of any reports of the effectiveness of *peer nutritional* counselors among PLHIV.

Here we examine the feasibility and preliminary effectiveness of a nutritional counseling intervention for PLHIV that was adapted for and delivered by peer counselors in Honduras. Specifically, we examined changes between pre- and post-intervention measures of nutritional knowledge, food insecurity, and dietary quality among people receiving ART. Anthropometric measures were also taken to examine any changes pre- and post-intervention to nutritional status, although funding limitations necessitated a short follow-up period, and thus made these secondary outcomes.

6.2 METHODS

6.2.1 Contextual Background

The study took place within an on-going collaboration between RAND (a non-profit research organization), the United Nations World Food Program

(WFP) in Latin America, the Honduran Ministry of Health, and the Honduran National Association of People Living with HIV/AIDS [or *Asociación Nacional de Personas Viviendo con VIH/SIDA en Honduras* (ASONAPVSIHA)]. This collaboration was formed to evaluate the role that food aid and nutrition counseling played in supporting HIV care retention, uptake of ART and adherence, and selected clinical outcomes [16]. Specifically, an NIMH-funded parent study used a cluster randomized controlled trial design to compare the effects of a monthly household food basket plus nutrition education versus nutrition education alone on ART adherence of HIV patients at four Comprehensive Treatment Centers in Honduras (referred to here as “HIV clinics”). Nutrition education in the parent study was provided by professional nutritionists who were trained in HIV-related nutritional issues by the study investigators. Although political will existed to extend nutritional counseling at all 38 of the nation’s HIV clinics, limited financial and human capital resources made this goal difficult to attain. For example, there was no nutrition training program in the country when the parent study began. Thus, a supplemental pilot study was designed to train peer counselors to provide the nutritional counseling, enabling the scale up of counseling across a larger number of the country’s HIV clinics. Although the pilot study was modest in scope (pre- and post- study design with no control group and no randomization, limited measures collected and brief follow-up period), we believe it can make an important contribution given the lack of such interventions in the literature and the need for scalable solutions.

6.2.2 Ethics Statement

The study was approved by RAND’s Human Subjects Protection Committee and the Institutional Review Board at the National Autonomous University of Honduras. Written informed consent was obtained from all participants.

6.2.3 Study Design

Fourteen government-run HIV clinics were chosen for the counseling extension project, as these represented the most HIV-affected areas in the country. The clinics provided care to nearly 80 % of patients receiving ART in Honduras, and were in geographical proximity to the four study clinics in the parent study, which served as training centers. One or two peer counselors from each center were trained in how to administer the counseling intervention as well as study

assessments (anthropometry, nutritional knowledge, dietary intake, food insecurity). All patients receiving ART at each of the 14 clinics over the course of one month were offered the peer nutrition counseling (i.e., there was no randomization); those who provided informed consent to participate in the study were assessed at baseline and 2 months post-baseline, with counseling offered monthly during the study period. This brief follow-up period was necessitated by funding limitations and the parent grant's timeline, though was also considered to be sufficient time to observe change in the more proximate outcomes (e.g., nutritional knowledge and dietary behaviors, including frequency of meals, and dietary diversity).

6.2.4 Theoretical Background

Our nutritional counseling intervention is based on the information-motivation-behavioral skills model [27, 28]. Specifically, we expected that culturally, locally, and HIV appropriate nutrition education would improve nutritional knowledge and dietary intake, which in turn would support a healthy nutritional status and minimize side effects of HIV and ART, such as nausea, diarrhea, oral ulcers, etc. We also expected that locally tailored nutritional education could reduce household food insecurity through improved diet quality, the ability to make the most of existing food resources, and decreased anxiety about procuring healthy food [29, 30]. Finally, we expected that the nutritional counseling would be reinforced and made even more salient when delivered by peer counselors, who are in similar circumstances (i.e., living with HIV and on ART) and can relate to participants' experiences.

6.2.5 Nutritional Counseling Intervention

A nutrition education curriculum with supportive visual aids and a reference technical manual were developed for use by professional nutritionists in the parent study after extensive formative research on locally available foods and dietary patterns among people living with HIV [16]. For the peer counselors, a simplified version of the training manual was developed and supported by educational materials such as flip charts, brochures, and pocket-sized cards meant to reinforce session content. The nutrition education curriculum was based on the WHO/FAO Manual on Nutritional Care and Support for People Living with HIV/AIDS [13, 31] and our formative research, and covered 5 basic topics

using concepts and language familiar to this population: 1) consuming a balanced diet; 2) food groups; 3) increasing vitamin and mineral intake through a varied diet; 4) food safety; and 5) how to deal with co-morbidities (diarrhea, acute respiratory infection, nausea, mouth sores, loss of appetite). For example, one way that the curriculum translated complex nutritional information into more understandable constructs is reflected in the conceptualization of different “food groups”: 1) *alimentos constructores* (building foods, or protein); 2) *alimentos energéticos* (energy foods or carbohydrates and fat); and 3) *alimentos reguladores* (regulating foods or vitamins and minerals) Further, given the setting and the generally low-income population, the curriculum promoted the most affordable, locally available food and culturally appealing ways to prepare them.

Peer counselors were selected from each of the communities where the HIV clinics were located in collaboration with the Ministry of Health and ASONAPVSI DAH, using the following criteria: HIV status (all peer counselors were HIV positive, ART patients); age 18+ years; completion of middle-school; full time availability for the training and project activities, and demonstrated leadership capability. Over a two-month period, peer counselors received 290 h of training (intensive workshop and practical training in one of the parent grant’s 4 study clinics—see Table 1 for training topics). Thirty-seven lay workers participated in the workshop training; 20 scored at least 75 % correct during the post-workshop assessments and were invited to participate in the practical training under supervision of the parent grant nutritionists; of these 17 were approved as certified Peer Nutritional Counselors, based on their performance during training. Certification was issued by the Honduran Ministry of Health, WFP and RAND, and was meant to help these workers be considered for future jobs once the project was completed. The peer nutritional counselors were paid for all their time on this project, including training, practicum, and implementation of the pilot.

Each peer nutritional counselor worked out of their local HIV clinic, in a private working space. Participants were recruited through referrals from medical and nursing staff and from the clinic waiting room. Once informed consent was granted, the counselor collected baseline information (survey and anthropometric measurements), delivered the nutritional counseling, and scheduled a date for a follow-up visit in one month, coinciding with the regular monthly visit to the clinic required to retrieve HIV medications. The nutritional counseling, which usually lasted an hour, was tailored to each individual, was highly participatory, and encouraged participants to share concerns about eating and learn about where to obtain certain foods and how to prepare them. The peer

counselor shared his/her own experience about how eating a better diet had helped him/her have a better quality of life.

TABLE 6.1 Overview of training provided to peer nutrition counselors

Training Settings	Total Hours	Topics covered
5 day intensive workshop	50	1 Nutrition and healthy eating
		2 HIV, nutrition and food security
		3 ART and adherence
		4 How to manage secondary effects of ART through diet
		5 Anthropometry and dietary assessment
Practical training in “Centro de Atención Integral”	240	1 How to deliver nutritional counseling
		2 How to use supportive educational materials
		3 How to administer evaluation questionnaires (food frequency recall, anthropometry)

6.2.6 Outcomes

Food insecurity was assessed using the validated Latin American and Caribbean Food Security Scale (ELCSA), which captures experiences of household food security over a specified time period (we used previous month for this pilot study), including food quantity and sufficiency, food quality and safety, and anxiety about food supplies [32]. Respondents with children <18 in the household are asked the full 15-item scale; respondents without children are asked the 8-item version of the scale. All questions received “yes” or “no” answers; raw scores were then tabulated as the sum of affirmative answers, with higher scores indicating higher levels of food insecurity. To maximize data in this intervention pilot, we calculated one food insecurity score (on a scale of 0–8) for all respondents and a separate food insecurity score (on a scale of 0–15) for those with children.

Nutritional knowledge was assessed through 13 “true/false” statements that were based on key concepts from the nutrition education curriculum such as the importance of eating a variety of food groups, foods that address anemia, and foods that prevent (and address) constipation and diarrhea. Correctly answered items summed to create a score from 0 (no items answered correctly) to 13 (all items answered correctly).

Dietary intake was assessed using a 24 h qualitative recall. Given the focus of the nutrition education curriculum on increasing the frequency of meals and

diversity of food types consumed, supervising nutritionists coded the dietary data for each participant to indicate: 1) the number of times participants reported having eaten in the last 24 h; and 2) the number of different food types consumed at each meal (*energéticos* or carbohydrates and fat, *constructores* or protein, and *reguladores* or vitamins and minerals) to create a measure of dietary diversity.

Nutritional status was assessed using Body Mass Index (BMI) and mid-arm and waist circumference measurements taken by the peer counselors, who were trained by the parent grant nutritionists and standardized according to accepted methods [33]. For descriptive statistics, we use World Health Organization classifications of underweight (<18.5), normal (18.5 to 24.9), overweight (25.0 to 29.9), and obese (≥ 30) [34].

6.2.7 Covariates

Socio-demographic characteristics included gender, age, household size, whether the participant had completed at least primary level education, and whether the participant currently had paid work (yes/no).

6.2.8 Analysis

We conducted descriptive analyses to characterize the sample and then multi-variable linear regression analysis examining pre- and post-intervention changes (comparing baseline and 2 month follow-up) in food insecurity, nutritional knowledge, dietary intake (number of times eaten and diversity of diet), and nutritional status (BMI and mid-arm and waist circumference), while controlling for baseline characteristics that could potentially confound the outcomes, including gender, age, education, and work status. Random effects were used to control for the correlations between repeated measures for each participant and the clustering of participants within each clinic. Among 482 participants at baseline, we had follow-up data for 364 (76 %). Of these, 8 were missing data on covariates used in the analyses, thus the final analytic sample was 356 adults. We did not have data on adherence to the nutritional counseling, thus the results represent an intention to treat analysis. We fitted the proposed model using the restricted maximum likelihood, which is a consistent estimator under the missing at random assumption. This approach is particular suitable when most missing data cases are in the outcome variables.

6.3 RESULTS

6.3.1 Baseline Characteristics

Table 2 summarizes the socio-demographic characteristics and primary outcomes for the sample at baseline, first among the final analytic sample (n=356) and then among those who dropped out or were missing data (n=126). Most of those in the analytic sample were women (62 %), Mestizo (85 %), and had at least a primary level education (52 %), a median age of 40 years, and a mean household size of 4 people. Labor force participation was generally low, especially among women (22 % reported currently working compared to 53 % of men). Study dropouts were generally similar to the analytic sample, but had a smaller percentage of completely primary level education (45 %), and a BMI distribution more skewed to the left (i.e. towards lower BMI).

TABLE 6.2 Participants’ socio-demographic characteristics and baseline measures of study outcomes (n = 356)

Characteristics	Study Completers			Study Dropouts
	Women (n=220)	Men (n=136)	All (n=356)	All (n=126)
Female, %	..	..	61.8	61.2
Ethnic group, %				
Indigenous	2.8	0.8	2.0	1.2
Mestizo	81.6	90.2	84.9	90.5
Afro descendants	14.8	9.0	12.6	8.3
Other/Don’t know/Not stated	0.8	0.0	0.5	0.0
Median age [IQR]	39.0 [16.0]	38.0 [15.0]	40.0 [15.0]	39.0 [15.0]
Median household size, n [IQR]	4.0 [2.5]	4.0 [3.0]	4.0 [2.5]	4.0 [2.7]
Actually has work, %	22.3	52.9	34.0	35.7
Completed primary level education, %	46.8	61.0	52.2	44.6
Baseline measures of study outcomes				
Median 8-item food insecurity score ^a [IQR]	6.0 [5.0]	6.0 [5.0]	6.0 [5.0]	6.0 [5.0]
Median 15-item food insecurity score ^a [IQR]	11.0 [9.0]	8.0 [10.0]	9.5 [8.0]	10.0 [8.0]
Median nutritional knowledge score [IQR]	11.0 [2.0]	11.0 [2.0]	11.0 [2.0]	11.0 [4.0]
Median # times ate in past 24 hours [IQR]	3.0 [1.0]	4.0 [1.0]	4.0 [1.0]	3.5 [1.0]
Median # food types at meals (past 24 hrs) [IQR]	2.0 [2.0]	2.0 [1.0]	2.0 [2.0]	2.0 [2.0]

TABLE 6.2 (Continued)

Characteristics	Study Completers			Study Dropouts
	Women (n=220)	Men (n=136)	All (n=356)	All (n=126)
Median Body Mass Index [IQR]	23.4 [7.1]	21.6 [5.4]	22.5 [6.6]	21.3 [6.1]
Underweight (<18.5), %	7.3	10.3	8.4	21.4
Normal (18.5-24.9), %	49.1	61.8	54.0	51.8
Overweight (25.0-29.9), %	26.4	19.9	23.9	17.0
Obese (30.0+), %	17.3	8.1	13.8	9.8
Median mid-arm [IQR]	27.0 [6.1]	27.0 [4.0]	27.0 [5.6]	26.0 [4.1]
Median Waist circumference [IQR]	85.0 [17.0]	80.2 [14.0]	83.0 [16.0]	83.0 [16.0]

*All participants were asked the 8-item household food insecurity scale. Only those who had children under 18 living in the household were asked the additional 7 items on children and thus are included under the 15-item food insecurity measure.

In terms of outcomes, levels of food insecurity were generally high, with a median of 6 on the 8-item scale and 9 on the 15-item scale, both indicating “moderate” food insecurity. Nutritional knowledge was also generally high, with a median of 11 correctly answered items out of 13. Median number of times eaten in past 24 h was 4 and median number of food types eaten per meal in past 24 h was 2. Median BMI was 23 kg/m², while median arm and waist circumferences were 27.4 cm and 83.5 cm, respectively.

6.3.2 Multivariable Regression Analyses (Table 3)

Household food insecurity decreased on average between baseline and follow-up among all participants (n = 356, 8-item scale, $\beta = -0.47, p < .05$) and among those with children under 18 (n = 303, 15-item scale, $\beta = -1.16, p < .01$). Not working currently was associated with greater food insecurity on both scales ($\beta = 0.48, p < .05$ and $\beta = 1.26, p < .01$, respectively), as was not having completed a primary school education ($\beta = 0.95, p < .001$ and $\beta = 2.14, p < .001$, respectively).

Nutritional knowledge also improved between baseline and follow-up ($\beta = 0.88, p < .001$). Not having completed a primary school education was associated with lower nutritional knowledge ($\beta = -0.25, p < .05$).

Dietary intake improved in terms of the number of times participants ate in the past 24 h ($\beta = 0.30, p < .001$) and the average number of different types

TABLE 6.3 Pre-and post-intervention changes in food insecurity and nutritional outcomes[‡]

Variable	Food insecurity (8 items)	Food insecurity (15 items)	Nutritional knowledge (13 items)	# eating occasions in past 24h	# food types at each meal (24h)	BMI	Mid arm circum.	Waist circum.
	N=356	N=303	N=356	N=364	N=364	N=356	N=356	N=356
Nutritional counseling treatment	-0.47 (0.19)[*]	-1.16 (0.40)^{**}	0.88 (0.11)^{***}	0.30 (0.07)^{***}	0.15 (0.04)^{***}	-0.30 (0.38)	-0.10 (0.40)	-1.46 (0.84)
Female gender	0.20 (0.32)	0.49 (0.71)	0.25 (0.17)	0.03 (0.08)	-0.16 (0.06)[*]	1.42 (0.42)^{***}	-0.69 (0.63)	1.60 (0.94)
Age	-0.01 (0.01)	0.00 (0.02)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.03 (0.02)	0.04 (0.02)[*]	0.12 (0.04)^{**}
Household size	-0.03 (0.04)	0.04 (0.08)	0.00 (0.02)	0.01 (0.01)	0.01 (0.01)	0.14 (0.08)	0.13 (0.08)	0.48 (0.17)^{**}
Not working	0.48 (0.23)[*]	1.26 (0.47)^{**}	-0.22 (0.13)	-0.16 (0.08)	-0.04 (0.05)	0.42 (0.45)	0.56 (0.47)	0.84 (0.99)
Less than completed primary ed.	0.95 (0.20)^{***}	2.14 (0.41)^{***}	-0.25 (0.11)[*]	-0.18 (0.07)[*]	-0.12 (0.04)^{**}	-0.59 (0.40)	-0.26 (0.42)	-1.15 (0.88)

*** p<.001;

** p<.01;

* p<.05

[‡]Nutritional counseling treatment and covariate effects were estimated by mixed-effect linear regression models adjusted for within-participant correlations and fitted by restricted maximum likelihood estimators.

of foods consumed at each meal ($\beta = 0.15$, $p < .001$). Less than complete primary education was associated with worse dietary intake on these two measures ($\beta = -0.18$, $p < .05$ and $\beta = -0.12$, $p < .01$, respectively).

Nutritional status as measured by BMI and mid-arm and waist circumferences showed no significant changes between baseline and 2 month follow-up. Female gender was associated with higher BMI ($\beta = 1.42$, $p < .001$) and age was associated with higher mid-arm and waist circumferences ($\beta = 0.04$, $p < .05$ and $\beta = 0.12$, $p < .01$, respectively). Larger household size was also associated with higher waist circumference ($\beta = 0.48$, $p < .01$).

6.4 DISCUSSION

A culturally and locally appropriate nutritional counseling intervention delivered by peer counselors was significantly associated with improved nutritional knowledge and dietary intake (diversity and frequency) among PLHIV in Honduras. Furthermore, even after controlling for other indicators of socioeconomic status, the intervention was significantly associated with improved food security. The results fill an important gap in evidence addressing the need for effective, sustainable nutrition education and counseling interventions for PLHIV in resource-limited settings [30]. To our knowledge, ours is the first study to demonstrate that a peer-delivered nutritional counseling intervention for PLHIV in resource-limited settings may improve dietary quality and reduce food insecurity among a population of diverse nutritional statuses (underweight, normal weight, and overweight and obese individuals).

The finding that peer nutrition education was associated with improved food insecurity is especially notable given the persistent negative effects of food insecurity on ART adherence [35] and subsequent immunologic and virologic outcomes [36, 37], as well as its association with higher morbidity [3] and mortality among PLHIV [38, 39]. Our counseling intervention focused not only on how to obtain good nutrition using locally available foods but also how to make the most of existing resources for food, which may have decreased food insecurity. The fact that peers delivered the counseling, sharing from their own experiences, likely made the strategies even more salient. The parent grant, which used randomization to assign individuals to study groups, found that nutritional education (both alone and in concert with a monthly household food basket), when delivered by trained nutritionists, significantly improved food security [40] and adherence across three adherence outcomes (missed clinic appointments, delayed prescription refills, and self-reported missed doses of ART)

[16]. Additional research is needed to determine if peer-delivered nutritional counseling can improve adherence among people on ART.

Peer nutritional education may be especially important in low-resource settings with high prevalence of overweight and obesity among food insecure PLHIV. The parent study found that nutrition education delivered by trained nutritionists significantly improved weight, with overweight and obese patients at baseline *losing* weight and underweight and normal weight patients *gaining* weight over the 12 month follow-up [40]. However, when evaluating the addition of food support to nutritional education, food support had the undesired effect of increasing weight significantly among already overweight and obese patients [40]. Further, food supplementation or aid is usually not sustainable in the long-term and thus may fail to address upstream and downstream health consequences [41]. Thus, a nutritional counseling intervention, in addition to being more scalable and sustainable than food support (particularly when delivered by peer counselors), might be more universally appropriate across settings where wasting or underweight is not the primary concern. Indeed, overweight and obesity among PLHIV is of increasing concern across multiple settings and in particular among those on ART, which can lead to increased risk of other chronic conditions including diabetes and cardiovascular disease [42, 43].

Our study had several limitations. The short follow-up period limited our ability to assess effects of the peer nutritional counseling on nutritional status (BMI, body circumferences) and ART adherence. Further, although dropouts and the analytic sample were similar in observed characteristics, we do not know whether the dropouts were systematically different from study completers in unobserved characteristics (such as morbidity or mortality); if so, this could result in selection bias and affect the estimated effects. Finally, our study is based on a pre-post comparison with only one study arm, thus we are unable to control for any secular trend in outcomes unrelated to the peer nutritional counseling. However, given the relatively short study period, it is unlikely that any such secular trend occurred.

6.5 CONCLUSIONS

Addressing the nutritional needs and food security of PLHIV with feasible, evidence-based, locally-tailored approaches is essential to sustainably improve HIV outcomes. The nutritional education model presented in this paper provides an

example of how training peer leaders to deliver HIV-specific nutritional counseling may improve key nutritional outcomes using readily available human capital. This approach has the potential to increase scalability and cultural relevance compared to approaches that rely on professional nutritionists. Our study fills a key gap in the literature on nutrition education and counseling interventions for PLHIV in resource-limited settings and future studies should rigorously test the effectiveness of peer-led nutritional education models on ART adherence and HIV outcomes.

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Relationship between Food Insecurity and Mortality among HIV-Positive Injection Drug Users Receiving Antiretroviral Therapy in British Columbia, Canada

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7.1 INTRODUCTION

Despite the tremendous benefits of antiretroviral therapy (ART) use on HIV disease progression and survival [1], [2], micro- and macronutrient malnutrition remain strong independent predictors of mortality among HIV-positive individuals in both high and low resource settings [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13]. A growing body of evidence suggests that socioeconomic determinants may also adversely impact survival among people living with HIV/AIDS [14], [15]. More recently, our study team found that among HIV-positive individuals receiving ART in Canada, being food insecure and

underweight was independently associated with a 1.94 increased risk of non-accidental death, compared to being food secure and of normal weight [16]. Poor dietary diversity, a component of food insecurity, has been associated with mortality among ART-naïve individuals in Uganda [17]. These studies suggest that food insecurity warrants prioritization by public health programs and policies for HIV-infected populations.

Illicit drug use is a well-known risk factor for food insecurity and poor nutritional status. Drug addiction alters dietary consumption patterns, leading individuals to eat fewer meals [18], to often skip meals for an entire day [19], and to rely on food distribution services for subsistence [20]. Studies have found that the diets of illicit drug users tend to be calorically insufficient and poor in quality [18], resulting in diverse micro- and macronutrient deficiencies [19], [21], [22], [23], [24]. Food insecurity is theorized to be linked to adverse HIV outcomes through distinct nutritional, mental health and behavioral pathways [25]. Studies in urban HIV-positive populations receiving HIV treatment, including a high proportion of illicit drug users, have found that food insecurity is associated with HIV-related wasting [19], virologic non-suppression [26], [27] and poor immunologic response to ART [27], [28], [29].

To our knowledge, no studies have examined whether food insecurity increases risk of excess death in this population. This study therefore aimed to assess the potential relationship between food insecurity and all-cause mortality among HIV-positive injection drug users (IDU) initiating ART across BC. In light of previous findings regarding the relationship between food insecurity and mortality in the general HIV-population in this setting [16], and theorized nutritional mechanisms linking these [25], this study hypothesized that food insecurity is independently associated with all-cause mortality.

7.2 METHODS

7.2.1 Study Sample: HIV/AIDS Drug Treatment Program (DTP)

Survey data for this analysis were obtained from the provincial HIV/AIDS Drug Treatment Program (DTP) administrative database. In BC, antiretrovirals have been distributed free of charge to HIV-positive individuals since 1986, and coordinated centrally since 1992 by the British Columbia Centre for Excellence in HIV/AIDS (BC-CfE) HIV/AIDS DTP, located at St. Paul's Hospital in Vancouver. Details of the HIV/AIDS DTP have been described elsewhere [1].

In brief, clinical eligibility for receipt of ART in BC is based on guidelines generated by the BC-CfE Therapeutic Guidelines Committee, and have remained consistent with current recommendations by the International AIDS Society – USA since 1996 [30]. Currently, the most frequently prescribed initial triple combination ART regimens in BC consist of a nucleoside reverse transcriptase inhibitor (NRTI) and a nucleotide reverse transcriptase inhibitor or two NRTIs as a backbone, plus either i) a non-nucleoside reverse transcriptase inhibitor (NNRTI), or ii) a protease inhibitor boosted with ritonavir (boosted PI) [31].

Prescribing physicians must complete a drug request form, which acts as a legal prescription, to enroll an eligible individual on ART. HIV/AIDS DTP enrollment forms elicit information about patient socio-demographics, HIV-specific drug history, CD4 cell counts, plasma HIV RNA levels, current drug prescription, and the enrolling physician. Prospective clinical, virologic, immunologic and drug-regimen data are collected on a quarterly basis. Epidemiological studies performed on DTP data form the basis of ongoing revisions to the BC-CfE's province-wide HIV treatment guidelines [31]. Patients provide voluntary written informed consent for the BC-CfE to access electronic medical records for research purposes. Ethical approval for these analyses has been provided by the Providence Health Care/University of British Columbia Research Ethics Board.

7.2.2 Variable Selection

The primary outcome variable of interest was all-cause mortality. This outcome includes individuals who died due to HIV/AIDS-related and non-related causes, including co-morbidities, injuries, accidents, trauma, assaults, drug overdose and suicide. Mortality data was collected on an ongoing basis through physician reports. This data was confirmed through electronic linkage to the British Columbia Division of Vital Statistics registry, which has been shown to capture upwards of 96% of all deaths in the province [32]. Study participants and individuals lost to follow-up were censored on Sept 30, 2011.

7.2.2.1 Primary Explanatory Variable.

The primary explanatory variable of interest was food insecurity, captured cross-sectionally at baseline in 1998/1999 as part of the DTP enrollment form for participants newly initiating ART. Food insecurity was measured using an

abbreviated version of the Radimer/Cornell scale. The Radimer/Cornell scale assumes that food insecurity comprises four distinct components that are experienced distinctly at household and individual levels. The scale poses questions regarding food depletion and intake (quantitative component), suitability and adequacy of food (qualitative component), feelings of anxiety and deprivation associated with food (psychological component), and patterns of food acquisition and eating (social component) [33], [34], and has been extensively validated in North America [33], [35]. Since the Radimer/Cornell scale was published in 1990, operational definitions and measurements of food insecurity have continued to evolve [36], [37]. The Radimer/Cornell scale understood ‘hunger’ to be a quantitative component of food insecurity, experienced purely at the individual level [33], [34], and defined as an “inability to acquire or consume an adequate quality or sufficient quantity of food in socially acceptable ways, or the uncertainty that one will be able to do so” [36]. A 2006 review of food insecurity and hunger measures by an expert panel for the United States Department of Agriculture (USDA) concluded that hunger should be considered an “indicator and possible consequence of food insecurity,” and be measured “distinct from, but in the context of, food insecurity” [37]. Conceptual research in the field of HIV/AIDS further emphasizes the need for multi-dimensional indicators to capture different dimensions (utilization, access, availability, stability) of food insecurity, and for stand-alone indicators to measure sub-components of food insecurity (quantity, quality, safety). Reconsideration of how food insecurity is measured is required to capture the complex experiences of food insecurity among people living with HIV/AIDS, to generate ‘actionable’ findings for public health programs and policies [38].

The analytic approach to measuring food insecurity and hunger in this study diverged from Radimer/Cornell’s and USDA’s published methodologies [33], [39]. Participants were categorized as experiencing household food insecurity if they gave a minimum of one positive answer (often/sometimes) to any one of the eight items measuring household food insecurity, which provided a conservative estimate of food insecurity. In the absence of a validated single-question measure of hunger to ascertain food insufficiency at the individual level [37], [38], and in light of public health policy and program requests in our setting to understand what sub-component (quantity, quality, safety) of food insecurity may be driving associations between food insecurity and adverse health outcomes, we extracted and analyzed hunger at the individual level, defined as responding ‘often/sometimes’ to the question: “I am often hungry, but don’t eat because I can’t afford enough food” [33], [34].

7.2.2.2 Secondary Explanatory Variables.

Secondary explanatory variables hypothesized to confound the relationship between food insecurity and mortality were selected based on findings from previous literature, including a previous study examining the impacts of food insecurity on mortality among HIV-positive individuals in this setting [16]. Socio-demographic variables included: age at ART start date (continuous); gender (male vs. female); Aboriginal ancestry (yes vs. no); annual income ($>$ CAD\$15,000 vs. $\leq$ CAD\$15,000), with a dichotomous split based on Canada Revenue Agency's low income threshold [40]; education ($>$ high school vs. $\leq$ high school graduation); and unstable housing (yes vs. no), defined as living in a hotel, boarding house, group home, jail, on the street, or having no fixed address at the time of the survey. Clinical variables considered in this analysis included nutritional status, measured by physician and self-reported body mass index (BMI) (kg/m^2) and calculated using the formula: $\text{weight}/(\text{height})^2$. Cut-offs for underweight status were based on current WHO standards for HIV-positive individuals, defined as $<18.5 \text{ kg}/\text{m}^2$ (underweight) vs. $\geq 18.5 \text{ kg}/\text{m}^2$ (not underweight) [41]. BMI reflects lean body mass and fat mass, has been shown to detect malnutrition at an earlier stage than other anthropometric measures, and is considered a sensitive screening tool for malnutrition among people living with HIV/AIDS [42]. Other clinical variables included use of triple combination highly active antiretroviral therapy (HAART) (yes vs. no); PI-based regimen (yes vs. no); AIDS diagnosis (yes vs. no), defined according to CDC classification [43]; plasma HIV RNA viral load (per $\log_{10}$ copies/mL), measured at most recent date prior to survey; CD4 cell counts (per 100 cells/ μL), recorded at most recent date prior to survey using flow cytometry and fluorescent monoclonal antibody analysis (Beckman Coulter, Inc., Mississauga, Ontario, Canada); and finally ART adherence, measured on the basis of prescription refill compliance [44], defined as the number of days ART was dispensed over the number of days an individual was eligible for ART in the past 12 months ($\geq 95\%$ vs. $<95\%$), at most recent date prior to survey. This adherence variable has shown to reliably predict survival among IDU in previous studies [44], [45]. All potential explanatory variables were collected at baseline in 1998/1999 from the HIV/AIDS DTP enrollment survey, except where indicated above.

7.2.3 Statistical Analysis

As a first step, bivariate analyses were performed on the entire study sample at baseline, stratified by food insecurity, hunger and all-cause mortality, respectively. Pearson's Chi-Square tests were used to compare categorical variables. In instances where counts were small (five or less), the Fisher's Exact Test was used. Continuous variables were compared using Wilcoxon Rank Sum Test. Next, two Cox proportional hazard confounder models were constructed to determine the association between food insecurity/hunger and all-cause mortality, controlling for potential confounders. A multivariate model was built using an adaptation of methods described by Greenland and colleagues [46], [47]. This manual backward stepwise approach involved first fitting a full model, including all explanatory variables, and noting the value of the coefficient associated with food insecurity/hunger. Reduced models were then constructed, each removing one secondary explanatory variable from the full set. Comparing the value of the coefficient for food insecurity in the full model and each of the reduced models, secondary variables were removed corresponding to the smallest relative change in the coefficient for food insecurity. This iterative process continued until the maximum change of the value for food insecurity from the full model exceeded 5%. The intent of this model building strategy was to retain secondary variables in the final multivariate model with greater relative influence on the relationship between food insecurity and mortality. This technique has been previously applied in studies of HIV-positive individuals to estimate the independent relationship between a hypothesized predictor variable and clinical outcome [48], [49]. As a sub-analysis, this process was repeated to examine the relationship between hunger and mortality. Ad hoc tests to assess potential cohort effects on survival were not deemed necessary since participants were all recruited after the introduction of ART, which led to a homogenous trend in reductions of HIV-related mortality over time [50]. All statistical analyses were completed using R v2.10.1 (R Foundation, Vienna, Austria).

7.3 RESULTS

Baseline characteristics of IDU enrolled in the BC-wide HIV/AIDS DTP in years 1998/1999, stratified by food security status, are shown in Table 1. A total of 254 individuals enrolled at baseline, responded to the food security scale question in the survey, and had consistent follow-up during the years under study. Of this analytic sample, 181 (71.26%) reported being food insecure, and 108

(42.5%) were hungry; the median age was 38.0 years [interquartile range [IQR]: 34.0–43.0]; 211 (83.07%) were male; 58 (22.9%) reported Aboriginal ancestry; and 219 (96.9%) had a BMI above 18.5 kg/m². The median CD4 cell count was 380.0 per 100 cells/ μ L (IQR: 220.0–510.0); the median viral load was 2.6 log₁₀ copies/mL (IQR: 2.6–3.7); 63 (24.8%) were diagnosed with AIDS; and 123 (48.4%) were $\geq$ 95% adherent to ART in the 12 months preceding enrollment. During the study period (between June 21, 1998 and Sept 30, 2011), a total of 105 (41.34%) individuals died. Bivariate comparison of participant characteristics by food security status revealed that individuals with lower incomes, receiving a protease inhibitor (PI)-based regimen, and initiating ART at a later year, were all significantly more likely to be food insecure ($p < 0.05$). Median follow-up time was 140.61 months (IQR: 59.63–151.20), and median survival time was 61.04 (IQR: 31.11–83.02). A total of 87 (48.1%) individuals who reported being food insecure died over the study period, compared to 18 (24.7%) individuals who reported being food secure ($p = 0.001$). A total of 54 (51.4%) individuals reporting hunger died, compared to 54 (36.2%) reporting no hunger ($p = 0.022$). Product limit survival estimates revealed that the death rate of the 254 IDU who answered the food security and hunger questions on the baseline survey did not differ from other IDU initiating ART during the same time period.

TABLE 7.1 Baseline characteristics among HIV-positive injection drug users initiating antiretroviral therapy across British Columbia, by food security status, between June 1998 and Sept 2011 (n=254).

Characteristic	Total N (%)	Food Insecure 181 (71.3%)	Food Secure 73 (28.7%)	p - value
Age				
Median, IQR ¹	38.0 (34.0–43.0)	38.0 (34.0–43.0)	38.0 (34.0–43.0)	0.933
Gender				
Male	211 (83.1%)	148 (81.8%)	63 (86.3%)	0.492
Female	43 (16.9%)	33 (18.2%)	10 (13.7%)	
Aboriginal ancestry				
Yes	58 (22.9%)	45 (25.0%)	13 (17.8%)	0.286
No	195 (77.1%)	135 (75.0%)	60 (82.2%)	
Unstable housing				
Yes	28 (11.8%)	21 (12.2%)	7 (10.8%)	0.936
No	209 (88.2%)	151 (87.8%)	58 (89.2%)	
Education status				
≥High school	161 (64.7%)	110 (61.5%)	51 (72.9%)	0.122
<High school	88 (35.3%)	69 (38.5%)	19 (27.1%)	

TABLE 7.1 (Continued)

Characteristic	Total N (%)	Food Insecure 181 (71.3%)	Food Secure 73 (28.7%)	p - value
Annual income				
>\$15,000	63 (28.1%)	23 (14.7%)	40 (58.8%)	,0.001
≤\$15,000	161 (71.9%)	133 (85.3%)	28 (41.2%)	
Body Mass Index				
≥18.5 kg/m2	219 (96.9%)	153 (96.2%)	66 (98.5%)	0.629
<18.5 kg/m2	7 (3.1%)	6 (3.8%)	1 (1.5%)	
AIDS diagnosis				
Yes	63 (24.8%)	44 (24.3%)	19 (26.0%)	0.899
No	191 (75.2%)	137 (75.7%)	54 (74.0%)	
ART start year				
Median, IQR ¹	1997 (1995–1998)	1997 (1996–1998)	1996 (1994–1998)	0.015
HAART use²				
Yes	191 (75.2%)	138 (76.2%)	53 (72.6%)	0.655
No	63 (24.8%)	43 (23.8%)	20 (27.4%)	
PI-based regimen³				
Yes	154 (60.6%)	101 (55.8%)	53 (72.6%)	0.019
No	100 (39.4%)	80 (44.2%)	20 (27.4%)	
Adherence to ART⁴				
≥95%	123 (48.4%)	82 (45.3%)	41 (56.2%)	0.153
<95%	131 (51.6%)	99 (54.7%)	32 (43.8%)	
CD4 cell count (per 100 cells/mL)				
Median, IQR ¹	380 (220–510)	360 (210–500)	400 (230–555)	0.149
Plasma HIV RNA (per log10 copies/mL)				
Median, IQR ¹	2.6 (2.6–3.7)	2.6 (2.6–3.8)	2.6 (2.6–3.2)	0.250
All-Cause Mortality				
Yes	105 (41.3%)	87 (48.1%)	18 (24.7%)	0.001
No	149 (58.7%)	94 (51.9%)	55 (75.3%)	

¹Inter-quartile range²Highly active antiretroviral therapy use³Protease Inhibitor-based regimen⁴Within last 12 months of interview

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Unadjusted and adjusted analyses of factors associated with mortality among IDU are presented in Table 2. In unadjusted analyses (Column 1), participants who were food insecure were more than twice as likely to die, compared to individuals who were food secure (hazard ratio [HR]=2.41, 95% Confidence Interval [CI]: 1.45–4.01). Participants who were hungry were almost twice as likely to die (HR=1.78, 95% CI: 1.21–2.61) compared to individuals with no hunger. Other factors significantly associated with all-cause mortality included Aboriginal ancestry, low income, <95% adherence to ART, lower median CD4 cell count and higher median plasma HIV RNA. In adjusted analyses, controlling for potential confounders, food insecurity remained significantly associated with all-cause mortality (adjusted hazard ratio [AHR]=1.95, 95% CI: 1.07–3.53) (Column 2), and hunger was no longer significant (AHR=1.05, 95% CI: 0.65–1.70) (Column 3). Additional factors associated with increased likelihood of death in the model examining food insecurity included having an annual income >\$15,000, Aboriginal ancestry, and a higher median viral load. In the model exploring hunger, additional characteristics associated with higher risk of mortality included older age, annual income >\$15,000 and a higher median viral load.

TABLE 7.2 Unadjusted and adjusted factors associated with all-cause mortality among HIV-positive injection drug users initiating highly active antiretroviral therapy in British Columbia, between June 1998 and Sept 2011 (n=254).

Characteristic	Unadjusted model HZ ¹ (95% CI) ²	Adjusted model including food insecurity AHZ ³ (95% CI) ²	Adjusted model including hunger AHZ ³ (95% CI) ²
Food insecure			
Yes vs. no	2.41 (1.45–4.01)	1.95 (1.07–3.53)	–
Hunger			
Yes vs. no	1.78 (1.21–2.61)	–	1.05 (0.65–1.70)
Age			
Per 10 year increase	1.19 (0.94–1.50)	1.27 (0.98–1.65)	1.46 (1.09–1.94)
Gender			
Male vs. female	0.64 (0.41–1.01)	–	0.59 (0.34–1.02)
Aboriginal ancestry			
Yes vs. no	1.92 (1.27–2.92)	2.15 (1.34–3.45)	–
Unstable housing			
Yes vs. no	1.50 (0.87–2.60)	–	0.92 (0.46–1.82)

TABLE 7.2 (Continued)

Characteristic	Unadjusted model HZ ¹ (95% CI) ²	Adjusted model including food insecurity AHZ ³ (95% CI) ²	Adjusted model including hunger AHZ ³ (95% CI) ²
Education status			
>High school vs. ≤high school	0.85 (0.57–1.25)	–	–
Annual income			
<\$15,000 vs. ≤\$15,000	0.27 (0.14–0.50)	0.33 (0.16–0.68)	0.28 (0.14–0.58)
AIDS diagnosis			
Yes vs. no	0.95 (0.61–1.49)	–	–
Body Mass Index			
≥18.5 kg/m ² vs. <18.5 kg/m ²	0.74 (0.27–2.01)	–	–
ART start year			
Per year increase	1.03 (0.93–1.14)	0.88 (0.78–1.00)	0.93 (0.81–1.06)
HAART use⁵			
Yes vs. no	1.21 (0.76–1.93)	–	–
PI-based regimen⁶			
Yes vs. no	0.69 (0.47–1.01)	–	–
Adherence to ART⁷			
≥95% vs. <95%	0.59 (0.40–0.87)	–	0.77 (0.48–1.22)
CD4 cell count			
Per 100 increase	0.89 (0.82–0.98)	0.96 (0.87–1.06)	0.96 (0.86–1.07)
HIV RNA viral load			
Per Log10 increase	1.50 (1.23–1.84)	1.42 (1.12–1.80)	1.36 (1.05–1.75)

¹Hazard Ratio

²95% Confidence Interval

³Adjusted Hazard Ratio

⁴Highly active antiretroviral therapy

⁵Protease Inhibitor

⁶Within the last 12 months of interview doi:10.1371/journal.pone.0061277.t002

Adjusted Kaplan-Meier survival probabilities for IDU in this BC-wide cohort, stratified by food insecurity and hunger status, are presented in Figures 1 and 2, respectively. Consistent with findings from the multivariate analyses, individuals reporting food insecurity had significantly reduced probability of survival, compared to individuals who were food secure; and individual reporting hunger

did not have lower probability of survival compared to individuals reporting no hunger.

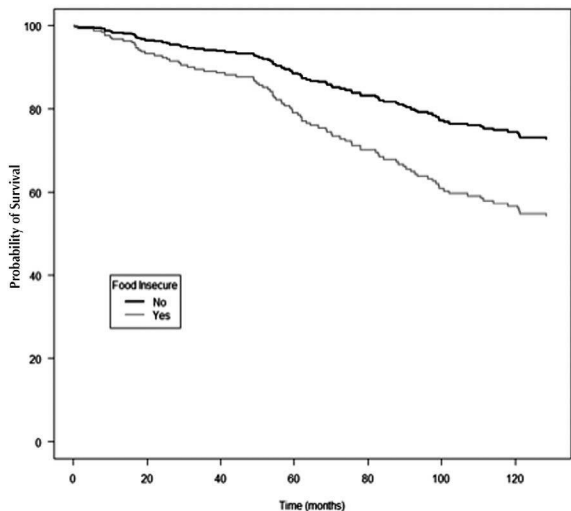


FIGURE 7.1 Adjusted cumulative incidence of all-cause mortality among HIV-positive injection drug users initiating antiretroviral therapy in British Columbia, stratified by food security status.

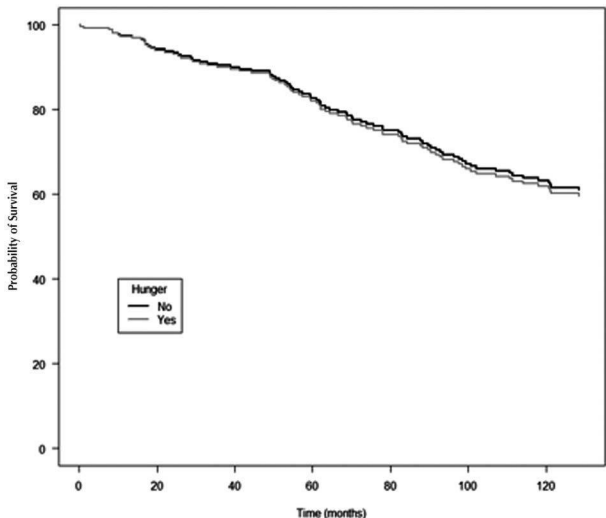


FIGURE 7.2 Adjusted cumulative incidence of all-cause mortality among HIV-positive injection drug users initiating antiretroviral therapy in British Columbia, stratified by hunger status.

7.4 DISCUSSION

This study builds on our existing body of research regarding the relationship between food insecurity and mortality among people living with HIV/AIDS [16]. This study is the first to examine the potential impact of food insecurity and hunger on mortality among HIV-positive IDU. Mortality rates were elevated in this sample of HIV-positive IDU. After 13.3 years of follow-up, individuals who reported being food insecure at baseline were almost twice as likely to die, when controlling for potential confounders. Hunger was associated with increased risk of death in univariate analysis, but the association was no longer significant after controlling for potential confounders in the adjusted analyses. Our results suggest that addressing food insecurity, in addition to other known social and structural barriers to ART adherence and virologic suppression among illicit drug users [51], [52], such as incarceration [53], homelessness [48], and gender-related factors [54], may be of paramount public health importance.

The finding that food insecurity, and not hunger, was significantly associated with all-cause mortality suggests that other aspects of food insecurity, measured within the Radimer/Cornell scale, may be driving this association, including poor dietary diversity and/or anxiety regarding food access. Food insecurity is theorized to be linked to adverse HIV-related outcomes through diverse nutritional, mental health and behavioral pathways [25]. Macro- and micronutrient deficiencies, which represent an extreme consequence of, and surrogate markers for, poor dietary diversity, have been associated with mortality among HIV-positive individuals in the ART era. Compared to non-IDU, active IDU may be at increased risk of developing nutrient deficiencies due to metabolic abnormalities and nutrient interactions associated with drug use [55]. Low albumin and phosphate levels have been associated with early mortality among malnourished individuals initiating ART [7], [9]. Deficiencies in zinc, Vitamin A, iron and B12 have also been associated with increased risk of HIV-related mortality in illicit drug-using populations [5], [13], [55], [56]. In particular, selenium deficiency is associated with a 20-fold increase in risk of mortality among HIV-positive IDU [55]. Findings from the current study, taken together with existing evidence regarding the relationship between nutrient deficiencies and mortality among HIV-positive IDU populations, suggest an urgent need for public health bodies to evaluate the possible role of screening for malnutrition and food supplementation to prevent excess mortality among IDU receiving ART in this setting.

The observed association between food insecurity and all-cause mortality in this sample of IDU receiving ART may also be explained by mental health mechanisms. Two questions on the Radimer/Cornell scale pertain specifically to feelings of anxiety regarding food access: “I worry whether my food will run out before I get money to buy more” and “I worry about whether the food that I can afford to buy for my household will be enough.” Obsessive or chronic worrying is recognized as a symptom of generalized anxiety disorder within the DSM-V [57]. Mental health disorders, including anxiety and depression, are commonly reported among HIV-positive populations, and believed to increase risk of mortality through both behavioral and biologic mechanisms. Symptoms of depression have been associated with poor virologic response [58], [59], [60], reduced immunologic capacity [61], and AIDS and non-AIDS related death among individuals on ART [49], [62], [63], [64], [65]. Feelings of guilt, fear and discrimination have been associated with delayed access to HIV treatment and care [66], and non-adherence to ART [67], [68], [69]. A recent study of 9,003 HIV-positive individuals in the US found that presence of mental health disorders, including schizophrenia and bi-polar disorder, were significantly associated with all-cause mortality [70]. Taken together with this previous evidence, findings from this study suggest a need to evaluate the possible role of comprehensive mental health support in the context of existing harm reduction and HIV treatment services in order to prevent excess mortality.

This study has several strengths and limitations that warrant consideration. Participants were not randomly selected, and therefore are not representative of the general HIV-positive or IDU populations in BC. Common to all survival analyses, the censoring of participants who were either event-free or lost to follow-up may have led to an underestimation of true time to event. Longitudinal data was not available for most socio-demographic and clinical variables. A major limitation of the study is that food security and hunger status were only collected at baseline. This study was therefore unable to ascertain the possible time-updated effects of food insecurity/hunger on mortality. Multivariate models in this study controlled for several variables that have been hypothesized to be on the causal pathway between food insecurity and mortality [25], and may have therefore underestimated true effect size. Information bias, and specifically responder bias, may have led to non-differential misclassification of hunger status, biasing Odds Ratio estimates towards the null. Residual confounding – due to dichotomization of continuous variables, use of surrogate markers, misclassification, or failure to account for unobserved/unknown confounders – may have introduced bias into effect estimates. Future studies could be strengthened

by considering the potential confounding impact of geographic region on the relationship between hunger and mortality, which has been independently associated with both HIV-related food insecurity (data not published) and mortality trends in BC[50].

Although the Radimer/Cornell scale is not considered the most contemporary of food insecurity measurement options, select measures within the scale have been incorporated into contemporary food security scales, including the United States Household Food Security Survey Module (HFSSM) [71] and Canadian versions of the module [72], offering some degree of geographic and temporal comparability. Notably, the hunger measure used in our analysis has remained consistent across different food security modules developed since the early 1990s, with the only difference being an emphasis on hunger frequency and duration in contemporary tools [37]. The advantage of the Radimer/Cornell scale used in this study is that it prompted respondents for 'current' food insecurity and hunger status, minimizing recall bias.

Because survey data were self-reported, this study may have also been susceptible to recall bias and social desirability bias. While the measure of hunger used in this study has been extensively validated in low income populations [27], [73], [74], future studies could be strengthened by applying robust dietary intake assessment methods validated for use among HIV-positive individuals, including 24 hour dietary recall and food frequency questionnaires [75],[76]. Use of self-reported weight and height for BMI may have been prone to bias, with studies demonstrating that individuals tend to under-report energy intake, weight and BMI, and over-report height [77]. Future studies could additionally consider clinical assessment of body weight loss and body cell mass, and subjective assessments of global nutritional status, which have found to be robust among people living with HIV/AIDS [42], and body composition and biochemical measures commonly used in HIV-positive IDU populations [76]. In summary, we found that food insecurity was associated with a two-fold increased risk of mortality, after controlling for potential confounders, among HIV-positive IDU receiving ART across BC, Canada. Further research is necessary to understand the mechanisms through which food insecurity drives this association, and to examine modifying effects of diverse nutritional, mental health and behavioral factors in the relationship between food insecurity and mortality. Public health organizations should prospectively evaluate the possible role of food supplementation and socio-structural supports on survival among IDU within HIV treatment programs.

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Shamba Maisha: Pilot Agricultural Intervention for Food Security and HIV Health Outcomes in Kenya: Design, Methods, Baseline Results and Process Evaluation of a Cluster-Randomized Controlled Trial

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8.1 BACKGROUND

Despite major advances in care and treatment of those living with HIV, morbidity and mortality among people living with HIV/AIDS (PLHIV) remains unacceptably high in sub-Saharan Africa, largely due to parallel epidemics of poverty and food insecurity (Weiser et al. 2011). There are an estimated 35.3 million

PLHIV worldwide, 70.8% of whom live in sub-Saharan Africa (Global report 2013). Food insecurity, defined as “the limited or uncertain availability of nutritionally adequate, safe foods or the inability to acquire personally acceptable foods in socially acceptable ways,” (Normen et al. 2005) is also highly prevalent in sub-Saharan Africa, where 240 million persons, or one in every four people, are estimated to be food insecure (FAO 2010). The prevalence of food insecurity is even higher among PLHIV in sub-Saharan Africa. Studies from Kenya and Uganda have shown that over 50% of PLHIV are moderately or severely food insecure (Mbugua et al. 2008; Weiser et al. 2010a).

Food insecurity and HIV/AIDS are leading causes of morbidity and mortality in sub-Saharan Africa and are inextricably linked, with each condition heightening vulnerability to, and worsening the severity of the other condition (Weiser et al. 2011). Food insecurity enhances HIV acquisition risk through increased risky sex and also increases susceptibility to HIV among those who are exposed (Weiser et al. 2007; Campbell et al. 2009; Webb-Girard et al. 2012; Weiser et al. 2011). Among PLHIV, food insecurity inhibits antiretroviral therapy (ART) initiation, retention in care, and ART adherence (Weiser et al. 2010b; Goudge & Ngoma 2011; Nagata et al. 2012; Weiser et al. 2009a; Wang et al. 2011; McMahon et al. 2011; Weiser et al. 2009b; Weiser et al. 2012). Food insecurity has been associated with a range of adverse clinical effects among PLHIV, including declines in physical health status (Weiser et al. 2009c; Weiser et al. 2012), decreased viral suppression (Weiser et al. 2009a; Kalichman et al. 2010a), worse immunologic status (Weiser et al. 2009c; Kalichman et al. 2010b), increased incidence of serious illness (Tsai et al. 2011), and increased mortality (Weiser et al. 2009b). In turn, HIV/AIDS worsens food insecurity by eroding economic productivity (Larson et al. 2008; McIntyre et al. 2006; Russell 2004), reducing social support due to HIV stigma (Tsai et al. 2011), and increasing medical expenses (McIntyre et al. 2006).

Although there has been a substantial increase in the allocation of international resources towards HIV care and treatment programs in Africa, food insecurity can significantly compromise the effectiveness of these programs due to its effects on morbidity and mortality as described above (Mamlin et al. 2009). As a result, the World Health Organization, UNAIDS and the World Food Programme have recommended integrating sustainable food production strategies into HIV/AIDS programming (Food and Nutrition Technical Assistance. HIV/AIDS: A Guide For Nutritional Care and Support; Nutrition and HIV/AIDS 2001; Blumberg & Dickey 2003; World Food Program 2003). Specifically, UNAIDS calls for international partners to “fund multisectoral HIV

programming that incorporates effective food and nutrition interventions, in line with scale-up towards universal access to prevention, treatment, care and support” (UNAIDS Policy Brief 2008). Yet, little research exists to document the beneficial effect of food security or sustainable agricultural interventions on antiretroviral (ARV) adherence, HIV clinical outcomes, women’s empowerment and HIV transmission risk behaviors among PLHIV in Africa or elsewhere.

To date, no randomized controlled trials have been conducted in resource-limited settings to examine the impacts of either food supplementation or sustainable food production strategies on HIV morbidity and mortality (Mahlungulu et al. 2007). Several small studies in developing countries have demonstrated the potential for programs that address food security to affect health outcomes among PLHIV (Mamlin et al. 2009; Cantrell et al. 2008; Agricultural initiatives for health in Haiti; Ochai 2008; Njenga et al. 2009; Byron et al. 2008). Yet, existing intervention approaches to impacting food security have focused primarily on direct macronutrient supplementation, which may be somewhat limited in its scalability and sustainability (Sztam et al. 2010). Livelihood interventions, which address upstream causes of food insecurity, may have a better chance of improving health outcomes, and may be more sustainable. Similarly, while microcredit programs can improve health and prevent disease acquisition by targeting poverty and gender inequality (Ashburn et al. 2008; Kim et al. 2008; Schuler & Hashemi 1994), they have been criticized in terms of their effectiveness as a stand-alone strategy. As a result, experts have recommended integrating microfinance and other livelihood approaches to maximize HIV prevention and treatment efforts and reduce poverty (Dworkin & Blankenship 2009; Weinhardt et al. 2009). Income generating activities are well suited to improving food security (Diagne 1998; Doocy et al. 2005), and to retaining patients in HIV care (Mamlin et al. 2009; Gomez et al. 2004).

Following our previously published theoretical model (Weiser et al. 2011), we set out to test the impact of a multisectoral agricultural intervention on HIV health outcomes and transmission risk behaviors in rural Kenya. In a previous small feasibility study conducted by our group, we showed that using a human powered irrigation hip pump combined with a microfinance loan led to increases in crop yields, household income, CD4 counts and BMI (Pandit et al. 2010). In the current study, we developed and tested a modified version of this combination agricultural and microfinance intervention called Shamba Maisha, Kiswahili for “farm life,” in a small community randomized control trial. In this study, we aimed to explore the acceptability and feasibility of the intervention and control conditions that will be used in a subsequent, larger cluster

randomized controlled trial, and examined preliminary impacts on outcomes of interest. Two similar district hospitals in southern Nyanza Province were randomized: one to the intervention and the other to the control group. We hypothesized that this multisectoral intervention will improve food insecurity, household wealth and HIV health outcomes. We developed and tested a theoretical framework for the pathways through which this multisectoral agricultural intervention may improve health. In this paper, we described our conceptual framework, study methods, baseline findings, as well as process evaluation findings of successes and challenges with implementation.

8.2 METHODS

8.2.1 Setting

The study took place in Rongu and Migori districts in Nyanza Province, Kenya. As of 2008, the HIV prevalence in Nyanza Province, Kenya, was estimated to be 15.3%, more than twice the national average (Kenya National Bureau of Statistics and ICF Macro 2010). Nearly all HIV-affected households in a recent Kenyan survey were considered to be moderately or severely food insecure (Mbugua et al. 2008). The province also has a significant shortage of accessible water making communities vulnerable to the impacts of drought, and a heavy dependence on an unstable agricultural sector. Farming and fishing are the primary means of income generation in Nyanza Province. Lack of irrigation and unpredictable rainfall leading to an inconsistent water supply remains a central barrier to successful farming for many in the region (Government of Kenya 2008).

8.2.2 Description of Intervention

The *Shamba Maisha* intervention consisted of three components: 1) a microfinance loan (~\$150) to purchase the farming commodities, 2) a micro-irrigation pump, seeds, fertilizer and pesticides, and 3) trainings in sustainable agricultural practices and financial literacy. KickStart, an international non-governmental organization (NGO), along with technical support of agricultural experts from the University of California Davis, led the agricultural component of the intervention. *Adok Timo*, a microfinance institution in Nyanza Province, implemented the economic aspects of the intervention with support from the UCSF and KEMRI research team. The intervention components are described below.

8.2.3 Loan Program

The microfinance loans were managed by *Adok Timo*, which has branches in Nyanza Province. The intervention group received training on financial management and marketing skills prior to receiving the loan. All trainings took place on participant's farms or a nearby location. Participants were required to save 500 Kenyan shillings (~\$6.00 USD) prior to receiving the loan. Each participant received vouchers to purchase the following items: the Hip Pump, 50 feet of hosing, fertilizer, and government certified seeds. These materials were purchased at a local farm store ("agrovet"). Loan repayment could begin at any time, but farmers were expected to make a minimum payment after the first harvest, usually 4–6 months after planting. Farmers were expected to repay in full by the end of two harvest seasons (approximately one year); however, if regular payments have been made, this deadline was extended based on the guidelines set out by the microfinance institution. Participants were not asked to forfeit personal belongings to cover loan payments. Control participants were eligible for the micro-credit loan and the *Kickstart* Hip Pump at the end of the 1-year follow-up period.

KickStart water pump and agricultural training: Irrigation technologies have been shown to improve agricultural output. (About KickStart) Recognizing the need for improved agricultural tools for poor farmers in Kenya, Kickstart developed a low-cost irrigation pump. These pumps enable farmers to irrigate their crops year-round avoiding dependence on seasonal rainfall thus capitalizing on higher crop prices in the marketplace. In prior evaluations in Kisumu Kenya, farmers using this hip pump have been able to enjoy up to a ten-fold increase in income (Brandsma 2003; Kihia & Kamau 1999; Stevens 2002; World Bank 2010).

Prior to receiving the microfinance loan, participants in the intervention group received eight training modules. The training modules were delivered to groups of farmers on participant's farms or at a nearby location by agricultural trainers from Kickstart, the loan officer from *Adok Timo*, and the study coordinator. The agricultural portion of the training included a didactic session and practical demonstrations on sustainable farming techniques, seed selection, soil and water conservation, fertilization and crop rotation, integrated pest and disease management (IPM), pre & post-harvest handling and marketing, the use of the MoneyMaker Hip Pump, and identifying improved market access for selling horticultural products. The field-based practical trainings were based on a training needs assessment and the crops selected by the participants. These trainings focused on plant spacing, seed selection, seed rate, crop combination, and a cost-benefit analysis for each crop selected and IPM. Participants were particularly

interested in locally available materials for IPM like wood ash, Mexican marigold and livestock urine in controlling pests on crops to enable them to reduce cost and maximize profits. Participants also conducted a market survey as part of the pre & post-harvest handling and marketing which revealed a large demand in the local markets for green vegetables and watermelon. The intervention participants also had an in-depth training on financial record keeping, the importance on savings and loans, and the basics of group dynamics.

8.2.4 Intervention Model

The primary aim of the pilot study was to test if a multisectoral agricultural intervention improves food security and HIV health outcomes. We hypothesized that the proposed multisectoral agricultural intervention will improve food security, prevent treatment failure, reduce co-morbidities, and decrease secondary HIV transmission risk among PLHIV.

We developed an evidenced-based causal framework (Figure 1) to understand the pathways by which food insecurity negatively impacts health outcomes. Food insecurity negatively impacts health outcomes through nutritional, behavioral, and mental health pathways, which emerge directly from the definition of food insecurity (Weiser et al. 2011). In terms of nutritional pathways, food insecurity has been associated with macronutrient and micronutrient malnutrition (Rose & Oliveira 1997; Lee & Frongillo 2001), and weight loss, low body mass index (BMI), and low albumin have been shown to hasten progression to AIDS and death (Stringer et al. 2006; Zachariah et al. 2006; Johannessen et al. 2008). HIV also increases metabolic requirements (Babameto & Kotler 1997; Macallan et al. 1995) and is associated with diarrhea and malabsorption of fat and carbohydrates (Babameto & Kotler 1997; Kotler et al. 1990; Stack et al. 1996; Fields-Gardner & Fergusson 2004). Lack of food may also impede optimal absorption of certain ARVs (Gustavson et al. 2000; Bardsley-Elliot & Plosker 2000; Food and Agriculture Organization 2010), which may contribute to treatment failure. In terms of behavioral pathways: Food insecurity is an important cause of ART non-adherence and treatment interruptions, (Weiser et al. 2010b; Weiser et al. 2009a; Kalichman et al. 2010a; Weiser et al. 2009d); Tuller et al. 2010) which are both well-known determinants of HIV treatment outcomes (Parienti et al. 2004; Parienti et al. 2008; Oyugi et al. 2007). In addition to ART non-adherence and treatment interruptions, as a result of competing demands between food and other resources, food insecure individuals often miss scheduled clinic visits,

and may be less likely to initiate ART (Weiser et al. 2010b; Tuller et al. 2010; Weiser et al. 2012). In terms of mental health pathways, food insecurity has been associated with depression and poor mental health status in sub-Saharan Africa and elsewhere, (Weiser et al. 2009c; Tsai et al. 2011; Anema et al. 2011) which in turn have been shown to independently contribute to lower ART adherence and worse HIV clinical outcomes (Ickovics et al. 2001; Tucker et al. 2003; Evans et al. 2002; Weiser et al. 2004). Food insecurity and poverty also contribute to lower levels of empowerment, including women’s empowerment, which can negatively impact health outcomes for HIV. For example, in Uganda, among HIV-infected women low sexual relationship power is associated with malnutrition (Siedner et al. 2012), depression (Hatcher et al. 2012), and worse virologic outcomes (Weiser et al. 2010a, b).

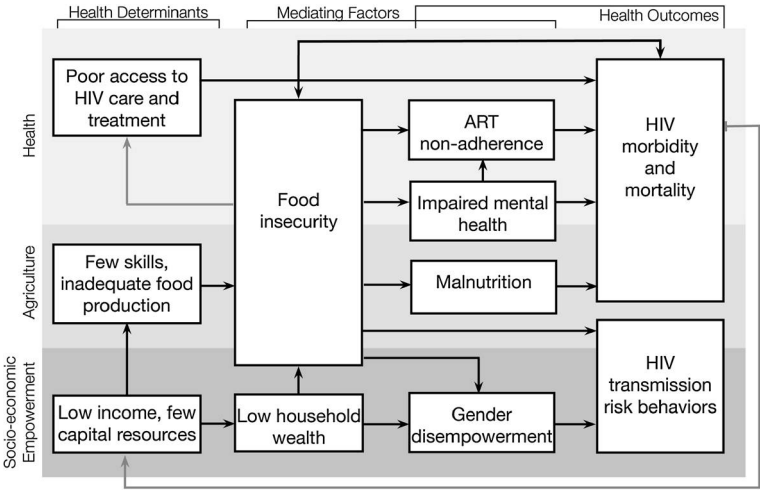


FIGURE 8.1 Shamba Maisha causal framework

Drawing upon this framework, we developed the intervention framework to describe the pathway by which we believe the multisectoral agrifunctional intervention impacts on mediating factors and eventually improves health outcomes among HIV-infected adults (Figure 2). Specifically, we hypothesized that: 1) The three intervention components together would directly lead to improvements in food security and household wealth (most proximal mediators); 2) Changes in food security and household wealth would, in turn, contribute to less macronutrient and micronutrient malnutrition (nutritional pathway), less

anxiety, stress and depression (mental health pathway), improved ART adherence and retention in care (behavioral pathway) and improved gender empowerment; and 3) Through these pathways, the intervention would ultimately contribute to decreased HIV morbidity and mortality and fewer HIV transmission risk behaviors.

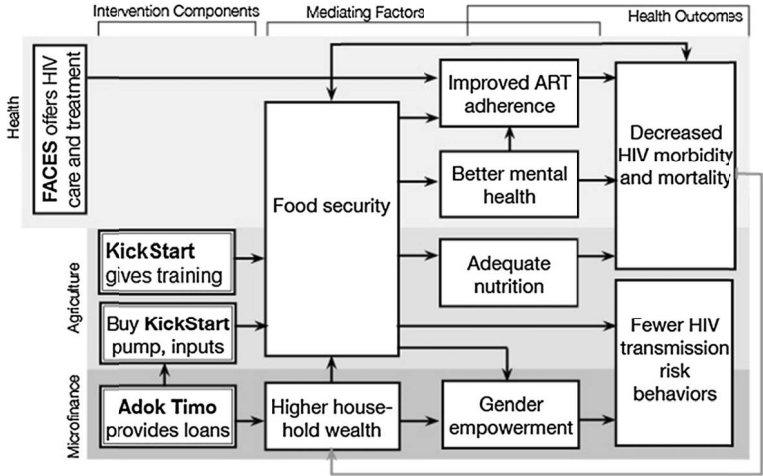


FIGURE 8.2 Shamba Maisha intervention framework

8.2.5 Randomization

We used a two-step process to select two sites from among 68 government health facilities in Rongo, Migori and Nyatike districts supported by Family AIDS Care & Education Services (FACES), a collaboration between the University of California, San Francisco (UCSF), and the Kenyan Medical Research Institute (KEMRI) (Lewis Kulzer et al. 2012). First, we limited to 20 sites where there were an adequate number of PLHIV on ART at the time of the study, and where farming was a primary means of livelihood in the communities. Next, we selected two government health facilities for the pilot randomized controlled trial (RCT) according to the following criteria: a) having adequate numbers of PLHIV on ART with non-overlapping catchment areas; b) having catchment areas that were relatively similar to one another according to rainfall patterns, health, topography and socioeconomic status; and c) meeting practical requirements for the intervention, including acceptable characteristics in topography to enable use of the water pump, having water access

year round, and having favorable soil composition to potentiate the intervention. One site was randomly selected as the intervention site and the other the control site by the study's biostatistician who used a computer random number generator and was not involved in fieldwork. Clinics, healthcare providers, patients, and researchers involved in implementing the study were not blinded to the allocation.

8.2.6 Ethics Statement

The study was approved by the Committee on Human Research at UCSF and the Ethical Review Committee at KEMRI. All participants in the study gave written informed consent prior to enrollment in the study, and had the cost of their transportation reimbursed up to 800 Ksh per clinic-based interviews (~\$9.4 USD) and 400 Ksh for home-based interviews (~\$4.70). This clinical trial was registered at ClinicalTrials.gov (NCT01548599).

8.2.7 Participants and Recruitment

The study population includes HIV-infected patients between the ages of 18–49 years receiving ART, have access to farm land and surface water, and have demonstrated evidence of moderate to severe food insecurity or malnutrition during the year preceding the study. Participants were recruited from Rongo (intervention site) and Migori (control site) District Hospitals in Nyanza Province beginning in April 2012. Research assistants introduced the study to patients waiting to be seen at the HIV clinic at the two health facilities. Individuals who expressed interest were consented and screened for eligibility. Among interested and potentially eligible individuals, home visits were conducted to verify that the participant had access to farming land and surface water. In addition to the eligibility criteria above, the study also aimed to ensure that at least 40% of participants at each site were of each gender. Individuals who met eligibility criteria were enrolled in the study after providing written informed consent. At intervention sites, participants were enrolled in a savings program in anticipation of receiving the asset loan. Control participants also agreed to save the down payment (~\$6) required for the loan by the study end. A total of 140 HIV-positive individuals were enrolled in the study during the period of April – July 2011 (See Figure 3); an additional two (1.4%) eligible screened participants declined to participate in the study.

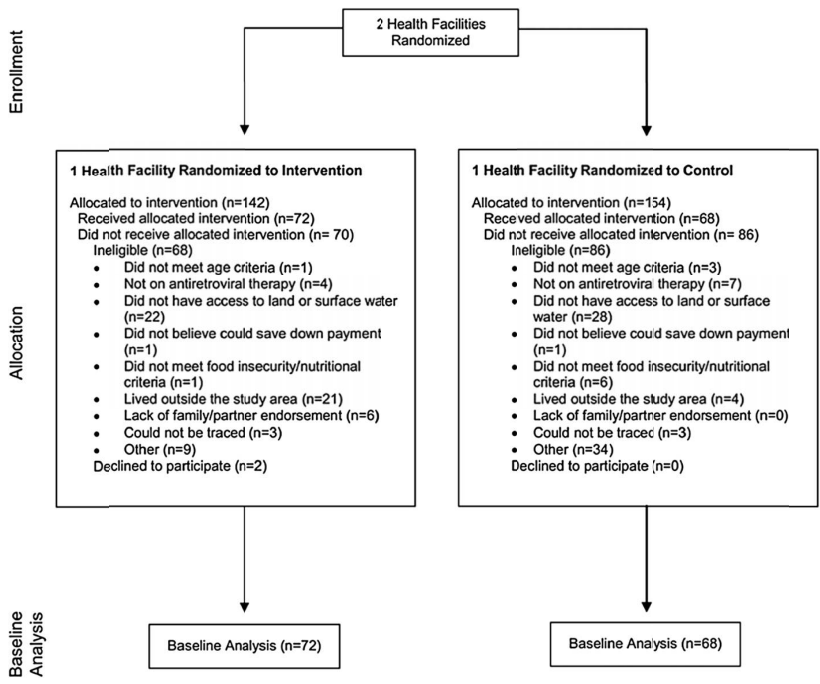


FIGURE 8.3 *Shamba Maisha* consort diagram

8.2.8 Data Collection

Participants were followed quarterly for structured interviews and ART adherence assessments by unannounced pill counts at their home. Anthropometry (i.e., mid upper arm circumference measurements [MUAC] and BMI measurements) and phlebotomy for viral load and CD4 determinations were conducted every six months. Viral load testing was performed on venous blood at the Centers for Disease Control-Kenya laboratory on the COBAS TaqMan HIV viral load platform (Roche Molecular Diagnostics, Pleasanton, CA) with a lower limit of detection of <20 copies/mL. Absolute CD4 count testing was performed on whole blood using the BD FACSCount (BD Bioscience, San Jose, CA). In addition, clinical data were abstracted from participant’s medical records.

Structured interviews for clinical and sensitive behavioral data were administered at baseline, 6 months and 12 months at the clinic and included the following data (see Table 1): health care access and competing demands, ARV history and adherence, physical and mental health, social support, women’s empowerment,

TABLE 8.1 Measurements

Path	Measurement	Definition	Frequency
Nutritional Pathway	Nutritional status	Nutritional status was assessed through body mass index (BMI) and mid-upper arm circumference (MUAC), commonly used to assess nutritional status (Physical Status 1995; Collins et al. 2000). The BMI reflects protein and fat reserves (James et al. 1988) and was assessed using an established grading system (Ferro-Luzzi et al. 1992). For MUAC, we used WHO sex-specific cut-offs of 22.0 cm for females and 23.0 cm for males with chronic energy deficiency (Doocy et al. 2005).	Semi-annually
	Food frequency	Food frequency, the number of different foods or food groups and the frequency consumed over a given reference period (Hoddinott & Yohannes 2002), as adapted from the World Food Programme Food Consumption Score was collected.	Quarterly
Behavioral Pathway	Pill count ART adherence	Participants received an unannounced visit to inventory medications and count pills (Bangsberg et al. 2001a; Bangsberg et al. 2001b; Bangsberg et al. 2000), a technique closely correlated with electronically monitored adherence, HIV viral load (Bangsberg et al. 2000) and progression to AIDS (Bangsberg et al. 2001c). The count of existing pills was reconciled with the participant's pharmacy refill history to determine the percentage of pills not yet consumed.	Quarterly
	Competing demands	Questions were modified from Gelberg and Anderson's Behavioral Model for Vulnerable Populations (Gelberg et al. 2000; Gelberg et al. 1997) to assess how often lack of food interferes with ability to procure drugs or visit the clinic	Semi-annually
	Healthcare access	Utilization of health care services including hospitalizations and clinic visits over the preceding 6 months were collected	Semi-annually
Mental Health Pathway	Mental health & depression	Mental health status was measured using the Medical Outcomes Study HIV Health Survey (MOS-HIV), a tool for assessing health-related quality of life (Wu et al. 1991) that has been validated in resource-limited settings (Chatterton et al. 1999; Mast et al. 2004). Depression was screened using the Hopkins Symptom Check-list for depression, a 15-item scale (Derogatis et al. 1974) which has been validated in sub-Saharan Africa (Bolton et al. 2004).	Semi-annually
	HIV-related stigma	We used the Internalized AIDS-Related Stigma Scale (Kalichman et al. 2009).	Semi-annually

TABLE 8.1 (Continued)

Path	Measurement	Definition	Frequency
Empowerment	Disclosure of HIV status	We asked about disclosure of HIV status to partners, family members, friends, colleagues, and public. These questions were adapted from our previous studies in Uganda, Botswana and Swaziland (Weiser et al. 2007; Wolfe et al. 2008; Tsai et al. 2013).	Semi-annually
	Alcohol use	To measure alcohol use, we adapted the Alcohol Use Disorders Identification Test (AUDIT-C) indicators. The AUDIT-C is a 3-item alcohol screen that can help identify persons who are hazardous drinkers or have active alcohol use disorders.	Semi-annually
	Gender empowerment	Empowerment indicators were adapted from a large cluster-randomized trial of an intervention including: greater challenges to established gender roles, communication with relationship partner about sexual matters in the prior 3 months, measures of financial decision-making, measures of attitudes towards gender roles and gender-based violence, and experience of controlling behavior by relationship partner in prior 3 months (Pronyk et al. 2006). In addition, we used the Sexual Relationship Power Scale (SRPS) (Pulerwitz et al. 2000), which conceptualizes sexual relationship power as a multi-dimensional construct consisting of relationship control and decision making dominance. The SRPS has been used successfully in observational research conducted in South Africa (Dunkle et al. 2004; Jewkes et al. 2010) and Uganda. (Weiser et al. 2010a, b) We also collected data on sexual victimization and perpetration in the prior 3 months.	Semi-annually
Proximal Mediators	Food insecurity	The Household Food Insecurity Access Scale (HFIAS) has been validated in eight countries (Coates et al. 2006a; Swindale & Bilinsky 2006; Frongillo & Nanama 2006; Coates et al. 2006b) and used successfully by our team in rural Uganda. (Weiser et al. 2010a; Tsai et al. 2011; Weiser et al. 2012; Tsai et al. 2012; Weiser et al. 2010a, b; Miller et al. 2011; Tsai et al. 2011)	Semi-annually
	Agricultural measures	Agricultural measures were adapted from outcome evaluations developed by Kickstart in Kenya and supplemented by outcome indicators found in an earlier pilot study and a rural assessment. These measures were designed to evaluate uptake and adoption, and to measure changes in agricultural practices including crop diversity and agricultural practices and production. In addition, we evaluated the effectiveness of the training, and specific topics within, so as to refine the training for the subsequent larger cluster-randomized trial.	Quarterly

TABLE 8.1 (Continued)

Path	Measurement	Definition	Frequency
Behavioral Outcome	Household economic indicators	A modification of the World Bank Living Standards Measurement Study (LSMS) questionnaire (Grosh & Glewwe 1998) was used to measure: a) expenditures (food, health, education and productive investments); b) consumption (food and non-food); c) income (from agriculture and all sources); and d) inter-household commodity and cash transfers.	Quarterly
	Risky sexual behaviors	The primary transmission risk outcome was unprotected sex. Other outcomes included: number of non-spousal/non-cohabiting sexual partners, sex-exchange (exchanging sex for money, food, or other resources) Dupas & Robinson 2010); Robinson & Yeh 2011).	Semi-annually
	HIV-related mortality	Burial permits and information from family members were used to determine cause of death.	As needed
Health Outcomes	Viral load suppression	Viral load testing was performed on venous blood on the COBAS TaqMan HIV viral load platform (Roche Molecular Diagnostics, Pleasanton, CA) with a lower limit of detection of <20 copies/mL.	Semi-annually
	CD4 Count	We abstracted data for CD4 counts from participant's medical records. Absolute CD4 count testing was performed on whole blood using the BD FACSCount (BD Bioscience, San Jose, CA).	Semi-annually
	HIV morbidity	HIV morbidity was measured through key outcomes from the medical record. We abstracted data every 3 months for ART treatment interruptions and episodes of opportunistic infections. We also gathered self-report data on opportunistic infections and symptoms during structured interviews.	Quarterly/Semi-annually
Covariates	Physical health	Health status was measured using the MOS-HIV, a tool for assessing health-related quality of life (Wu et al. 1991) that has been validated in resource-limited settings (Chatterton et al. 1999; Mast et al. 2004).	Semi-annually
	Demographics	Age, religion, education, marital/partnership status, number of children and household census.	Baseline

TABLE 8.1 (Continued)

Path	Measurement	Definition	Frequency
	Social support	To measure social support, we adapted the Functional Social Support Scale (Antelman et al. 2001), a modified version of the Duke University–University of North Carolina Functional Support Questionnaire (Broadhead et al. 1988) consisting of questions related to perceived emotional and instrumental support. Higher scores reflect higher levels of social support.	Semi-annually
	ART history and Self-reported ART adherence	Detailed ART history, ART self-reported adherence and barriers to ART adherence were collected. For self-report adherence, we used the visual analog scale (Oyugi et al. 2004) and the three day recall.	Semi-annually

stigma, HIV disclosure, alcohol use, and sexual behavior. Additionally, quarterly home visits were conducted to collect unannounced pill counts for ART adherence, food frequency, food security, income, housing, assets and wealth, and specific data related to agricultural output, labor, harvesting, marketing, and irrigation.

8.2.9 Data Collection Methods

Structured interviews administered at the health facility and at participants' farms or homes were conducted by trained research assistants who used a hand-held computer tablet for data entry (Morotola™ Xoom Android Tablets operating Open Data Kit (ODK) Collect (Hiarlathie et al. 2014). Research assistants conducted structured interviews in the local language (Dholuo) or English and completed paper-based data collection forms for the majority of baseline data collection (Table 1). Forms were later entered into the tablet using ODK Collect. Research assistants entered subsequent data directly into the tablet. Data for anthropometry (MUAC and BMI), and viral load results were entered into ODK Collect forms (Table 1). Medical history and CD4 determinations were abstracted from patient records and entered into the tablet (Table 1).

8.2.10 Monitoring

The study team conducted internal monitoring such as form completion and quality control of data entry monthly. Procedures to promote data quality including range and logical checks were built into the data entry program, and we ran a series of additional error checks on the databases following data entry. In addition, we used a rainfall gauge at the two study sites to record total precipitation by month.

8.2.11 Process Evaluation Methods

In order to understand the implementation successes and challenges, we conducted a detailed process evaluation alongside the Shamba Maisha trial. We interviewed 40 intervention participants and 20 key informants at two time points (3–5 months after study start and study end) to understand successes and challenges with implementation (for a total of $n = 120$ interviews).

Interviews were conducted in English, Dhuluo or Kiswahili, and lasted between 45 minutes and 2 hours. We used a semi-structured interview guides to probe for feedback on recruitment and retention as well the key intervention components (the microcredit loan, the agricultural training, and the use of the hip pump), and elicit suggestions on how to improve each of these components. Interviews were transcribed verbatim and (as necessary) translated into English. Data were managed using Dedoose, (Dedoose Version 5.0.11 et al. 2014) a qualitative software that allows for real-time access to a secured database by a number of people in an analysis team. In line with previous qualitative process evaluations of complex interventions (Hargreaves et al. 2010), we used an inductive-deductive approach. First interviews were coded for broad themes by four researchers, using a structured coding framework developed from topics covered in the interview guide. Next, a second stage of inductive coding allowed sub-themes to emerge. Process evaluation findings are used to suggest how these might help refine the intervention in a future trial.

8.2.12 Statistical Methods

For this baseline manuscript, we compared baseline characteristics between participants enrolled in the intervention and control sites using proportions for categorical variables and means or medians (as appropriate) for continuous variables. An assessment of the distribution (normally or skewed) of continuous variables was performed. Statistical tests for descriptive analyses included chi-square tests for categorical variables, and Wilcoxon rank-sum or t-tests and for continuous variables.

8.2.13 Analysis of Outcome Data

This pilot was not powered for formal significance testing of the intervention effect on primary health, behavioral and gender empowerment outcomes. Rather, analyses will focus on assessing the effects of the intervention on proximal mediating factors (Figure 2), and separately on primary outcomes. Analyses for mediating variables will generally treat scores as continuous measures. For example, food security will be measured using the Household Food Insecurity Access Scale (HFAIS) score at the 1-year visit; change in household economic indicators over the 1-year follow-up period will be measured by subtracting baseline from 1-year follow-up data for household expenditures, consumption

and income (from agricultural and other sources). Initial comparisons will be based on group-specific descriptive summaries of observed outcomes and rank-based tests comparing outcomes between groups. We will also use regression methods to compare outcomes between groups and control for baseline characteristics. Analyses for primary health outcomes will proceed similarly, with appropriate choices of model for outcome type. For example, we will use pooled logistic regression for between-group comparisons of rates of viral load suppression, and mixed effects regression to compare changes in CD4 counts between groups. We will also make preliminary assessments of degree of mediation in models for primary outcomes via inclusion of mediating factors, with assessment of direct and indirect intervention effects of key mediating variables (Petersen et al. 2006). Finally, we will also perform intent-to-treat and per-protocol analyses of the pilot data, with the per-protocol subset limited to participants that obtained and used the intervention consistently over the 12-months of follow-up. Although these analyses will likely be underpowered for formal testing purposes, the resulting estimates and confidence intervals will be important for planning for the subsequent RCT.

8.3 RESULTS

8.3.1 Screening and Enrollment

Figure 3 describes study screening and enrollment numbers, along with reasons for participant ineligibility. We screened 142 and 154 adults, respectively at the intervention and control sites. We enrolled 72 and 68 participants at the intervention and control sites, respectively; four participants withdrew from the study, four from the intervention site and zero from the control site. One participant in the intervention arm failed to save the down payment necessary to receive the loan and was subsequently withdrawn from the study. The most common reasons for study ineligibility of screened participants included: did not have access to land or surface water, lived outside the study area, not on ART, and “other” reasons.

8.3.2 Baseline Characteristics of Participants

At baseline (Table 2) participants at the intervention and control sites, respectively were similar in age (37 vs. 38 years), gender (51% female in both),

education (19% vs. 18% completed secondary school) and marital status (75% vs. 79% married). Mental health and gender empowerment measures were similar among participants enrolled at the intervention and control sites. Reported monthly household income was lower among participants enrolled at the intervention in comparison to the control site ($\sim \$104$) vs. ($\sim \273), $p = 0.008$).

TABLE 8.2 Comparison of baseline sociodemographic, economic, sexual risk behavior, dietary intake, clinical, mental health, gender empowerment, clinical and laboratory findings of participants enrolled in *Shamba Maisha* at the intervention and control sites

	Intervention N = 72	Control N = 68	P-value
Sociodemographic variables	n (%)	n (%)	
Mean age in years (SE)	37 (0.80)	38 (0.80)	0.16
Female gender	37 (51)	35 (51)	0.92
Education $\geq$ secondary school	14 (19)	12 (18)	0.82
Current married	54 (75)	54 (79)	0.25
Mean number of people in household (SE)	6 (0.2)	7 (0.3)	0.12
Food security level			
Moderately food insecure	14 (20)	14 (21)	0.86
Severely food insecure	57 (80)	53 (78)	0.86
Body Mass Index (BMI) <18.5	13 (18)	5 (7)	0.054
Economic indicators			
Mean (SE) Monthly Household Income (USD*)	104 (21.3)	273 (53.1)	0.008
Land ownership (Self or Jointly)	60 (83)	49 (73)	0.14
Sexual risk behavior			
Any unprotected sex	13 (18)	12 (18)	0.95
Sex exchange (ever)	15 (21)	28 (41)	0.009
Sex exchange (last 3 months)	2 (3)	6 (9)	0.12
>1 Sexual partners in the past 3 months	9 (13)	9 (13)	0.92
Dietary intake (frequency of consumption - times/week)			
Grains mean (SE)	19.0 (0.8)	20.8 (0.8)	0.1320
Vege's mean (SE)	20.3 (0.9)	25.9 (0.7)	<0.0001
Fruit mean (SE)	9.0 (0.6)	10.6 (0.9)	0.1352
Meat, Poultry mean (SE)	3.4 (0.3)	5.3 (0.3)	<0.00001
Eggs mean (SE)	0.9 (0.1)	1.3 (0.2)	0.117
Dairy mean (SE)	1.9 (0.3)	4.5 (0.5)	<0.0001

TABLE 8.2 Comparison

	Intervention N = 72	Control N = 68	P-value
Cooking fat mean (SE)	5.0 (0.3)	6.8 (0.1)	<0.00001
Sweets mean (SE)	7.1 (0.7)	11.9 (0.7)	<0.00001
Mental health			
Depression score ≥ 1.75 (clinical depression)	1 (1)	4 (6)	0.2
Mental health summary score (SE)	57.1 (3.4)	42.8 (5.6)	0.15
Mean internalized AIDS related stigma scale (SE)	14.1 (0.2)	13.7 (0.2)	0.19
Disclosed to husband/wife/partner	65 (97)	63 (95)	0.68
Mean Social Support Score (SE)	53.4 (10.8)	35.8 (8.3)	0.2
Problem drinking based on audit C	1 (1)	2 (3)	0.53
Gender empowerment			
Mean sexual relationship power scale (women only) (SE)	54 (10)	47 (8)	0.59
Mean decision making dominance scale (SE)	46 (5)	42 (4)	0.46
Clinical, Laboratory and antiretroviral (ART) adherence			
WHO clinical stage 3 or 4	15 (21)	22 (33)	0.12
Median CD4 (IQR) cells/mm ³	446 (330–629)	475 (356–679)	0.33
Baseline CD4 ≤ 350 cells/mm ³	20 (29)	16 (24)	0.467
Viral load above the limit of detection (≥ 20 copies/mL)	34 (49)	19 (28)	0.010
Physical health summary score (SE)	54.3 (3.6)	45.5 (4.0)	0.03
Hospitalized in the last three months	3 (4)	5 (7)	0.4
Reported ART adherence per Visual Analogue Scale < 90%	0 (0)	6 (9)	0.01

*Converted Kenyan shillings (Ksh) to US dollar (85 Ksh/\$).

A similar proportion of participants at the intervention and control sites reported moderate and severe food insecurity based on the HFAIS, although a greater proportion of participants at the intervention site had a low BMI in comparison to participants at the control site (18% vs. 7%, $p = 0.054$) (Table 2). In regards to dietary intake, participants enrolled at the intervention site reported less frequency of vegetable, meat/poultry, dairy, cooking fat, and sweets than participants enrolled at the control site (Table 2).

Twenty-one percent and 33%, respectively of intervention and control site participants had WHO stage 3 or 4 disease. While median CD4 count was similar between arms (intervention: 446 cells/mm³ vs. control: 475 cells/mm³, $p=0.33$), a greater proportion of participants enrolled at the intervention arm had a detectable HIV viral load than participants enrolled at the control arm (49% vs. 28%, respectively, $p < 0.010$); Self-reported ART adherence $< 90\%$ per visual analogue scale was rare in both arms of the trial (Table 2).

8.3.3 Implementation Successes and Challenges

A variety of implementation successes and challenges were documented during the qualitative process evaluation. Positive aspects of *Shamba Maisha* included high acceptability during recruitment, successes with agricultural and financial training, and labor savings from using the pump. Implementation challenges included considerable concern about repaying loans, agricultural and irrigation challenges related to weather patterns, and a challenging partnership with the microfinance institution.

8.3.4 Successes with Shamba Maisha Implementation

1. *Strong willingness to join.* Nearly all participants interviewed expressed a strong interest in taking part in *Shamba Maisha*. Many had expectations that this intervention would improve their households and lives as expressed by one participant:

“What motivated me more to join the project was the training that they were coming to train us, they gave us some very good training. So when I heard about the type of training, the targets they put for us and the amount of money we would get... that if we got it then life would change for the better.”
(Male participant, 3 months, 31 years old).

2. *Excellent agricultural training.* The agricultural portion of the training was a success and participants noted positive impacts even before they received the agricultural inputs, including increased and diversified crop production. The newly acquired farming skills were discussed with great pride by participants. The agricultural techniques resulted in larger

harvests from smaller pieces of land – an outcome that many participants cherished:

“Before Shamba Maisha we just used to farm very huge pieces of land and get very small harvests. From the training we realized that we are able to farm a small piece of land and get a bumper harvest. This was really an eye opener for us.” (Female participant, 3 months, 42 years old).

Another woman explained crucial techniques around plowing, ridge planting, and nursery beds:

“We were taught on how to farm in order to get something good; for you to realize a good harvest, you need to plough deeply, then break it into more fine particles. Then you make ridges that we were given to help us in making the seedbeds and nursery. You make the nursery then plant them then later transfer then to the main farm.” (Female participant, 3 months, 45 years old).

Some participants even explained how neighbors were drawn to them as a result of the improved techniques:

Because of *Shamba Maisha*, I was able to embrace a modern way of farming that has attracted people from all over to come and learn from it. (Male participant, 12 months, 44 years old).

3. *Bolstering financial skills.* Some participants spoke of the utility of financial trainings, in particular the lessons around savings and record keeping:

“On savings we learnt a lot from the leader on the microfinance team on how we can save in the bank, we also learnt on record keeping while farming and how we can build our lives relying on the trainings... That was very good.” (Male participant, 3 months, 38 years old).

4. *Ease of irrigation with water pumps.* For a number of *Shamba Maisha* participants, the pump was easier to implement than previous irrigation strategies, such as bucket irrigation, leading to labor savings.

“I use the pump with a well. It helps in irrigation, at the times when these things need water I can use it. And I find it to be easier as compared to how I could have done it in the past where I could have taken maybe a bucket and use it to pour water.” (Male participant, 3 months, 33 years old).

“Before I used to fetch water from the borehole then I used a calabash to pour water directly. But now once I get two people, I just take the machine and pump water straight from the water source and irrigate just by pressing. So I use less energy in irrigation unlike before.” (Male participant, 12 months, 44 years old).

8.3.5 Barriers to Shamba Maisha Implementation

Despite these successes during implementation, participants noted a number of challenges, and had some recommendation for improving the intervention.

1. *Fear of loan repayment.* Some participants talked about the loan repayment as a potentially discouraging aspect of the intervention:

“We were going to be given loan and we’d be expected to repay some money back. This discouraged people and it’s still a factor that continue to discourage others.... here in Luo, they are scared of ‘debt recoveries.’” (Male participant, 3 months, 43 years old).

2. *Lack of choice in how to use loan.* While many were satisfied with the commodities provided as part of *Shamba Maisha*, some suggested that to improve the intervention, *Shamba Maisha* should provide the loan but allow people to decide how best to use it. For example, one man spoke about preference for livestock over farming:

“Farming, it is very difficult and requires you to take a lot of time, because people like us if you are doing it, it is something that you do full time. But we were thinking that if there was a different way other than farming, if one could choose what he could do then I think it could be better. ... If I was told to choose then I would prefer to be given a cow, because that is something that I know and I have had some experience with.” (Male participant, 3 months, 35 years old).

Another participant wished for crops that were less perishable so that they can be stored and sold when the market was better:

“In my own view to help people more, if we could be introduced to a new type of farming or crop, that could uplift us because vegetables are little in terms of production and also are very perishable. So if you can introduce some new crops that even after harvesting can be stored until they fetch a good price in the market. You can keep them and later decide on the quantity to sell to repay the loan.” (Female, 12 months, 40 years old).

3. *Agricultural Challenges.* While agricultural productivity was reported to have improved by the majority of participants, variability in weather patterns impacted crop production throughout the course of the study period and across the communities. There were periods of flooding and hail storms which adversely affected crop production. For example, one woman complained of weather-related crop damage, despite describing having been very well trained to farm in the program “All my crops have been destroyed by the hailstorm and I have no means of repaying the loan.” (Female participant, 3 months, 38 years old) Rain gauges were used to monitor precipitation at the district hospitals in the intervention and control communities. Annual rainfall was reported to be higher than normal over the course of the one-year intervention with extended rainy seasons. As a result, the irrigation technology was not utilized as much as expected, decreasing some of the potential advantages.

Irrigation is good, though we haven’t embraced it to an extent that it can fully benefit us because when we started it ... the rain started. Our pumps are not being used because currently it’s rainy season and you can’t really sow vegetable seeds when there is too much rain. (Male participant, 12 months, 44 years old).

4. *Pump Challenges.* Although most participants reported that the pumps were easy to use, some male and female participants had difficulty operating the pumps on their own. As described by one participant:

It is impossible to operate it comfortably as an individual. It demands that it is operated by two or three people with one person pumping the water as one directs the pipe to the shamba [farm]. When I used it, my sons had to assist me. (Female participant, 3 months, 30 years old).

5. *Challenges with Microfinance Institution.* The local microfinance organization selected for the study had poor governance and was unable to fulfill the obligations of the study. Specifically, there were significant delays in dispersal of the loans and fiscal insolvency, leading to the closure of the local branch:

It [The microfinance organization] could be closed for even 3 months. You go there and find the offices are closed and sometimes your money is in there... so it leaves you with a lot of doubts... And that is the main reason why many people ended up having fears that their money would get lost here. (Male participant, 3 months, 28 years old).

Based on this finding, which emerged early in the process evaluation data collection, study leadership terminated the partnership with *Adok Timo* and transferred the loans to a local NGO which managed the loan collection for the remainder of the study period.

8.4 DISCUSSION

This pilot study was designed to determine the acceptability and feasibility of the intervention and control conditions, and to determine the preliminary impact of the intervention on mediating outcomes (food security, and household economic indicators). In the baseline evaluation of *Shamba Maisha*, we demonstrated that screening and enrollment into the intervention and control groups was rapid. Enrollment of the 140 participants took only four months, and the screening to enrollment ratio was similar between study arms. Thus, patients at the two study facilities were interested to screen and enroll in the study, i.e. enrollment into the control conditions did not appear to mitigate interest in study participation. This finding has important implications in regards to feasibility for advancing the intervention into a phase 3 cluster randomized controlled trial.

We found that the participants in the intervention and control groups were relatively similar demographically. However, participants at the control site reported a higher household income and dietary intake of vegetables and various protein sources. Importantly, participants in the control group were more likely to have an HIV-1 viral load below the limit of detection than participants enrolled in the intervention group. Self-reported ART non-adherence was uncommon in both groups. The lower proportion of non-detectable plasma viral loads in the intervention group may be related to the fact that the intervention

group was economically worse off at baseline, and other studies have shown that markers of lower socioeconomic status are associated with delayed entry into care and worse HIV outcomes. In prior clinical programs in sub-Saharan Africa, viral load suppression ranges from 18% - 41% in observational studies (Hassan et al. 2014; Liegeois et al. 2012; Anude et al. 2013). Thus, our findings are relatively consistent with these results. Of note, this pilot study was not powered or designed to detect differences in viral load suppression by study arm. Rather the future trial will address variability and heterogeneity by randomizing approximately eight matched pair cluster (16 sites). We plan to match sites on a variety of criteria including sociodemographic factors, average rainfall, soil type, access to predominant source of surface water for irrigation (lake, vs. river, vs. shallow wells) and facility type (dispensary, vs. health center, vs. hospital).

Process evaluations garner in-depth knowledge around implementing complex interventions, which aids both interpretation of trial findings and informs potential replication (Oakley et al. 2006). Our process evaluation suggested robust acceptability of the *Shamba Maisha* intervention and trial, which aligns with the nearly 100% follow-up rate for both intervention and control participants at trial close. We also found that agricultural and financial training has strong advantages on their own, and that training should be integral to successful microfinance organizations. As anticipated, our qualitative data suggest that the microirrigation intervention can be laborsaving.

We also had significant challenges, most notably with regard to the microfinance component of the intervention. The partnering microfinance institution was unreliable, insolvent, and had a local branch closure during the trial. This is perhaps not surprising, given that past attempts to offer microfinance alongside HIV-related activities have experienced major challenges (Epstein 2006; Gregson et al. 2007). Researchers from the IMAGE intervention concluded that a strong microfinance partnership is indeed a pre-requisite to sustainably scaling this type of multisectoral intervention (Hargreaves et al. 2011). Thus, the replication of this trial in a larger setting should entail partnering with a microfinance institution that is financially stable and whose business model can accommodate *Shamba Maisha*. Participant concerns around loan repayment are an important ethical consideration; particularly in light of recent findings that microfinance may fail to provide enough income for financially disadvantaged households (Stewart et al. 2010; Barnes et al. 2001; Kaboski & Townsend 2008). As a result, we plan to consult local and global experts in microfinance in order to ensure that this component meets the needs of the study, and is designed with the potential for scale-up and sustainability in similar settings in East Africa.

These findings should be considered in light of design limitations. The pilot cluster-randomized design included two sites, and thus will need to be replicated in a larger cluster randomized trial. Second, qualitative process evaluations may suffer from respondent bias, particularly if participants held the impression that researchers were part of the intervention delivery team. We attempted to address this shortcoming by hiring separate in-depth interviewers that were not part of the primary study team. Lastly, the challenges with our microfinance organization made it difficult to assess the full potential of that component of the intervention.

We expect the pilot study will provide critical new evidence regarding the implementation of a multisectoral agricultural intervention aimed to improve food insecurity, household economic indicators and health among HIV-infected persons in rural Kenya. Following evaluation of the quantitative and qualitative results from this study, we plan to scale up this pilot to a cluster randomized trial to definitively assess the effectiveness of this intervention on the health of PLHIV using ART.

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PART IV

Food Security and Obesity and Diabetes



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Challenges of Diabetes Self-Management in Adults Affected by Food Insecurity in a Large Urban Centre of Ontario, Canada

Justine Chan, Margaret DeMelo, Jacqui Gingras, and Enza Gucciardi

9.1 INTRODUCTION

By 2020, the cost to treat diabetes mellitus, its complications, and its associated loss of productivity and life will exceed CAN\$19 billion a year [1]. Compelling evidence supports the benefits of intensive glycemic, lipid, and blood pressure control in the prevention and management of diabetes complications [2]. However, diabetes self-management is a challenge for many people as it involves learning and adopting self-care and self-monitoring practices [3]. For instance, medical nutrition therapy, a cornerstone in diabetes management, is one of the most challenging aspects of management [4, 5], encompassing not only healthy eating, but also insulin dose adjustment to carbohydrate consumed, as well as prevention and treatment of hypoglycaemia.

Household food insecurity is significantly more common among Canadians with diabetes (9.3%) compared to Canadians without diabetes (6.8%) [6], which is similar to that of other countries [7, 8]. Food security exists “when all people, at all times, have physical and economic access to sufficient, safe, and nutritious food to meet their dietary needs and food preferences for an active and healthy life” [9]. Notably rooted in poverty, food insecurity for people with diabetes poses additional challenges, principally, the lack of adequate and appropriate food and the effect on diabetes management [10]. Studies of adults who are food insecure show that they are more likely to have poorer health, inferior social support, and more comorbid conditions (e.g., obesity, high blood pressure, heart disease, and allergies) [11] as well as greater psychological distress and unhealthy behaviours, including smoking, physical inactivity, and low consumption of fruits and vegetables [6, 11]. Specifically, food insecure adults with diabetes are more likely to have poor glycemic control, long-term complications, and severe and frequent hypoglycaemia [12–16]. While it is clear that those that are living with diabetes and are food insecure experience more health problems and poorer overall health, knowledge on how they cope and manage with this health intersection and information on their lived experiences to date have been primarily absent in the literature. This type of knowledge can provide insight on how to better support and care for this population.

Using in-depth interviews with adults living with diabetes and food insecurity, our research paper explores these lived experiences and tries to understand how food insecurity affects people’s ability to manage their diabetes. The semistructured interview guide was based on the Social Determinants of Health Framework, given the significant influence of material deprivation and financial constraints on diabetes management decisions [17]. The findings will be novel as there is very limited qualitative research in this area.

9.2 MATERIALS AND METHODS

9.2.1 Qualitative Methodology

There is little contextual research on how and why individuals with diabetes coping with food insecurity are more likely to practice unhealthy behaviours and endure greater psychological distress. Using six phases of analysis, we chose qualitative, deductive thematic analysis, as it is flexible in its approach to extract themes from participants’ accounts [18].

9.2.2 Participant Recruitment

With the help of diabetes educators and flyers promoting the study, we conducted one-on-one interviews with clients from the local community, three community health centres, and a community-based diabetes education centre serving a low-income population in the Greater Toronto Area, Ontario, Canada. Eligibility criteria included a diagnosis of type 1 or 2 diabetes, English speaking, and having experienced food insecurity in the past year. Three questions were adapted from the Household Food Security Survey Module (HFSSM) [19] to identify participants: (1) In the past year, were you ever not able to buy your basic foods, such as fruits and vegetables? (2) In the past year, were you ever not able to buy your favourite foods? (3) In the past year, did you ever have to eat less than you felt you should have because of a limited budget? Eligibility was based on at least one affirmative response to the above questions. Homeless individuals were excluded, as the complexity of psychosocial vulnerabilities and mental health issues would extend far beyond the scope of our research question. See Table 1 for our sample demographics. Participant recruitment ended when theme saturation was achieved [20].

TABLE 9.1 Sociodemographic characteristics of participants.

	Number (n = 21)
Gender	
Women	10
Men	11
Ethnicity	
Caucasian	12
Caribbean	5
African	2
Middle Eastern	2
Place of birth	
Canada	12
Outside of Canada	9
Age	
20–30	1
31–40	1
41–50	7
51–60	9
61–70	3

TABLE 9.1 (Continued)

	Number (n = 21)
Marital status	
Married/common-law	2
Single	9
Divorced/separated/widowed	10
Education	
High school or less	7
University or less	4
College or less	9
Graduate school	1
Duration of diabetes	
≤5 years	11
6–10 years	4
11–20 years	2
21–30 years	2
>30 years	2
Type of diabetes	
Type 1	1
Type 2	20

Ethics approval for this research study was obtained from Ryerson University’s Research Ethics Board in Ontario, Canada (REB 2008-294). Initial data collection for this study was completed in 2009-2010. The four-member research team are comprised of one academic expert in diabetes (Enza Gucciardi), one expert in qualitative research (Jacqui Gingras), and two practice experts in diabetes (Justine Chan, Margaret DeMelo).

9.2.3 Procedure for Data Analysis

Eligibility, demographic information, and verbal informed consent were confirmed by the lead author prior to the interview. In total, 21 individual face-to-face interviews were conducted, lasting 30 to 90 minutes.

The semistructured interview guide is as follows.

Introduction

- Can you remember when you were first diagnosed with diabetes? What was it like?
- How did you react to the news?

Health Services

Think back to when you first learned about what you would need to do to manage your diabetes. How was that experience for you?

- What did the doctor/nurse/and so forth tell you about what you had to do to manage your diabetes? What was it like learning about what you needed to do in terms of food, physical activity, and medication? What challenges did you face in trying to follow the recommendations of your physician or the diabetes health care team?
- Can you tell me when you first found it difficult to buy or find food? Was this before or after you found out you had diabetes?

Income and Social Status

How did you manage through the times when you found it hard to buy or find food? How has this affected you in the past year? If they have kids or living with family: When providing meals for other people in the household, what were your major concerns?

Social Environments/Social Support Networks

Were you able to get the help/assistance/understanding/support you felt you needed during these times?

- What support was available to you at this time (formal support from health/social care providers, family, friends, church group, etc.)? Would you tell a bit me about these experiences? What supports really made a difference for you; what was most helpful to you? What more can they (health care providers, government, etc.) do to better help you?
- How have concerns around food affected your daily life?

Personal Health Practices and Coping Skills

Some of the things we've been talking about sound like they may have been very difficult/challenging for you. What have been the biggest challenges overall? What have been your "survival" strategies through all this? How confident are you now in your ability to manage your diabetes?

Cool-Down/Wrap-Up

Looking back on your own experiences, what would have made this whole journey easier for you?

- If you could send a message to other people in your situation, what would it be?
- What about healthcare providers? What would you like them to know?
- Is there anything else about this experience that was important to you that we haven't talked about?
- The responses you have provided may lead to some more questions. If so, can we contact you for a follow-up interview?

Probes were used to encourage participants to elaborate on their experiences. Participants received CAN\$30 honorarium at the end of their interviews. All interviews were digitally recorded and transcribed verbatim. Following data collection, we removed all participant identifiers to protect anonymity.

Our analysis process required six phases [21], beginning with the research team reviewing interview transcripts, while making notes for potential codes to return to at a later stage in analysis. The second phase involved developing preliminary codes, 50 in total, to capture as many potential themes as possible. We grouped transcript excerpts under these codes both manually and by NVivo data management software. Following phase two, we created clusters of codes and grouped them into ten major themes using the repetition technique where recurring topics generated the most relevant ideas [21]. In the third phase, we used thematic networks [22] to systematically present the study findings by listing our themes from specific to broad, that is, basic, organizing, and global themes, respectively. In the fourth phase, we met frequently to further refine our themes and triangulate the data. The basic themes were then grouped under three overarching themes. In the fifth phase, we refined theme wording to capture the meaning of what was said. The sixth phase involved writing and revising

the manuscript report, while the research team carefully considered the most meaningful extracts.

9.3 RESULTS

Our data analysis produced three main themes that captured the experiences of people with diabetes who are food insecure: (1) barriers to preparing and accessing appropriate food, (2) social isolation, and (3) enhancing agency and resilience (see Figure 1).

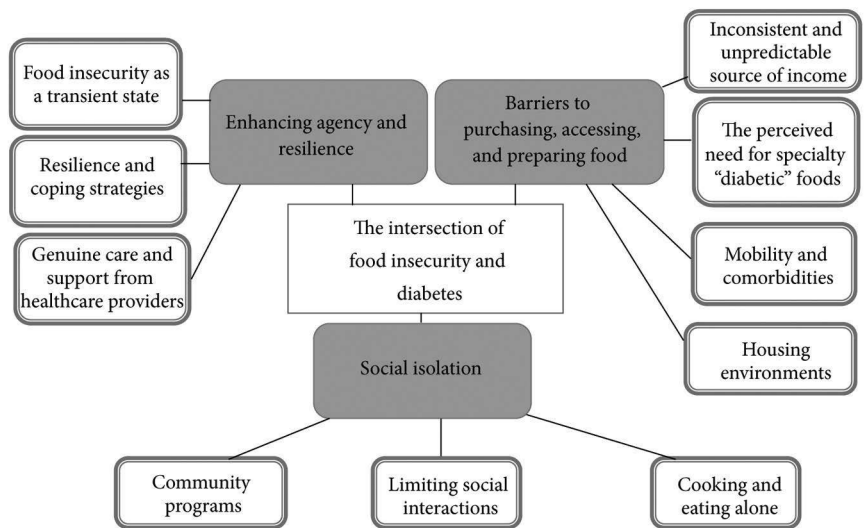


FIGURE 9.1 The intersection of food insecurity and diabetes.

9.3.1 Themes and Additional Supporting Quotes

Theme 1 (barriers to preparing and accessing appropriate food). Most participants could not afford foods appropriate for their diabetes management. Always buying “healthy foods,” counting carbohydrates, or tracking serving amounts were unrealistic approaches to meal planning because food supplies were often erratic due to an inconsistent and unpredictable source of income. When grocery shopping, their goal was to buy whatever cost the least (see Interviewee 1). Participants also worried about not having enough food to eat and described the

additional challenges brought on by a limited budget (see Interviewee 2). Meal planning was difficult and many depended on other resources, such as food banks and community kitchens. Inappropriate foods available at food banks (i.e., high in starch, salt, and sugar) were voiced (see Interviewees 4 and 5). Unfortunately, participants still struggled with access to these food sources (see Interviewee 3). For example, a single mother modified her work hours with the food bank's operating hours. Access to food was often better at the beginning of the month, resulting in more erratic blood sugars by month's end.

Housing environments presented barriers to food preparation. Many did not own a stove, resorting to microwaveable foods (see Interviewee 6). A lack of proper cooking facilities resulted in greater use of higher sodium foods such as processed and canned foods.

Misperception of the type of foods recommended for diabetes management was widely common. Participants discussed how specialty foods, such as those containing artificial sweeteners or labeled "diabetic," were perceived as "better," expensive, and, contrary to current nutrition recommendation, understood to be necessary for the management of diabetes (see Interviewees 7 and 9).

The barriers resulting from the intersection of diabetes and food insecurity were especially evident for those who had to cope with debilitating comorbidities. Retinopathy and neuropathy, in particular, greatly reduced their access and selection of both fresh and appropriate foods (see Interviewee 8). For example, many voiced the challenge of no longer being able to travel to food banks or grocery stores and had difficulty selecting and preparing food (see Interviewee 2).

Interviewee 1: I don't have a lot of money... so I'll buy junk food, instead of real food... because the junk food is cheaper.

Interviewee 2: I'm on [disability benefits] at the moment, so sometimes I find it's a bit hard... I have to be very conscious of... and trying to think of not just buying food but planning meals and planning food throughout the month that will last throughout the month... sometimes I worry about running out of food and, because I'm diabetic, I can't just skip meals... I find I have to be more conscious of what I eat and when I eat... I find that a bit troubling.

Interviewee 3: It's all controlled by how much money you make... how much you pay rent. Most places [food banks] say you can come once every two weeks – and they give you one shopping bag of groceries and that's supposed to last you two weeks. If you don't have the funds, how are you supposed to eat? So you have to go to the food kitchens... you have your days kept busy running back and forth

to find places to eat...some days you might not make it there...so you don't eat properly.

Interviewee 3: A lot of my food comes from the food bank. They only give you certain types of foods that don't really help you with diabetes, more or less go against your diabetes—a lot of sugar, cookies, stuff like that.

Interviewee 4: It's mostly pastas, heavy in starch, pasta, rice, pasta sauce...and cereals, stuff that's got sugar in it. There's not an alternative they give you.

Interviewee 5: You don't have enough fruits – juice is no good. The fruits are better, but you have zero access. They have fruit roll ups, they have junk food which I don't eat, so I give back most of the stuff.

Interviewee 6: The fact that I have the necessary facilities to cook...I've got a stove...but I never use it because...the person before [was]...I found this little thing and it'd blow up on me...I mean it looks nice, it's kept clean and it's spotless inside, but so is a hand grenade before you pull the pin too...I bought my own microwave...I use everything microwave or I eat out of a can cold.

Interviewee 7: I have to get...artificial sweetener now, too, and that's expensive compared to other stuff...I get the diet soft drinks, and I get juices. But then there's a lot of sugar in the juices, so I try and mix it with water, and then I find that not a lot of grocery stores have just a specific section. I've noticed that some of them, like the drug stores...have a certain section. Some of the items that are in the diabetic aisles...they are expensive too, right?

Interviewee 9: It'd be easier for me if I could just buy regular food, I don't have to buy special stuff that's low sugar and stuff. If I want it, I'd have to pay more for it.

Interviewee 8: For the past 4, 5 years...all the eye problems and everything else...it made it difficult to do things. You can't manage. You can't see to cook...the finger gets numb because of the diabetes. The nerves and the fingers, you cannot hold things...and even when you're buying stuff...you're holding it, but you can't really tell whether it's...good or [if] it's not good...I just...use the canned goods.

Interviewee 2: I hate going [to] the grocery store and getting...loads and loads...of groceries. I'd much prefer to shop every two or three days, but that's not really practical in terms of getting enough food and...making sure it

keeps fresh...it's hard when...I've got some physical problems and hauling it around...is...difficult.

Theme 2 (social isolation). Most participants were single and described the impact of food and eating alone on their well-being. Socializing incurred more cost on travel and clothes (see Interviewee 5). Because lack of funds limited social interactions, many felt isolated and depressed (see Interviewee 6).

While some considered eating out a special treat, especially for those who felt lonely and isolated, the impact of limited finances and having diabetes further restricted social interactions. Feeling the need to justify their food and beverage choices and to eat and drink differently from their friends were apparent barriers (see Interviewee 9).

Community food initiatives such as community kitchens and gardens, volunteering at food distribution centres, connecting to a church group, and attending drop-in meal programs were all means of connecting with others and were considered a valuable resource that helped to ameliorate both food insecurity and social isolation (see Interviewees 10 and 11).

Interviewee 5: I've...been inverting myself more to a cocoon?...I've stopped socializing...don't feel like it...cost of going, even if it's just subway or gas, it's money. So...I finally went to [an event] last week, because...I really had the feeling that if I didn't show up this time, they weren't going to invite me again...but people don't know...yes, I'm in between, going through a hard time, but that's about it. You can't admit that you're doing what you're doing. And most people don't recognize me dressed this way...I'm really careful where I go. So I basically don't go out unless I have to.

Interviewee 6: Since I can't always get what I really want, it adds to the depression...I can't go to the restaurant with my friends, "cause the guys are, like, "C"mon let me just take you for a cup of coffee or something outside"...I don't have the money to do that. I feel bad, I can't offer. A lot of times you have to go off your diet because, one, you can't afford it or, two, you have your meds. Thank God it's [diabetes medication] been covered, to compensate for what you don't have. I might go...to get a taco...or something that I haven't had in a long while, or go into the local grocery store. They have good pizza...and other things are cheap...it's also a treat...I've got a can opener that works, but how often...[do] I go...I've been eating alone in [my] apartment.

Interviewee 9: I really can't look forward to going out to eat...I'm having lunch with a friend of mine...I couldn't do that on my own...but he's treating me...I'd

like to go out more, and I really can't, you know? I'm tired of saying "Well, we can't really go out...can we do this instead?" which doesn't cost any money...I feel a little bit guilty about that. ...I don't know what people think of me...I can't really say "Oh I'm diabetic", and I can't do this, this, and this, without making myself look like...I'm really, really sick...and I'm not really that sick, it just means that I've got to limit myself... [if] somebody says "Let's go to a club or somewhere"...I can't drink because you know when you drink...even beer, it's got sugar in it. If I have one beer, it's going to affect me the next day...if I go to a club and order a Diet Coke, you know they're just going to say "What's wrong with him?" I'm not going to really want to get into a big explanation about how sugar affects me.

Interviewee 10: I think mostly it's the social factor of eating alone. I don't like eating alone. So...there's a community dinner that I go to, my [church group]... I've gone there for years...I go to drop-ins with my friends for two reasons: one, because I like to eat with other people, and two, because I can't afford to buy food anymore...some of the places have really good food. Some of them have food that's very high in carbohydrates, which isn't good for diabetics...plus it puts weight on you.

Interviewee 11: I go to a church and they are helpful too...if I go to church on Sunday, somebody will take me home. Most Sundays I go home with somebody...that is the next supportive group, my church...they take me home and I'm fed for the day.

Theme 3 (enhancing agency and improving resilience). Some participants considered their food insecurity to be temporary. One or more major life events, such as financial loss, job loss, marital separation, or divorce coincided with the onset of food insecurity. Many described survival strategies that buffered current adversity. For example, participants used positive self-talk, such as "Believe in your heart that it will be alright," "My life will get back on track", "You just live one day at a time", and "I will survive". Others expressed optimism through such phrases as "It's gotta be over...one way or the other".

The role of healthcare providers is pivotal in enhancing agency and resilience. Participants drew on the heartfelt help and practical diabetes management strategies received from healthcare providers who they found to be "genuinely caring," "gentle," and "loving" (see Interviewee 14). Feeling cared for was referred to as "the human factor" and resonated in the examples participants gave, serving as empowerment to better manage their diabetes. Other participants appreciated when their healthcare providers inquired about issues not related to diabetes (see Interviewee 15).

Participants offered suggestions to care providers on what was helpful to them: “Keep information simple for people to understand”, “Listen to patients,” “Be positive, and encouraging and supportive”, and “Do not be judgmental”. Practical advice and counselling helped them regain their agency in managing diabetes and coping with food insecurity. More specifically, participants suggested “specific inexpensive menus,” “more lists, more recipes, and low-cost ideas of meals,” creative ways to share food, and alternatives to food choices (see Interviewee 9). In these ways, healthcare professionals can tailor their advice specifically to the needs of food insecure clients.

Participants demonstrated resilience by implementing various strategies to better manage their diabetes, given their circumstances. For example, several participants spoke about including protein with meals, saving time and costs by batch cooking and buying starchy foods in bulk, comparison-shopping for sale items, and buying nonbrand items from discount grocery stores. Participants acknowledged that taking their medications regularly helped to compensate for their limited control over food intake and compromised food choices (see Interviewee 6 and Interviewee 2).

Interviewee 14: I know from what I’ve seen with you and your staff, you people do genuinely care about us. That’s a big step... it means a lot. I mean ... since I was here last week till now, I’ve felt better about the whole situation because I know there [are] people out there that do actually care that I’m a diabetic... it really does make you feel better. It makes you wanna stay on track even more... And the way I see it, this is only human nature. Because everyone wants to feel loved somewhere, somehow, and when you know you have a group like that behind you, it, it makes you stronger.

Interviewee 15: Every time I go see [my family doctor] ... he’s not just like, “Yeah, okay you’re here for the visit. Thank you very much. See you next month” ... He’ll ask me ... “Emotionally, how do you feel? Is anything bothering you? Are you getting the shakes? Are you taking too much salt in?” So ... I listen to him ... he’s good.

Interviewee 9: I’d say the most help I get is through this dietitian. You know, she’ll tell me ... “why don’t you try this or you know, mix that with that?” ... and, you know, I tell her my budget is limited and she’ll say, “okay, this is cheaper, try that”, and it’d be things I would never think of.

Interviewee 6: Where the food is cheap... if you take your medication, it will counteract the stuff that you’re not supposed to have ... you eat what you can get, when you can get it. A lot of times you have to go off your diet because, one, you

can't afford it or, two, you have your meds. Thank God [they're] covered, to compensate for what you don't have.

Interviewee 2: I think just keeping a positive outlook and just...making sure I take my medications...I guess I figure that the medication will make up for some of the lapses that I've done, because I know that some people are able to perfectly manage diabetes.

9.4 DISCUSSION

Individuals living with diabetes who are food insecure face many challenges that greatly impact their ability to self-care [10–16]. Our findings demonstrate that these individuals have a limited ability to acquire, select, and prepare appropriate foods, in addition to maintaining consistent carbohydrate intake and meal spacing throughout the day. Barriers to observing an appropriate diet for diabetes management include financial constraints, a knowledge deficit for healthy meal planning on a limited budget, housing environments unconducive to food preparation and storage, inadequate community resources, and physical disabilities associated with comorbidities. The literature in Canada [10, 23] and Australia [7] confirms that many have insufficient income left after paying rent to purchase appropriate food. This was further compounded by the misperception that a “proper” diabetes diet requires “diet” foods that are low in sugar, contain artificial sweeteners, and are labelled “diabetic” [7]. Given the rising cost of healthy food [7], the circumstances of those who are food insecure can only get worse. Many study participants relied heavily on canned and convenient, high sodium, high carbohydrate foods. They stressed the inadequacy of food banks and community kitchens in meeting their special diet needs, a finding consistent with Tarasuk’s research on community-based responses to food insecurity [23, 24]. López and Seligman suggest that the reliance on low-cost, energy dense foods and the inability to afford nutritious food can have a cascading effect not only on glycemic control, but also on depression, distress, and fatigue, all of which can negatively impact self-management behaviours [13]. Clinicians should therefore focus their recommendations on reducing portion size of foods that are available and accessible to them rather than focusing on food and beverage substitutions that may not be attainable [13].

Individuals with diabetes are more likely to have comorbidities than those without diabetes; it is estimated that all individuals with diabetes in Canada have some form of diabetic retinopathy, a frequent cause of legal blindness, and 40 to

50% of Canadians with type 1 or type 2 diabetes will manifest painful neuropathy within 10 years of diagnosis [4]. Several of our participants reported these complications and consequently had difficulty traveling to grocery stores, selecting fresh produce, and cooking nonprocessed foods due to sight and mobility impairments, creating a food insecure state in and of itself. Clinicians should therefore keep an inventory of meal or food delivery resources such as “Meals on Wheels,” “Grocery Gateway,” or “Heart to Home Meals,” all of which can assist an individual with physical disabilities to access, budget for, and prepare healthy foods without leaving the home and this has been supported by other research [13].

Based on our findings, we recommend that clinicians systematically screen for food insecurity, refer to the registered dietitian as needed, tailor the care plan, and identify increased health risks, particularly for hypoglycemia that often results from missed meals or inadequate carbohydrate intake. Treatment regimens should incorporate medications that have a lower risk of hypoglycemia and that can be adapted to unpredictable or inadequate food intake as a result of food insecurity [13, 15].

Trying to manage diabetes in conjunction with a low income led to social isolation for many; most of them lived in single-person households, a common characteristic of food insecure individuals [23]. Our participants had no one to share and prepare meals with; they also limited social interactions to save costs, increasing their risk of depressive symptoms. They used resources such as community kitchens, church groups, and food coops to cope with their food insecurity and social isolation. Canadian research has shown decreased psychosocial distress and increased food security among community kitchen participants [18]. We also recommend that clinicians incorporate more group-based learning opportunities such as workshops that focus on food budgeting, low-cost meals, and, as other authors have suggested [13], strategies for more affordable healthier substitutions (e.g., buying frozen instead of fresh vegetables). Including a hands-on component such as a food skills demo is essential in engaging and motivating clients to try these strategies on their own.

Research suggests that food insecurity is cyclical, shifting between periods of food scarcity and food adequacy [14] and that food insecurity can be either chronic or temporary [25]. Similar to research among low-income Canadians, most participants in our study viewed their food insecurity as a temporary setback [10] and employed various survival strategies to endure this setback. Participants also valued the “genuine” care and “support” received from health care providers. Valued relationships with healthcare providers can be the key for patients to regain their agency to manage their diabetes during bouts of food

insecurity. Norwegian research suggests that healthcare providers can encourage diabetes self-management by employing an empathetic, individualized approach [26]. It also has been suggested to move beyond the “patient-centered approach” to one that is “empowering and partnering” and that builds an emotional relationship between the healthcare professional and the client [27]. Furthermore, a recent study reported that food insecure clients respond well to diabetes self-management support programs as evidenced by a decrease in hemoglobin A1c and an increase in self-efficacy and fruit intake [28].

The study has the following limitations. While we acknowledge that the experience between those with type 1 and type 2 diabetes differs, the goal of our paper was not to compare but to obtain the general challenges that these people experience. Also, there currently is a lack of research available to distinguish the major differences in experience between the two groups. We interviewed participants in a large urban centre and, therefore, our findings may not be transferable to people in small towns and rural areas. Future research should examine the benefits of physician screening for food insecurity and diabetes self-management programs tailored to food insecure clients as this has the potential to save significant medical costs and influence the future of diabetes care.

9.5 CONCLUSION

Food insecurity presents a great challenge to diabetes self-management, an already complex chronic illness. In our study, participants faced multiple barriers to accessing appropriate foods: insufficient income, misperceptions about healthy food choices, multiple comorbidities, and inadequate cooking facilities that cumulatively impact food acquisition, selection, and preparation. Social isolation compounded these barriers, although it was somewhat buffered by the coping strategies they used and by the community food initiatives and social support networks they were able to access. Without access to healthy food, the identified barriers can potentially result in fatigue, decreased social well-being, and increased health problems, ultimately discouraging an individual to practice self-care behaviours (e.g., blood glucose monitoring, physical activity, and healthy coping). Healthcare providers should be aware of the challenges that food insecurity poses for people with diabetes, as well as the potential they have to optimize their encounters with patients. Our findings underpin the importance of understanding diabetes through the perspectives of patients’ lives and tailoring diabetes management plans and community programs within the context of food insecurity.

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Children's Very Low Food Security is Associated with Increased Dietary Intakes in Energy, Fat, and Added Sugar among Mexican-Origin Children (6-11 Y) in Texas Border *Colonias*

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10.1 INTRODUCTION

The Southwestern United States border region is home to many *colonias*. These settlements are occupied by a growing population of people who share a similar Mexican heritage, language, and socioeconomic standing and who have unacceptably high rates of poverty, adult and childhood obesity, and food insecurity [1–3]. Border-region *colonias* can be considered an archetype for the increasing number of new destination immigrant communities [1]. Many of these communities of Mexican immigrants are located throughout the United States, including many non-traditional interior locales [4–6].

Food insecurity underpins an emerging national issue of nutritional health inequity among Mexican-origin and Hispanic households. The 2009 Current

Population Survey Food Security Supplement identified low or very low food security in 26.9% of Hispanic households, compared with 14.7% in all U.S. households, and in 18.7% of Hispanic households with food-insecure children compared with 10.6% in all households [7]. In a study of Mexican immigrant families in Minnesota, Kersey and colleagues observed much higher rates of child hunger among 1,310 Mexican immigrant families than among 1,805 non-immigrant families (6.8% versus 0.5%) [8]. Food insecurity is much more prevalent among Mexican-origin households in the Texas border region compared with other regions of the U.S. [3, 7]. In a study of food access among 610 adult women in Texas border *colonias*, researchers found 49% of all households and 61.8% of households with children could be classified at the most severe level of food insecurity—child insecure [3].

At the same time, nutrition-related health conditions, such as obesity and type 2 diabetes, are increasing in Mexican-origin youth. Risk factors for obesity and type 2 diabetes are more common in Mexican-origin children than other racial/ethnic groups [9–11] and include increased intakes of energy-dense and nutrient-poor foods, such as fats, sweeteners, desserts, and salty snacks. Energy-dense foods are highly palatable and promote higher calorie intakes [12, 13]. Diets with proportionally more contribution from energy-dense foods increase the risk for inadequate intakes of vitamin D, calcium, potassium, and dietary fiber and the likelihood of consuming excessive amounts of added sugar, fats, and sodium [14]. For limited-resource populations (households with limited economic and physical resources and limited access to healthy foods), including children of Mexican-origin, energy-dense foods may also be more accessible, available, and affordable [2, 15–17]. This may be especially true for Mexican-origin children in Texas border *colonias* who reside in food-insecure households in communities lacking access to nutritious food [2, 3, 18]. For children, residing in a food-insecure household can prevent them from achieving the nutrient intake needed for optimal development and health, as well as impede their academic performance [19–26].

Thus, it is critically important to understand the relationship between food insecurity and children's dietary intake among limited-resource Mexican-origin children. However, few studies have examined this association. Prior studies among Hispanics relied exclusively on parental reports of household food-supply adequacy and their child's diet and experiences. These studies revealed multiple associations between food insecurity and diet. Food-insecure children were less likely to meet recommended food-group guidelines [27], have greater intakes of fats, saturated fats, sweets, and fried foods [28], and lower fruit and

vegetable intake at home [29]. Among 5th grade students who reported dietary intake using three 24-hour dietary recalls and whose mothers reported food security, food-security status was not associated with dietary intake [30]. Only one study assessed dietary intake through child-reported dietary recalls, and none measured food security from the child's perspective.

Although mothers often spare their children from nutritional deprivation and report that children are more protected from household food insecurity [31, 32], this experience is from the parent's perspective [33]. There has been a call for research to assess the relationship between food security and children's diet [34], yet little research has focused on child's perceptions or experiences of food insecurity and their association with dietary intake [35]. Current measures represent household food security status of the household or children within the household as a group, rather than the experiences of a particular individual within the household [36]. Children best report their own experiences [37]. Measurements of food security as reported by the child, which may be more sensitive of the food issues experienced by children, is essential for understanding the influence of food insecurity on the nutritional health of children [35]. Understanding the relationship between children's experience of food security and their dietary intake [30] is needed to comprehend the effect of food insecurity on children's nutrient intake [38]. The current study seeks to assess the relationship between children's experience of food insecurity and nutrient intake from food and beverages by (1) assessing food security status as reported by 50 Mexican-origin children (ages 6-11 years), (2) examining nutrient intakes from three 24 hour dietary recalls from each child, and (3) determining the relationship between food security status and nutrient intake.

10.2 METHODS

10.2.1 Setting

The study was conducted in two large areas of *colonias* in Hidalgo County, located in the Lower Rio Grande Valley of Texas along the Mexico border. From prior work and in consultation with community partners [2], 10 census block groups (CBG) were identified in the western part of the county and 10 in the eastern portion of the county. In both areas, a majority of CBGs are considered to be highly deprived neighborhoods [2]. Highly deprived neighborhoods are those with overall high proportions of unemployed adults, households without

telephone service, families receiving public assistance, households lacking complete kitchen facilities, households lacking complete plumbing facilities, adults with less than 10 years of education, or those living below the poverty threshold [2]. Forty *colonias* were spatially selected, with at least one colonia in each of the 20 CBGs.

10.2.2 Study Sample

The study sample consisted of 50 family dyads (mother and child 6-11 years), who were recruited for a cohort study by team *promotora*-researchers; 25 dyads were recruited from western area *colonias* and 25 from eastern area *colonias*. Letters of invitation were personally delivered by *promotora*-researchers, and eligibility was determined by the presence of one child (age 6-11 years) residing in the household. The study was explained to each prospective adult participant (e.g., inform about assessments, confidentiality, financial incentive, etc.), and the first of three in-home assessments was scheduled within two days. The mother provided consent for both members of the dyad to participate in the study, and the child provided assent for participation. All materials and protocols were approved by the Texas A&M University Institutional Review Board.

10.2.3 Data Collection

This analysis focuses on data collected March to June 2010 from all 50 children during three in-home visits: survey data and anthropometrics from the first visit and dietary recalls from all three visits. The survey included sections on demographics and food security and was interviewer-administered by *promotora*-researchers, who received training in collection of survey, anthropometric measures, and 24-hour dietary recalls. All materials were reviewed by community partners and were validated by local/area experts. A pilot test was conducted in *colonias* not selected from the study area and necessary modifications were made. *Promotora*-researchers received the equivalent of four full days of training on data collection and protection of participant confidentiality. All measures were translated into Spanish using translation-back translation method with the following steps: 1) translation of the original English into Spanish, ensuring that the English meaning is maintained; 2) back-translation

into English by an independent translator who is blinded and is not familiar with either the Spanish or English version; 3) comparison of the two English versions; and 4) resolution of any discrepancies. Community partners and promotoras-researchers verified translation accuracy and appropriateness to ensure semantic, conceptual, and normative equivalence. All survey and 24-hour dietary recall data were collected in Spanish, which was the language spoken in the homes of all participants.

10.2.4 Measures

Demographics included child's sex, age, school grade, and country of birth.

Anthropometric measure of body mass index (BMI) was used to gain a general sense of body fatness. Weight was measured (to the nearest 0.1 kg) in the home with a portable, self-zeroing scale. Weight was measured twice, with the children wearing light clothing and no shoes. Standing height (to the nearest mm) was measured twice with a portable stadiometer. Using the mean of the two measures of weight and height, BMI was calculated as weight (kg)/[height (m)]². Appropriate Centers for Disease Control and Prevention (CDC) BMI-for-age-and-sex growth charts were used to classify each child's BMI status as underweight (< 5th percentile), healthy weight (5th percentile to < 85th percentile), overweight (85th percentile to < 95th percentile), or obese ($\geq$ 95th percentile) [39, 40].

Children's food security was assessed using the nine-item child food security measure developed by Connell and colleagues [33]. Pilot testing of the food security measure with a sample of children similar to participant children was performed to determine understandability and face validity. Participant children were asked by the *promotora*-researcher whether they experienced each of the nine items during the last three months (see Table 1). Response options included "a lot," "sometimes," or "never." Each item was constructed as a binary variable; yes (a lot or sometimes) vs. no (never). Iterative common factors analysis on the nine items identified one factor (eigenvalue = 3.2) that explained 79% of the shared variance; and internal reliability was good (Cronbach's α = 0.81). Affirmative responses to the nine items were summed into an ordinal children's food security score [34], which was used to categorize each child as having high food security (score = 0), marginal food security (score = 1), low food security (score = 2-4), or very low food security (score = 5-9).

TABLE 10.1 Children self-reported food security (n = 50)

In the last 3 months,	N (%)¹
1. Did you worry that food at home would run out before your family got money to buy more?	25 (50)
2. Did the food that your family bought run out and your family did not have money to get more?	23 (46)
3. Were you not able to eat a variety of healthy foods at a meal because your family didn't have enough money?	20 (40)
4. Did your meals only include a few kinds of cheap foods because your family was running out of money to buy food?	27 (54)
5. Was the size of your meals cut because your family didn't have enough money for food?	17 (34)
6. Did you have to eat less because your family didn't have enough money to buy food?	16 (32)
7. Did you have to skip a meal because your family didn't have enough money for food?	15 (30)
8. Were you hungry but didn't eat because your family didn't have enough food?	4 (8)
9. Did you not eat for a whole day because your family didn't have enough money for food?	6 (12)
Food Security Categories	
High food security	9 (18)
Marginal food security	9 (18)
Low food security	18 (36)
Very low food security	14 (28)

¹Affirmative response = combination of "a lot" and "sometimes"

10.2.5 Dietary Intake

Three 24-hour (previous day) dietary recalls occurring on randomly selected, nonconsecutive days (one recall measured weekend intake and two measured weekday intake) were collected in the home from each participant child by the same interviewer (*promotora*-researcher). In most cases, the mother observed and assisted the children if necessary. Dietary intake training for the interviewers included review of all protocols and scripts, modeling of interviewing, practice interviews with children similar in age to the study participants, use of tools for portion-size estimation, quality control, and focus on children's reporting of food items. The first recall occurred during the first in-home visit, and the second and third recalls were collected in the home during the second

and third visits (within two weeks of the first visit). Detailed information on food and beverage consumption, including description, brand name, location of preparation and consumption, and preparation method during the previous day was collected using standardized protocols following a modification of the multiple-pass interview technique of the Nutrition Data System for Research (NDS-R) [41]. Data were collected on hard copy in Spanish, modified from an approach previously used [42], and then entered into NDS-R 2009 in English [41]. Children were first asked to provide a quick list of generic food and beverage items consumed during the previous day based on short time intervals (e.g., before breakfast, at breakfast, between breakfast and lunch, and at dinner); prompts included food consumption occasions and locations. This was followed by a review of the quick list. During this pass, the interviewer probed for forgotten foods by asking about snacks and beverages (including water) and about the source of the food or beverage. The third pass provided food details such as the time and place of the eating occasion, food descriptions, brand name, ingredients and preparation, and portion size and quantity consumed. As a result of pilot testing, multiple approaches were used for estimation of portion size and included measurement of typically-used cups, glasses, bowls, and containers in the home, food and beverage models, geometric shapes (circles, rectangles, and wedges), and three-dimensional thickness aides. The fourth pass was a final and comprehensive review of the previous-day's intake. Nutrient calculations were performed using NDS-R 2009 software. Three-day mean nutrient intakes, with equal weighting for each of the three days (2 weekdays and 1 weekend) of dietary recall were calculated for each child for total energy (kcal), protein (g), dietary fiber (g), calcium (mg), vitamin D (mcg), potassium (mg), sodium (mg), Vitamin C (mg), percentage of calories from fat, percentage of calories from added sugars, and percentage of calories from saturated fat.

10.2.6 Analysis

All analyses were performed using Stata Statistical Software: Release 11 (College Station, TX: StataCorp, 2009). Descriptive statistics were calculated for each child's baseline characteristics, BMI status, food security status, and nutrient intake. Wilcoxon Signed-Rank Test was used to compare weekend and weekday nutrient intake by level of food security. Non-parametric test for trend across ordered groups of food security was used to examine each nutrient. Separate multiple regression models with robust (White-corrected) Standard errors (SEs), were individually fitted for total energy (kcal), protein (g), dietary fiber

(g), calcium (mg), vitamin D (mcg), potassium (mg), sodium (mg), Vitamin C (mg), percentage of calories from fat, percentage of calories from added sugars, and percentage of calories from saturated fat. All models included sex, age, country of birth, BMI status, and food security status as independent variables. These variables were selected based on their documented association with dietary intake.

10.3 RESULTS

Table 2 shows baseline characteristics for the 50 participant children. Sixteen children (32%) were born in Mexico and twenty-one (42%) were overweight or obese based on the Centers for Disease Control and Prevention BMI-for-age-and-sex growth charts [40]. Results from the nine-item children's food security measure are shown in Table 1. Thirty-two children (64%) reported low ($n = 18$) or very low food security ($n = 14$). Although BMI status was not significantly associated with food-security status, 48 percent of the sample was measured as being of healthy weight and reporting low or very low food security. Nutrient intake and dietary recommendations for the entire sample and nutrient intake by food-security status are shown in Table 3. Using the 2010 Institute of Medicine age- and sex-specific recommendations [43], 28% ($n = 14$) met the recommendations for calcium, none for potassium or vitamin D, 10% ($n = 5$) for dietary fiber, and 6% ($n = 3$) for sodium (data not shown). Although all children exceeded the recommendation for protein, as a percent of total calories, protein intake ranged from 11.8% to 22% (data not shown). Weekend intakes for calcium, vitamin D, potassium, and vitamin C were significantly lower than weekday consumption, and percentage of calories from fat, and combined percentage from fat and added sugar (data not shown) were significantly higher on weekends than weekdays. Children who were identified with low food security consumed significantly less calcium and vitamin D on weekends, compared with weekdays, and very low food-security children consumed a greater percentage of calories from fat on weekends than weekdays. Three-day average intake for total energy, protein, percentage of calories from added sugar, and percentage of calories from saturated fat demonstrated a significant and positive trend (indicating greater intake) with reduced food-security status. The same positive trend was observed for weekend intake of total energy, and for weekday intake of percentage of calories from added sugars and saturated fat.

TABLE 10.2 Baseline characteristics of Mexican-origin children (n = 50)

	Mean ± SD (Median)	N (%)
Sex		
Female		31 (62)
Age, y	9.1 ± 1.3 (9.2)	
Country of birth		
Mexico		16 (32)
United States		34 (68)
Weight status ^a		
Underweight		5 (10)
Healthy weight		24 (48)
Overweight		9 (18)
Obese		12 (24)

^a Based on BMI-for-age-and-sex growth charts. Underweight = < 5th percentile; healthy weight = 5th percentile to < 85th percentile; overweight = 85th percentile to < 95th percentile; and obese = ≥ 95th percentile

The multiple regression results, presented in Table 4, show the association of children’s food-security status, sex, age, BMI status, and country of birth to nutrient-specific intakes. Very low food security was associated with greater intakes of total energy, calcium, and percentage of calories from added sugar. In data not shown in Table 4, marginal ($\beta = 4.8$, SE = 2.2, $p = 0.032$), low ($\beta = 4.4$, SE = 1.9, $p = 0.028$), and very low ($\beta = 8.4$, SE = 2.0, $p < 0.001$) food security were associated with increased intake as a percentage of calories from combined fat and added sugar. In addition, increased age was associated with lower intakes of calcium and vitamin D; being born in Mexico with greater intake of sodium; and being female with lower calcium intake. BMI status was not associated with any of the nutrients.

10.4 DISCUSSION

Previous work has recognized the relationship between food security and children’s diets [34, 35, 37], but this is apparently the first study to assess the relationship between food security and children’s nutrient intakes in Mexican-origin children, based on children’s reports of both their experiences of food

TABLE 10.3 Nutrient intake (3-day average, weekday average, and weekend) overall and by food security status^a

	Dietary Recommendations		Total Sample	Food secure	Marginal food secure	Low food security	Very low food security
	6-8 y	9-11 y	(N = 50)	(N = 9)	(N = 9)	(N = 18)	(N = 14)
Total energy (kcal)	1400-1600	1600-2200					
3-day average ^{c2}			2034.9 (372.8)	1766.9 (354.5)	2049.2 (287.0)	1994.2 (340.7)	2250.2 (376.6)
Weekday			2008.1 (375.8)	1757.4 (313.9)	2081.7 (318.0)	2020.7 (363.4)	2105.8 (423.0)
Weekend day ^{c2}			2097.5 (717.6)	1785.9 (761.6)	2023.0 (687.5)	1947.0 (611.9)	2539.1 (700.9)
Protein (g)	19	34					
3-day average ^{c1}			82.9 (19.7)	73.3 (17.9)	78.4 (14.1)	84.8 (20.2)	89.5 (22.0)
Weekday			81.1 (19.9)	70.7 (18.0)	78.8 (11.8)	86.7 (21.7)	82.1 (21.9)
Weekend day			86.4 (36.7)	78.6 (36.3)	76.5 (30.2)	81.6 (35.8)	104.1 (39.3)
Dietary fiber (g)	17-20	22-25					
3-day average			15.2 (5.0)	15.7 (3.3)	14.3 (4.2)	16.2 (5.3)	14.1 (6.2)
Weekday			15.5 (5.3)	16.6 (5.1)	16.2 (5.6)	16.5 (5.8)	13.1 (4.3)
Weekend day			14.6 (9.8)	13.8 (6.9)	10.8 (4.6) ^{b1}	15.6 (7.1)	16.1 (15.4)

TABLE 10.3 (Continued)

	Dietary Recommendations		Total Sample	Food secure	Marginal food secure	Low food security	Very low food security
	6-8 y	9-11 y	(N = 50)	(N = 9)	(N = 9)	(N = 18)	(N = 14)
Calcium (mg)	1000	1300					
3-day average			993.4 (300.5)	820.4 (266.4)	1077.5 (245.4)	951.6 (228.1)	1104.3 (387.6)
Weekday			1056.3 (299.6)	918.2 (360.2)	1131.5 (149.1)	1095.7 (321.3)	1046.2 (300.8)
Weekend day			898.2 (566.2) ^{b2}	624.7 (355.8)	999.7 (609.7)	733.6 (381.5) ^{b2}	1220.6 (709.3)
Vitamin D (mcg)	15	15					
3-day average			6.9 (2.9)	5.4 (2.9)	7.6 (1.9)	6.2 (2.5)	8.4 (3.4)
Weekday			7.5 (2.7)	6.3 (3.1)	7.9 (2.6)	7.2 (2.2)	8.6 (3.0)
Weekend day			5.8 (4.4) ^{b3}	3.6 (3.5) ^{b1}	6.8 (2.1)	4.6 (4.3) ^{b2}	8.0 (5.1)
Potassium (mg)	3800	4500					
3-day average			2530.1 (554.4)	2499.1 (482.4)	2489.6 (451.5)	2457.6 (530.4)	2669.4 (701.4)
Weekday			2640.3 (602.8)	2649.6 (573.2)	2692.4 (466.5)	2650.3 (695.9)	2588.0 (628.9)
Weekend day			2332.9 (955.2) ^{b1}	2197.9 (976.7)	2052.4 (716.3)	2152.2 (782.3)	2832.3 (1164.0)

TABLE 10.3 (Continued)

	Dietary Recommendations		Total Sample	Food secure	Marginal food secure	Low food security	Very low food security
	6-8 y	9-11 y	(N = 50)	(N = 9)	(N = 9)	(N = 18)	(N = 14)
Sodium (mg)	< 1900	< 2200					
3-day average			3450.7 (913.2)	3083.0 (750.9)	3165.0 (330.6)	3687.8 (1050.7)	3565.9 (1021.4)
Weekday			3372.1 (994.8)	3100.0 (881.8)	3180.7 (357.7)	3698.0 (1227.5)	3251.0 (981.2)
Weekend day			3553.5 (1695.0)	3049.0 (1074)	3042.9 (1198.7)	3561.5 (1934.2)	4195.7 (1881.8)
Vitamin C (mg)	25	45					
3-day average			101.1 (52.7)	114.2 (64.6)	92.7 (55.9)	87.8 (36.8)	113.7 (59.4)
Weekday			110.5 (63.8)	124.7 (72.2)	105.1 (69.2)	93.8 (57.4)	122.6 (64.2)
Weekend day			81.4 (70.4) ^{b2}	93.3 (98.6)	62.2 (56.8)	78.9 (52.8)	95.8 (82.0)
Fat (percent of calories)	25-35	25-35					
3-day average			34.0 (4.1)	32.2 (4.4)	33.0 (3.8)	35.3 (4.5)	34.2 (3.2)
Weekday			32.5 (4.2)	30.3 (3.2)	32.9 (5.3)	33.4 (4.4)	32.7 (3.7)
Weekend day			36.8 (7.8) ^{b3}	35.9 (10.1)	33.6 (4.0)	38.7 (9.7)	37.1 (4.9) ^{b1}

TABLE 10.3 (Continued)

	Dietary Recommendations		Total Sample	Food secure	Marginal food secure	Low food security	Very low food security
	6-8 y	9-11 y	(N = 50)	(N = 9)	(N = 9)	(N = 18)	(N = 14)
Added sugars (percent of calories)							
3-day average ^{c1}			15.0 (5.5)	11.8 (2.8)	16.5 (5.3)	13.0 (4.5)	18.7 (6.0)
Weekday ^{c1}			14.8 (6.3)	11.1 (4.1)	15.3 (5.2)	13.5 (6.0)	18.7 (7.0)
Weekend day			15.5 (7.7)	13.5 (4.7)	20.0 (9.0)	12.1 (6.7)	18.3 (7.9)
Saturated fat (percent of calories)							
	< 10	< 10					
3-day average			12.6 (2.0)	11.4 (2.0)	12.8 (1.4)	12.8 (2.2)	12.8 (1.9)
Weekday			12.3 (2.2)	11.4 (1.7)	13.1 (2.3)	12.5 (2.4)	12.0 (2.2)
Weekend day			13.2 (4.2)	11.4 (3.8)	13.1 (3.8)	13.4 (4.7)	14.2 (3.8)

Dietary Recommendations for children from USDA/ARS Children's Nutrition Research Center at Baylor College of Medicine, available at <http://www.bcm.edu/cnrc/consumer/archives/percentDV.htm>

^a Nutrient intake reported as mean (SD)

^b Comparison of weekday and weekend day nutrient intake by level of food security, using the Wilcoxon Signed-Rank Test

^c Test for trend across ordered groups of food security

Level of statistical significance: ¹p < 0.05 ²p < 0.01 ³p < 0.001

TABLE 10.4 Children's food security and demographic correlates of children's nutrient intakes from multiple regression models¹

	Energy	Protein	Fiber	Calcium	Vitamin D	Potassium	Sodium	Vitamin C	Fat	Added Sugar
	(kcal)	(g)	(g)	(mg)	(mcg)	(mg)	(mg)	(mg)	(% kcal)	(% kcal)
Food security										
Marginal	238.06 (142.06)	2.34 (8.16)	-0.65 (2.21)	270.57 (109.28)**	1.93 (1.24)	-96.78 (235.54)	-62.01 (288.16)	-16.45 (25.06)	0.16 (2.22)	4.15 (2.14)
Low	166.71 (140.92)	8.54 (7.39)	0.16 (2.02)	91.00 (102.56)	0.60 (1.09)	-109.31 (190.62)	377.84 (371.94)	-30.17 (21.19)	2.25 (1.77)	1.65 (1.48)
Very low	377.16 (169.91)*	10.54 (9.32)	-0.94 (2.30)	187.29 (139.25)*	1.71 (1.40)	22.11 (275.27)	278.73 (365.86)	-3.68 (25.64)	0.97 (1.80)	6.82 (2.05)***
Female	-118.83 (124.52)	-5.51 (6.87)	-1.20 (1.89)	-189.29 (84.62)*	-0.86 (0.82)	-130.99 (194.59)	-124.02 (362.36)	0.66 (19.27)	-1.44 (1.40)	2.31 (1.56)
Age	-48.27 (54.08)	-2.24 (2.58)	0.89 (0.69)	-83.56 (29.02)**	-1.18 (0.28)***	-67.15 (76.77)	-30.30 (115.29)	-6.74 (6.44)	-0.35 (0.45)	0.04 (0.54)
BMI status										
Overweight	-60.29 (150.37)	-4.65 (8.32)	0.65 (2.16)	50.17 (79.68)	0.42 (0.77)	-183.03 (210.69)	7.43 (440.01)	-3.19 (21.13)	-0.85 (1.77)	0.12 (1.62)
Obese	22.25 (121.58)	2.09 (7.37)	0.35 (1.44)	50.11 (109.81)	1.05 (1.04)	-11.24 (202.18)	-81.29 (300.96)	-21.66 (17.85)	-1.87 (1.64)	2.02 (1.68)
Country of birth										
Mexico	78.80 (118.59)	3.73 (6.49)	1.66 (2.13)	-53.06 (80.62)	-0.85 (0.59)	43.00 (211.25)	689.84 (337.07)*	-10.73 (20.01)	0.76 (1.44)	0.23 (1.73)
R ²	0.271	0.156	0.120	0.353	0.478	0.078	0.220	0.118	0.145	0.290

¹ Coefficients are reported; robust SEs are in parenthesis and are corrected with the White-Huber correction. There were 50 observations. Reference categories (variables) omitted to prevent perfect collinearity: food security (food secure), female (male), BMI status (Normal/Underweight), and country of birth (U.S.). Age was entered as a continuous variable.

* $p < 0.05$ ** $p < 0.01$ *** $p < 0.001$

insecurity and dietary intake. The national prevalence of household food insecurity is greater among Hispanic households in the U.S [7] and substantially greater among Mexican-origin households in *colonias* [3]. Findings from this study expand our understanding of the experience of food insecurity by school-age, Mexican-origin children and the association of food-security status with nutrient intakes.

Results present additional evidence that food insecurity is more prevalent among Mexican-origin children in Texas border *colonias* than previous estimates suggested. For instance, national data from 2009 indicated that 18.7% of Hispanic households, regardless of race or country of origin, had food-insecure children [7]. A community-based nutrition assessment of 610 Mexican-origin adults in Texas border *colonias* reported that 49% of all households and 61.8% of households with children were classified as child food insecure [3]. In the current sample, 28% of children reported very low food security and 64% reported low or very low food security. At least one-third of children reported having to skip a meal, go hungry, or not eat for a whole day because of limited or no food resources in the home, which supports and is supported by the community assessment. Children's total energy and nutrient intakes in this study were similar to or greater than previously reported among Mexican-American children (6-11 years) [44]. In addition, the present study showed that decreasing food-security status was associated with increased intake of total calories and percentage of calories from fat and added sugars, which confirms the work of Rosas and colleagues [28], and is in contrast to the work of Matheson and colleagues, which reported a not-significant relationship between household food security and children's dietary intake [30].

This paper not only emphasizes the alarming rates of food insecurity for this Hispanic subgroup, but describes the associations for food insecurity and diet among this sample of Mexican-origin children. Such findings have implications at a regional and national level, as the Mexican-origin population continues to grow along the border and in new destination communities [8, 45]. Immigrants from Latin America have provided the largest percent of foreign-born population since 1990: 44.3% in 1990, 51.7% in 2000, and 53.6% in 2007 [46]. People of Mexican-origin represent approximately 64% of both the native and foreign-born Hispanic population [46]. Of the 29.2 million Mexican Hispanics, 40 percent were foreign born. The percentage of all children living in the United States with at least one foreign-born parent increased from 15 percent in 1994 to 23 percent in 2010 [47]. In 2010, 33 percent of foreign-born children with foreign-born parents and 26 percent of native children with foreign-born parents lived below the

poverty line [47]. Data presented here may foreshadow higher rates of nutrition-related health conditions, such as obesity, type 2 diabetes, and cardiovascular disease among Mexican-origin children. Child-reported food insecurity situations could serve as a screen for nutrition problems in children. Further, the National School Lunch and School Breakfast Programs, which play a major beneficial role in children's weekday intakes, may not be enough to keep pace with the nutritional needs of low and very low food secure Mexican-origin children.

The present study has several particular strengths. First, this is a study of hard-to-reach Mexican-origin children in border *colonias*. This population is of increasing national importance because such *colonias* can be considered an archetype for the new-destination Mexican immigrant communities that are now found in great numbers throughout the U.S. Second, to our knowledge, this is the first study that uses children's report of their food-insecurity experiences in the past three months to describe food-security status, which is preferable and reduces the cognitive burden placed on respondents by the conventional twelve-month time period [7]. As such, this study builds on the work of Connell and colleagues and Fram and colleagues [33, 35, 37], that identified the importance of the child's perspective in understanding food insecurity and its consequences [35, 37]. Third, usual dietary intake was determined by three 24-hour dietary recalls that included weekday and weekend intakes. Each recall was conducted face-to-face in the home, multiple strategies were used to estimate portion size, and a modified multiple-pass method was used to capture home and away-from-home (e.g., school) food intake. Young children can provide information on their diet as accurately, or more accurately, than their parents, especially for food eaten outside the home [48–51].

There are several limitations to this study that warrant mention. Data were collected during one season of the year, which limits our ability to describe seasonal variation in dietary intake or food-security status or to make causal inferences. This could have important implications for times of year when children are unable to participate in school nutrition programs, such as during the summer or holidays. Although the three-month time frame was much better than asking about food security experiences in the last 12 months, this study did not collect data on frequency or duration of food insecurity situations. This limits our ability to differentiate between acute and chronic food insecurity. An additional limitation is an absence of data on food coping strategies employed by children to help manage food resources [37]. Finally, the study sample is small and is limited to two areas of *colonias* in the Texas border region, which limits our ability to generalize these results. Future work should focus on expanding

our understanding of seasonal variation in the frequency and duration of children's experiences of food insecurity.

10.5 CONCLUSIONS

Despite these limitations, the results of this study further the knowledge of children's experiences of low and very low food security and the association of food security status with children's dietary intake. The Mexican-origin population is rapidly expanding throughout the United States; record numbers of individuals and families are experiencing food insecurity, and for children living in rural or underserved areas such as the colonias, food insecurity may be an ongoing reality. The prevalence of low and very low food security in this border area is alarming, despite the participation of all study participants in the School Breakfast and National School Lunch Programs. The high prevalence of low and very low food security among these children is especially troubling given the importance of good nutrition on optimal growth, function, and health [19, 20]. Young children of Mexican immigrant families have a greater risk for hunger and household food insecurity [8], and are less likely to meet dietary recommendations than other children [27]. In this sample of Mexican-origin children, not only did most of the children not meet dietary recommendations in key nutrients, but children with very low food security consumed higher levels of energy, fat, and added sugars. The results also indicate the importance of further examining the frequency and duration of low and very low food security in children. Enhanced research efforts are needed that will lead to better understanding of coping strategies and the use of federal and community food and nutrition assistance programs for reducing food insecurity. Clearly, systematic and sustained action on multiple levels that integrates multi-sector partnerships and networks is needed for culturally-tailored health promotion and policy efforts to reduce child food insecurity.

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Obesity Prevention and National Food Security: A Food Systems Approach

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11.1 INTRODUCTION

The burdens of obesity and food insecurity are unequally distributed in the USA population, with shared risk factors rendering certain socioeconomic and racial and ethnic subgroups at greater risk for both [1–3]. The intersection of obesity and food insecurity in the USA points to a public health imperative for scientists, practitioners, and policy makers to document and address food system inadequacies and leverage existing social programs to simultaneously address the nutrition issues of obesity and food insecurity [3]. Both food insecurity and obesity are increasingly recognized as forms of malnutrition resulting from poor dietary quality (higher intakes of nutrient-poor energy-dense foods) [4]. Food insecurity and obesity stem from a shared food system, therefore, corrective action must be taken within the underlying system from which they derive [5, 6].

In this paper, we briefly discuss findings from research examining associations between food insecurity and obesity in the United States (USA) and emphasize the need for greater synergy between food insecurity policies and initiatives and national public health goals around obesity prevention. We identify the common ground between these nutrition-related public health issues and

call for a broadening of scope in the research and advocacy communities to align efforts around the shared goal of improving the health of at risk populations. We propose an ecological framework that identifies levers for change within the physical and social aspects of food systems to guide simultaneous attention to the pressing public health problems of food insecurity and obesity.

11.2 OBESITY AND FOOD INSECURITY

Although obesity and food insecurity historically have been viewed as distinct public health issues, there has been increasing interest in understanding the seemingly paradoxical association between obesity and food insecurity, with escalating public health concern over the dual burden of food insecurity and obesity shouldered by certain populations [3, 7, 8]. Rates of obesity have steadily increased in the USA over the past several decades, increasing dramatically among adult, child and adolescent populations [9–16]. Recent estimates from the National Health and Nutrition Examination Survey indicate that over one-third of the USA adult population is obese [12, 15]. Similar data from the National Survey of Children's Health indicate that approximately 16% of USA children are obese [17]. Obesity and related chronic disease are significant contributors to preventable morbidity and mortality and current population trends in obesity threaten to stall or reverse trends toward greater health and longevity in the USA population [9, 16, 18–20].

Food security is defined by the United States Department of Agriculture (USDA) as having access to enough food for all household members, at all times, to lead active, healthy lives [1, 21–23]. Households wherein members experience uncertainty around obtaining enough food due to insufficient resources are considered food insecure [21, 23]. Food-insecure households may experience *low food security* or *very low food security*. Households experiencing *low food security* often avoid substantially disrupting their eating patterns by engaging in coping strategies such as eating less varied diets, participating in federal food assistance programs, and accessing community feeding programs [1, 21–24]. Households experiencing *very low food security* lack sufficient resources to obtain food, which disrupts the normal eating patterns of one or more household members [1, 21–23].

Evidence from research examining the nature of the relationship between food insecurity and risk of obesity in children and adolescents is somewhat mixed [3, 7, 8, 25–37]. Recent meta-analytic reviews and research syntheses identify

a relationship between food insecurity and obesity among certain subpopulations such as households with incomes below the poverty line, households led by a single adult, and households headed by African American and/or Hispanic persons [1, 38, 39]. Regardless of whether a causal association exists between food insecurity and obesity, growing evidence documents a coexistence of these nutrition-related problems [3]. Thus, collaborative efforts to prevent obesity and eradicate food insecurity in the USA are needed [3, 5, 6].

The overlap in risk factors for obesity and food insecurity is undeniable [3, 11, 32, 33, 38, 40–43]. Current evidence documents an excess burden of food insecurity and an excess burden of obesity among households living in poverty [2, 3, 40, 44]. Differential access and affordability of more nutritious food options (e.g., fruits and vegetables) have been proposed as potential contributors to existing health disparities and the higher rates of diet-related chronic disease and obesity experienced by low-income and racial ethnic minority populations [45]. The term “food desert” has been used to describe geographic areas with limited access to affordable and nutritious food. Populations at greatest risk for obesity, including those living in food deserts, are also at increased risk for experiencing food insecurity [1, 46, 47].

Efforts to address obesity and food insecurity in the USA have often been singular, yet parallel. For instance, obesity prevention efforts include the “Let’s Move” campaign, as well as the push by federal and philanthropic organizations to reverse the trend of childhood obesity by 2015; concurrently there are separate initiatives to alleviate or end childhood hunger, including the pledge by President Obama to end childhood hunger by 2015. Nutrition-relevant policy changes and interventions should simultaneously attend to issues of food insecurity and obesity to ensure that efforts to control obesity do not create additional burden for those struggling with food insecurity or put more households at risk for food insecurity [3, 5]. It is equally important that efforts to reduce food insecurity do not inadvertently contribute to the obesity epidemic through provision of nutrient-poor, energy-dense foods [3].

11.3 FOOD ASSISTANCE INITIATIVES AND PUBLIC HEALTH NUTRITION GOALS

Evidence linking participation in food assistance programs and obesity has been mixed and fraught with methodological limitations [3, 48, 49]. The growing obesity epidemic in the USA, coupled with the disproportionate burden of

obesity and related chronic disease shouldered by populations who access food assistance programs, represents a public health imperative to leverage existing food assistance programs and other resources to support the health and well-being of disadvantaged populations [3].

The USDA directs 15 food and nutrition programs in the USA, assisting approximately one in four Americans each year [24]. The five largest USDA administered domestic food and nutrition assistance programs include the Supplemental Nutrition Assistance Program (SNAP), the National School Lunch Program, the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC), the Child and Adult Care Food Program, and the School Breakfast Program [24]. During fiscal year 2010, each of these programs expanded, proving a nutritional safety net to an increasingly food insecure population [24]. SNAP, formerly known as food stamps, was initiated in the 1960s and expanded in the 1970s to address growing rates of underconsumption and inadequate nutrient intake and is now the largest food assistance program in the USA. In 2010, SNAP served approximately 44.7 million people each month [50].

Despite increasing population reliance on federal food assistance programs, the most significant nutrition-related public health problem in the USA population today has shifted from one of deficiency to one of excess; rates of overweight and obesity and associated chronic disease have grown at an alarming rate in the USA population over the past three decades, particularly among low-income ethnic minority populations [48]. Existing evidence documents an excess burden of obesity among populations with lower socioeconomic position and among food insecure populations [2, 38–40, 44]. Interest in identifying policy and programmatic actions to address this public health disparity is mounting [5].

The disproportionately higher incidence of overweight and obesity and associated chronic disease among certain low-income populations has stimulated public health researchers and policy makers to explore ways in which food assistance programs, such as SNAP, might be modified to improve the dietary quality of recipients and thereby prevent or reduce obesity [49]. Proposals to facilitate and/or place restrictions on the types of foods that can be purchased with food supplement benefits (e.g., increased fruits and vegetables and decreased sugar sweetened beverages), to provide incentives for buying more healthful foods, and to expand nutrition education efforts have been suggested as means to support improvements in dietary quality among recipients to reduce risk factors for obesity and related chronic disease [51]. Improvements in federal food assistance programs, including the income supplement for the purchase of fruits and

vegetables in the SNAP Healthy Incentive Program, Electronic Benefit Transfer (EBT), and Double Up Food Bucks Programs to promote purchase and consumption of local produce at farmers markets, modification of the WIC food package to include vouchers for fruits and vegetables and changes to meals in the National School Lunch Program to adhere to USDA nutrition guidelines, heed the call for greater synergy in efforts to reduce obesity and improve food security [27].

11.4 PUBLIC HEALTH GOALS AND RESEARCH PRIORITIES AROUND OBESITY AND FOOD INSECURITY

Current public health goals around obesity prevention are beginning to reflect an understanding of the power of public policy and environmental change to influence both individual- and population-level behavioral change while acknowledging the importance of promoting population food security as part of such efforts. Implementation of public policy at a macrolevel, including local, state, or federal legislation, is an effective and comprehensive means to affect change in population behavior. Policy-level changes influence the environments that subsequently influence the behavior and choices of individuals. Effective public health policy and environmental change can encourage populations to practice more healthful behavior [52]. That is, effective policies can change environments to have improved access (and lower costs) to healthier foods and to subsequently make the healthy choice the easy or default choice [52–57].

The *Nutrition and Weight Status* objectives identified for Healthy People 2020 are centered on an overarching goal to promote health and reduce chronic disease risk through healthful diets and maintenance of healthy body weights [58]. The stated objectives emphasize that efforts to improve diet and reduce obesity require attention to the policies and environments that support individual behavior across a variety of settings. Increasing household food security and eliminating food insecurity are specified in the Healthy People 2020 objectives as integral to goals of promoting healthful diets and healthy weight [58].

Responding to the growing childhood obesity epidemic, the White House Task Force on Childhood Obesity developed and is working to implement an interagency plan to eliminate child obesity [59]. The Task Force published an action plan with specific recommendations for addressing the childhood obesity epidemic, including a call for further research and related policy to address food insecurity [59]. During the first year of this initiative, the Healthy, Hunger-Free

Kids Act was enacted to expand children's access to healthy school meals [60]. This act aims to increase the number of eligible children enrolled in school meal programs through direct certification of children who receive other federal assistance and improve access to nutritious meals in schools [60].

The National Institutes of Health (NIH) has also convened an Obesity Research Task Force to develop a strategic plan to accelerate multidisciplinary research efforts to address the population burden of obesity and related chronic disease. The task force identified and recently published a series of research challenges and opportunities to inform NIH research planning [61]. Importantly, the NIH Strategic Plan for Obesity Research explicates the need to integrate research results into community programs and clinical practice [61]. Historically, this need has not plainly taken into account food insecurity. However, given the congruency in population health goals around chronic disease prevention and overlap in risk factors and mechanisms, it is apparent that efforts to promote food security should be woven more closely with obesity prevention.

11.5 A FOOD SYSTEMS APPROACH TO REDUCING FOOD INSECURITY AND PREVENTING OBESITY

Public health advocates have long sought to unify food assistance efforts with high-quality nutrition. Focused attention on how current food system policies and practices may impact public health and diet-related chronic disease and obesity is essential to developing a systematic strategy that simultaneously achieves community food justice and public health success [5, 6]. The American Public Health Association has defined a sustainable food system as “one that provides healthy food to meet current food needs while maintaining healthy ecosystems that can also provide food for generations to come with minimal negative impact to the environment. A sustainable food system also encourages local production and distribution infrastructures and makes nutritious food available, accessible, and affordable to all.” [62]. Furthermore, per the Healthy People 2020 Nutrition and Weight Status objectives, greater attention to food insecurity, food systems, and food justice is encouraged in public health efforts to reduce or prevent obesity [58].

Our call for a systematic approach to simultaneously address the pressing public health issues of food insecurity and obesity points to an opportunity that is ripe for the integration of the existing evidence and further strategic development of the science around food insecurity and obesity to inform public policy

and community programs about food with concurrent consideration of both issues [5, 6]. Efforts to close the gap between science and public policy around food security and obesity will require changes in both the research and advocacy communities to align efforts around the shared goal of improving the health and well-being of at-risk populations [5, 6]. Strategic science aimed at changing public understanding of the link between food insecurity and obesity coupled with science-based efforts to inform agricultural and nutrition legislation, policy and regulations offers a useful paradigm for harnessing obesity prevention and nutrition science to change public policy with relevance to food security.

Typical approaches to public health problems with behavioral or lifestyle components, such as obesity and food insecurity, have focused mainly on individual change through motivational or educational interventions. This approach, as applied at the intersection of food insecurity and obesity, has been a failed experiment. Despite decades of individual-focused interventions for obesity and expansion of investments in nutrition education for food assistance recipient [58], we have not reversed the trend of either condition. To effectively reduce the public health burden of obesity in food insecure populations, science and advocacy efforts must align focus on systemic and environmental factors to cultivate “optimal defaults” for individual nutrition-related behavior by making the healthful option the easy option. {Thaler, 2008 number 51}. An example of an optimal default may be placing fruits and vegetables at the front of school cafeteria lines to make them more accessible or including apple slices as the “default” side dish instead of French fries in children’s meals.

The processes underlying food insecurity and obesity derive from a shared food system [5]. Therefore, efforts to address food insecurity and obesity must emulate the complexity of the system from which they emerge. The food systems concept describes the required inputs, processes, and generated outputs involved in the provision of food and nutrients for sustenance and health including growing, harvesting, processing, packaging, transporting, marketing, consuming, and disposing of food [63, 64]. A set of shared food system principles supporting economically, ecologically, and socially sustainable food systems that promote the health of individuals, communities, and the environment have been developed through the cooperative efforts of the Academy of Nutrition and Dietetics (formerly the American Dietetic Association), the American Nurses Association, the American Planning Association, and the American Public Health Association [65]. Accordingly, health-promoting food systems are defined as those that support the physical and mental health of producers and consumers with accountability for the public health impact across the food

system including production, processing, packaging, labeling, distribution, consumption, and disposal. Sustainability of food systems thus derives from the conservation and regeneration of natural resources and biodiversity to manage current food and nutrition requirements with transparency and equity in process and outcomes without compromising future system efficacy and output [63, 64]. Health-promoting and sustainable food systems are necessarily diverse in size and scale, geography, and culture to ensure resiliency in the face of ecological and economic challenges and to promote diversity and equity in the availability of healthful food options [63, 64].

Adopting a food systems approach facilitates awareness of the complexity of food systems and of the social, economic, environmental, and political contexts within which they operate [63, 64]. Aligning food assistance initiatives with public health nutrition goals requires a systematic approach to simultaneously address food insecurity and obesity through research and practice efforts aimed at establishing sustainable food systems to promote health, improve food security, and prevent obesity [5]. Individual, environmental, and policy level changes to promote the development of healthy sustainable food systems that simultaneously address the nutrition-related public health goals of obesity prevention and food security are needed.

11.6 LEVERS FOR CHANGE IN THE MACRO- AND MICRO-FOOD SYSTEM ENVIRONMENTS

Several opportunities exist for cultivating greater synergy between public health efforts around food insecurity and obesity prevention. Delineation of areas for potential intervention and public health impact can be organized according to the ecological perspective inherent in the food systems approach. Specifically, priorities for addressing shared risk factors and health outcomes in obesity prevention and food security can be identified and operationalized according to the size and nature of the environments in which intervention is to be implemented. This approach, originally described as the analysis grid for environments linked to obesity, conceptualizes environments in terms of size and type to identify potential interventions [66].

This ecological approach can be adapted and expanded to conceptualize the shared physical, economic, political, and sociocultural environments of obesity and food insecurity and to identify levers for change and opportunities for intervention that may impact individual behavior (see Table 1). Within this

TABLE 11.1 Levers for change in the macro- and microenvironments to influence obesity in food insecure populations.

	Environment type			
	Physical	Economic	Political	Sociocultural
Macroenvironmental settings	Modify agricultural, housing, transportation, and social policies that influence food production and distribution.	Offer monetary incentives for healthy food options (e.g., subsidies) and disincentives for unhealthy options (e.g., taxes).	Promote agricultural, social, and food security and nutrition policy informed by obesity prevention science.	Food marketing and advertising environment in economically disadvantaged areas to promote health and prevent obesity.
Microenvironmental setting	Food retailers and food service outlets determine local healthy food options.	Institutional financial support for health promotion and nutrition programs; financial support for support local food production.	Institutional rules and policies influencing availability of healthy food options.	Institutional climate around nutritious eating and healthy body weight maintenance.

framework, macroenvironmental sectors describe the greater influencing context of industry and supporting infrastructure on available and consumed food options [66]. For example, macroenvironmental sectors relevant to the food environment may include food production and manufacturing, distribution, and marketing as well as relevant technological and social infrastructure. The framework describes microenvironmental settings as the settings that involve food where people gather for specific purposes [66]. Examples of microenvironments include homes, schools, workplaces, community venues, food service or retail outlets (e.g., supermarkets, restaurants, etc.), and healthcare settings. Within both macroenvironmental sectors and microenvironmental settings, several environmental types with relevance to obesity prevention and food insecurity have been identified including the physical environment, the economic environment, the political environment, and the sociocultural environment [66]. We examine each of these types, in turn, to identify effective interventions to concurrently address obesity and food insecurity.

11.6.1 Physical Food Environment

The physical food environment refers to the availability of food outlets, relevant training opportunities, and nutrition-related information within specific settings (e.g., supermarkets, communities, schools, etc.) [66]. Identifying levers for change within the physical environment requires understanding the ways in which macroenvironmental physical factors including resource inputs, food production, distribution, and transportation systems influence the availability of healthy food venues by geographic region. Resource inputs refer to the raw materials, biophysical factors, and social factors available in a given environment for input into the food system. Food production involves transformation of resource inputs into raw agricultural goods, and food processing involves transformation of production output agricultural goods into food for distribution. Many low-income populations live in “food deserts” wherein failures in distribution result in geographic areas devoid of retail establishments offering healthy food options thereby limiting access to affordable, nutritious food in such neighborhoods [67, 68].

Opportunities for intervention in the macroenvironmental physical food environment may legislative efforts to modify existing agricultural, housing, transportation, and social policies to address the dual issues of food security and obesity prevention [5, 68]. For example, currently retailers authorized to

participate in SNAP are required to sell staple foods for home preparation and consumption and must offer on a continuous basis, at least three different varieties of foods from the four staple food categories, with at least two of the food categories being perishable foods [68]. Alternatively, authorized SNAP retailers must have more than half of their total gross sales from staple foods. This policy aims to increase access to healthy food options, although most SNAP retailers are authorized under the first criterion and therefore can meet said requirements by offering a small number and variety of staple food items [68]. Efforts are underway by the USDA to review current regulations with the goal of striking a balance to maintain an adequate supply of required foods while retaining retailer participation in SNAP [68]. Modifications to WIC food packages to include whole grains, fruits and vegetables, and reduced fat milk (versus whole milk) for children over 2 years of age have also been successful in improving the diets of WIC recipients [54, 57, 69]. Other policy level interventions at the macroenvironmental level that may influence the physical food environment include incorporation of community food access into housing and community development planning and transportation development and planning and related policy [67, 68].

Food distribution determines the local availability of points of access including wholesale or retail entities, the food service industry, and public and private food assistance programs and is therefore the vital link to consumer acquisition at the microenvironmental setting level. At the microenvironmental level, grass-roots and local community food projects to improve availability of food options have shown promise in improving access and the dietary intake in at risk populations [68, 70]. The USDA Community Food Projects Competitive Grants Program has funded hundreds of community food projects under the umbrella aim of supporting communities in local efforts to improve local food systems [70]. Examples of community food project activities may include: increasing the availability of locally produced, healthy food options through community gardens, farmers markets, and food assistance programs; improving dietary composition through nutrition education, cooking classes, and engagement in food production; increasing participation in nutrition programs; and working to integrate food system issues into community planning and local public health initiatives [68, 70]. Although there is considerable diversity in community food projects as per the needs of diverse communities, a systematic review of five years of funded projects revealed the following shared aims of community food projects: they focus on the food needs of low-income populations; they aim to connect local food producers and consumers; they strive to increase the

local food production and self-reliance; and they attempt to develop integrated solutions to agriculture, food, and nutrition-related problems [70]. These goals coincide with community food security and obesity prevention goals and strive to develop local food systems that promote health, sustainability, and community self-sufficiency.

Opportunities for intervention may also occur at the point of purchase, wherein the concept of optimal defaults could be applied to location of healthy food options in retail and wholesale settings to promote consumption [52]. Possibilities for dissemination of nutrition information also abound, with product and menu labeling, and in-store educational campaigns aimed at raising consumer awareness of healthy and affordable food options [71–73]. Addressing physical environment food system vulnerabilities requires identification of specific deficits in human and/or technological resources resulting in food system failure at the point of resource inputs, production, processing, distribution, or point of purchase (e.g., food labeling) that must be addressed in order to produce and distribute adequate and healthful food resources for a given population [63].

11.6.2 Economic Food Environment

The economic environment describes the costs related to food production, manufacturing, distribution, retailing, and purchase [66]. Economic factors at both the macro- and microenvironmental level are strongly related to both obesity and food insecurity [2, 38, 40, 44]. Expansion of federal antipoverty initiatives, including food and nutrition assistance programs such as SNAP and WIC, school meal programs, the Head Start program, the Earned Income Tax Credit, and the Temporary Assistance for Needy Families program, may serve to improve access to healthy food options [48, 74–76].

Individuals may also lack the necessary resources, awareness, and/or skills to obtain consistent access to nutritious food. Monetary incentives, such as food subsidies, for production and consumption of healthy food options and monetary disincentives for the production and consumption of unhealthy food options, such as taxes, represent potentially powerful levers for change in both obesity prevention and food insecurity [66]. Other promising interventions to prevent obesity and reduce food insecurity may include institutional financial support for health promotion and nutrition programs and financial support to promote local food production efforts [68]. Efforts to incorporate

nutrition education into existing programs, including school-based programs, Head Start, WIC, and SNAP, that reach at risk populations have been successful in improving nutrition-related knowledge and behavior and are particularly encouraged [75–79].

11.6.3 Political Food Environment

The political food environment refers to the laws, regulations (macroenvironment), and institutional rules (microenvironment) that influence available food options and related individual behavior [66]. The political environment holds prominent opportunities for wide-spread change in population burden of food insecurity and obesity. As per our prior discussion of policy level interventions to influence the physical and economic food environments, agricultural, transportation, social legislation, and resultant food and nutrition policy informed by obesity prevention science and public health goals around food security could promote the health and well-being of the population [45]. At the macrolevel, additional regulatory forces in the political environment determine nutrition labeling standards, health claims on packages and in stores, and the nature of food advertisements aimed at youth. Packaging, labeling, and advertisement exert considerable influence on consumer behavior, and therefore represent significant levers for change in the political environment. At the microlevel, schools, hospitals, and workplaces may adopt policies regarding the nature of food services, including requirements for the quantities and qualities of foods served in cafeterias, vending machines, and other outlets [80, 81].

11.6.4 Sociocultural Food Environment

The sociocultural food environment refers to the social and cultural norms or beliefs, values, and attitudes about food, embraced by a community or society [66]. At the macroenvironmental level, food marketing and advertising can be leveraged as compelling interventions to promote health and prevent obesity. At the microenvironmental level, institutional climate around nutritious eating and healthy body weight maintenance can be targeted within specific settings (e.g., schools or worksites) to encourage and educate around healthful and affordable food options. Homes also represent an important microenvironmental context in which social and cultural norms about food are shaped. The home environment and parenting styles and practices, in particular, have received increasing

attention with regard to the role that parents play in children's eating behaviors. For example, parents are not only responsible for the amounts and types of food made available in the home; they are the first socializing agent for children's eating. A large body of research has demonstrated that children's eating is shaped instrumentally by the foods that parents bring into the home and by modeling. A growing evidence base suggests that the ways in which parents go about attempting to shape children's eating is also important. For example, a parent may limit a child's junk food intake by restrictive practices such as not allowing certain foods in the home at all or vigilantly monitoring their child's eating behaviors. By comparison, a parent may also limit junk food intake by talking to the child about why salty and sugary snack foods are "sometimes" foods to be eaten only in small amounts or on special occasions. Evidence suggests that parental feeding practices that include behaviors such as providing age-appropriate rationales and some structure and limit settings (i.e., a middle ground between allowing children to make all of the decisions and forbidding eating some foods like junk food while demanding eating others like fruit and vegetables) result in children eating and self-regulating food intake better [82–84].

Although there is evidence that parental feeding styles and practices influence children's eating behaviors, less is known about the precursors to parental feeding styles and practices. Food insecurity may be one such factor. Indeed, when parents are food insecure it is likely that they will interact with their children around eating differently than if they are confident that they will have sufficient food for the next meal, the next day, or for the next month. For example, they may be more likely to encourage children to eat more when it is available, even after the child has indicated that he or she is full. Literature on the parental feeding practice of "clean your plate" (i.e., eat everything that is on your plate) indicates that this is one mechanism by which children stop paying attention to physiological cues of hunger and fullness and instead rely on cues in the physical environment [85]. More recent evidence suggests that pressuring children to eat may backfire in terms of children's food preferences, which has important implications not only for the quantity of foods consumed but for their quality [86]. Although food insecure parents may be engaging in this practice for good reason, the potential long-term consequences of encouraging children to eat past the physiological sense of fullness have important implications for eating regulation and obesity. Food insecure parents may also be more likely to purchase and serve foods that they are certain their children will eat (e.g., sugary or salty food), because they do not want to risk-wasting resources on foods that their children may not eat.

11.7 CONCLUSION

Increasing population burden of food insecurity and obesity speaks to the critical need for development of a comprehensive approach to reform existing food systems to simultaneously address issues of community food justice, food security, food quality, and public health success related to obesity prevention. Interventions that cultivate sustainable food systems to promote health, improve food security, and prevent obesity, with multiple social, ecological, and economic benefits, based on an ecological approach that conceptualizes the shared physical, economic, political, and sociocultural environments of obesity and food insecurity are needed. Current food insecurity initiatives and national obesity prevention public health goals could be coordinated through the adoption of a food systems approach to conduct strategic science to inform public health interventions aimed at improving population health through environmental and policy level changes to promote nutrition environments with optimal defaults to support individual behavior. Continued efforts are needed to systematically identify policy gaps and opportunities for and barriers to merging food security and obesity prevention initiatives, as part of an ongoing process of developing and implementing an integrated and comprehensive strategy for addressing the nutrition-related needs of at risk populations.

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PART V
Policy, Power, and Politics



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Food Sovereignty: Power, Gender, and the Right to Food

Rajeev C. Patel

12.1 POWER OVER FOOD

One of the most enduring misconceptions about hunger is that it is primarily the result of a deficit in global food production. If this were so, we might expect food to be absent at times and in places where people die of hunger. Yet economist Amartya Sen has shown that in the majority of cases of widespread famine-related death since WWII, food has been available within the famine-affected area. People have died not for want of food, but for want of the entitlement to eat it [1]. Questions about hunger and its attendant pathologies, therefore, ought to begin with questions about social and political configurations around power over food, rather than about the mere presence or absence of food in the vicinity of a hungry individual.

Although no single commonly agreed definition of hunger exists, two common standards prevail: “undernourishment” and “food security.” The former refers to the number of people “whose dietary energy consumption is continuously below a minimum dietary energy requirement for maintaining a healthy life and carrying out a light physical activity” [2]. Undernourishment is a condition suffered by individuals. It is, however, usually established not through individual surveys but through an analysis of a country’s food availability, household

purchasing power, and entitlements [3],[4]. Current estimates put the worldwide number of undernourished people at nearly one billion [3].

The concept of “food security” attempts to capture the notion of hunger as a deficit not of calories, but as a violation of a broader set of social, economic, and physical conditions. In 1996, the Food and Agriculture Organization of the United Nations (FAO) established at its World Food Summit the most widely agreed definition [5] that “Food security, at the individual, household, national, regional and global levels [is achieved] when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life.”

By definition, more people are food insecure than are undernourished, and food insecurity precedes undernourishment. Although there are few people in the United States whose calorie intake is continuously below the threshold of a maintaining healthy life, there are many who, at some point during any given year, are unable to meet their food needs. According to the United States Department of Agriculture (USDA), in 2010 there were 48.8 million US citizens living in food-insecure households. The distribution of food insecurity is uneven. In the US, 21.6 million children lived in food-insecure households, and 35.1% of all female-headed households were food insecure in 2010, compared to 25.4% of male-headed households [6].

Since food insecurity is a broader measure than that of undernourishment, it has been correlated both with hunger and obesity, particularly among women [7]. If hunger is a symptom of a lack of control over the socioeconomic context in which one attempts to eat, it is not unreasonable to understand that lack of control as correlated with factors associated with obesity too. It is possible to have sufficient calories, but insufficiently nutritious food for a healthy life. Armed with this understanding, and with persistent evidence across countries of women and girls’ disempowerment compared to men and boys [8], it becomes easier to appreciate the systematically higher rates of food insecurity among women.

12.2 GENDER AND FOOD

The link between gender and food becomes clearer through an understanding of power and control in the food system. Giving away food does little to address the underlying causes of disempowerment that lead to hunger [9]. One group that has articulated this is an international peasant movement called La Via Campesina (see Box 1). They argue that if governments aim merely for food

security as a policy goal, the politically difficult questions of inequality in power that produced food insecurity would be ignored, and a broken system would be patched up with entitlements [1]. It is possible, after all, to be food secure in prison where one might continually access safe and nutritious food, yet remain fundamentally disempowered over the process and politics of the food's production, consumption, and distribution.

BOX 1. LA VIA CAMPESINA

La Via Campesina is an organization of farmers, peasants, and landless workers' movements with over 150 million combined members in 70 countries [46]. Its first meeting was held in 1993, and it was constituted as an umbrella organization for a range of social movements that had, through the 1980s, begun to work more closely in Asia, the Americas, and Europe. These movements had come into contact with one another through their attempts to understand, resist, and offer alternatives to "free market" agricultural trade. Even before the organization was officially created, La Via Campesina's member organizations had undertaken a range of actions to confront what they saw as inequality in power within the food system. In India, 200,000 farmers protested the patenting of seeds by multinational corporations. In Europe, 30,000 farmers marched on Brussels to offer an alternative policy goal to the achievement of food security. In Brazil, hundreds of thousands of people occupied farmland, upon which they built thriving communities. In 1996, at the same World Food summit at which the most recent definition of food security was written, La Via Campesina codified its vision for an alternative food system under the rubric of "food sovereignty." At a 2009 La Via Campesina meeting, one of the slogans offered by the assembly was that "food sovereignty is an end to all forms of violence against women."

Instead of food security, Via Campesina has advocated for "food sovereignty." Just like the definition of food security, food sovereignty is an evolving and many-faceted term, but it has an invariant core: "communities have the right to define their own food and agriculture policy" [10]. To be clear, sovereignty is not a call for self-sufficiency, for states to grow within their borders sufficient food to feed their citizens. La Via Campesina instead calls for people to be

sovereign over their food systems, for people to have the power to decide what the system should look like. This is an intentionally vague call, with many questions left open-ended, so that the communities involved in claiming food sovereignty might answer issues around production, distribution, and consumption of food for themselves. It is through food sovereignty, La Via Campesina argues, that food security might be achieved, and undernourishment eradicated.

The main demand in food sovereignty is that, for the first time, decisions about the shape of the food system ought to be in the hands not of powerful corporations or geopolitically dominant governments [11], but up to the people who depend on the food system. For the discussion to be representative of the community's desires, however, a non-negotiable element of food sovereignty is women's rights. In order for a democratic conversation about food and agriculture policy to happen, women need to be able to participate in the discussion as freely as men.

Peasant movements, and those who support them, have been castigated as romantics pining for an unattainable past [12]. An insistence of women's rights places food sovereignty firmly in the twenty-first century. This has a practical purpose. Of those undernourished, 60% are women or girls [13]. It is hard to conceive a discussion about hunger without connecting the epidemiology of hunger to women's disempowerment.

On the production side of the food system, women constitute 43% of the agricultural workforce, more often involved in producing food for domestic consumption than export. They are discriminated against in issues ranging from land tenure to wages, from government support to access to technology. The FAO notes that "if women had the same access to productive resources as men, they could increase yields on their farms by 20–30 percent. This could raise total agricultural output in developing countries by 2.5–4 percent, which could in turn reduce the number of hungry people in the world by 12–17 percent" [14].

In addition, women stand to bear a disproportionate burden of the consequences of the twenty-first century's predicted global increase in non-communicable disease (NCD) prevalence. In South Asia, for example, NCDs are projected to account for 72% of deaths by 2030, up from 51% in 2008. In Sub-Saharan Africa, the estimates are 46%, up from 28% over the same period [15]. In addition to the duties of paid work, women bear a disproportionate burden of care work in the management of morbidity associated with NCDs [16],[17], especially in contexts of poverty [18]. These are the kinds of inequities to which food sovereignty calls attention.

12.3 SYSTEMIC INEQUITY AND THE RIGHT TO FOOD

Beyond an examination of the inequitable distribution of power at a household level, food sovereignty suggests an investigation of power relations at meso- and macroeconomic levels. La Via Campesina members are, for example, concerned about corporate power within the global economy. The food system's dysfunction continues to be lucrative for a range of food and agriculture companies. Profits often derive from the increased consumption of processed food, which in turn have driven a global obesity epidemic. Yet the distribution mechanisms within the food system that ration food on the basis of ability to pay have produced the paradox of a billion hungry during a time when there are more than 1.5 billion people overweight [19],[20].

Within the food system, power is concentrated in the hands of a few corporations. In 2008, the top ten agrochemical corporations controlled almost 90% of the global sales of pesticides. Of the US\$22 billion global proprietary seed market, only ten corporations controlled 67% [21]. In 2005, the top four beef packing firms controlled 83.5% of the market in the US [22], and worldwide, 40% of all groceries were sold by only 100 retailers [21]. These trends across the food industry have been on an almost-steady climb since they were recorded first in the 1970s. As the US government recently found, "for example, in the pork sector, the market share of the largest four hog slaughtering firms increased from 36 percent in 1982 to 63 percent in 2006. In addition, at the retail level, the share of grocery store sales held by the largest four firms more than doubled, from 16 percent in 1982 to 36 percent in 2005" [23].

This concentration of power has gendered consequences. In contexts where women perform the majority of horticultural and agronomic innovation, they can find their agroecological knowledge supplanted by the technologies of industrial agriculture. Pesticide companies own the largest seed companies, and their agricultural model, dependent on purchased supplies of hybrid seeds and chemical inputs, favors larger, more capital-intensive farms. Women have systematically less access to both land and capital than men, and despite an often sophisticated level of knowledge about farming systems, women's views seldom matter in the shaping of choices around agricultural technologies and food policy [24]. In addition, employment within agriculture consistently pays women around 25% less than men. When food is accessed through market mechanisms, this increases women's systemic risk of hunger [25].

It is for these reasons that women leaders within peasant movements have taken strong stands against multinational corporations such as Monsanto and

Cargill [26]. To be sure, concentration of agricultural power is not new. At the turn of the nineteenth century, four firms—Dreyfus, Cargill, Continental, and Bunge—dominated global grain trading [27]. Today, however, the extent to which food markets matter is far greater. Agricultural market concentration is evident not only in international trade, but across domestic production, distribution, and consumption. This concentration matters more when there are fewer alternatives to the markets in which concentration occurs.

12.4 THE ROLE OF MARKETS AND GOVERNMENTS

To understand why the private sector has achieved such power, it is worth looking at other actors' roles within the food system. Philanthropic foundations have, for example, been responsible for advancing the kinds of industrial agriculture that has imperiled La Via Campesina's members [28],[29]. The "Green Revolution," in which farmers were encouraged and sometimes forced by governments to adopt a system of farming involving hybrid seeds, fertilizer, and pesticides, was initially funded by the Rockefeller and Ford Foundations, and is currently being encouraged by the Gates Foundation in Africa [30],[31],[32]. These farming systems have had gender-negative impacts, as women's knowledge is excluded, and women are systematically less able to control the capital required to participate in resource-intensive farming [33],[34],[35].

National governments and international organizations have also been faulted for their behavior in shaping the food system. Of particular interest to La Via Campesina is the extent to which, through international economic agreements such as the World Trade Organization's (WTO's) Agreement on Agriculture, governments have enabled private sector markets to expand their influence within the food system. A central demand in La Via Campesina's call for food sovereignty is for the WTO to "get out of agriculture" [36]. By this they mean not only ought the Agreement on Agriculture within the WTO be nullified, but that a range of other WTO provisions that affect agriculture, such as rules on intellectual property rights on seeds and phytosanitary measures, also be suspended. Trade agreements rules are influenced by the corporations that subsequently benefit from them [37], with demonstrated gendered impacts as a result [38],[39].

Food corporations continue to attempt to shape domestic and international public policy. PepsiCo, for instance, has gone to great lengths to claim a place at the table in addressing public health issues [40]. Yet the company has since 2000 spent US\$26.88 million on lobbying in the US [41], in particular in response

to taxes on its products and voicing its concerns on restrictions on marketing its foods to children [42],[43]. PepsiCo's behavior is emblematic of a wider trend in private sector spending within the food system. In a context of shrinking public budgets, and the transformation of public institutions such as schools into sites for the sale of obesogenic products [44], the influence of private interest in public policy matters immensely. Yet the food industry is pushing public debate toward an interpretation of the rise of NCDs as fundamentally a problem of individuals [45]. To accept this is to urge a policy response in which NCDs can be remedied by better individual behavior, rather than more regulation. With women more responsible than men for children's diets, this has the effect of pathologizing individual women, rather than finding fault with a system that removes their freedom to make their children's diets healthier.

12.5 CONCLUSION

The inequalities in power that characterize the food system can be found in households, corporations, regional and state governments, private philanthropic foundations, and international organizations. The strengths of a food sovereignty approach lie in the heuristic approach to power relations that it invites, particularly with respect to gender. For La Via Campesina, and many others, identifying inequities in power within the global food system is more than an academic exercise—it is a means not only to interpret the system, but also to change it.

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Big Food, Food Systems, and Global Health

David Stuckler and Marion Nestle

13.1 INTRODUCTION

As the *PLoS Medicine* series on Big Food (www.ploscollections.org/bigfood) kicks off, let's begin this essay with a blunt conclusion: Global food systems are not meeting the world's dietary needs [1]. About one billion people are hungry, while two billion people are overweight [2]. India, for example, is experiencing rises in both: since 1995 an additional 65 million people are malnourished, and one in five adults is now overweight [3],[4]. This coexistence of food insecurity and obesity may seem like a paradox [5], but over- and undernutrition reflect two facets of malnutrition [6]. Underlying both is a common factor: food systems are not driven to deliver optimal human diets but to maximize profits. For people living in poverty, this means either exclusion from development (and consequent food insecurity) or eating low-cost, highly processed foods lacking in nutrition and rich in sugar, salt, and saturated fats (and consequent overweight and obesity).

To understand who is responsible for these nutritional failures, it is first necessary to ask: *Who rules global food systems?* By and large it's "Big Food," by which we refer to multinational food and beverage companies with huge and concentrated market power [7],[8]. In the United States, the ten largest food companies control over half of all food sales [9] and worldwide this proportion is about 15% and rising. More than half of global soft drinks are produced by large multinational companies, mainly Coca-Cola and PepsiCo [10]. Three-fourths

of world food sales involve processed foods, for which the largest manufacturers hold over a third of the global market [11]. The world's food system is not a competitive marketplace of small producers but an oligopoly. What people eat is increasingly driven by a few multinational food companies [12].

Virtually all growth in Big Food's sales occurs in developing countries [13] (see Figure 1). The saturation of markets in developed countries [14], along with the lure of the 20% of income people spend on average on food globally, has stimulated Big Food to seek global expansion. Its rapid entry into markets in low- and middle-income countries (LMICs) is a result of mass-marketing campaigns and foreign investment, principally through takeovers of domestic food companies [15]. Trade plays a minimal role and accounts for only about 6% of global processed food sales [15]. Global producers are the main reason why the "nutrition transition" from traditional, simple diets to highly processed foods is accelerating [16],[17].

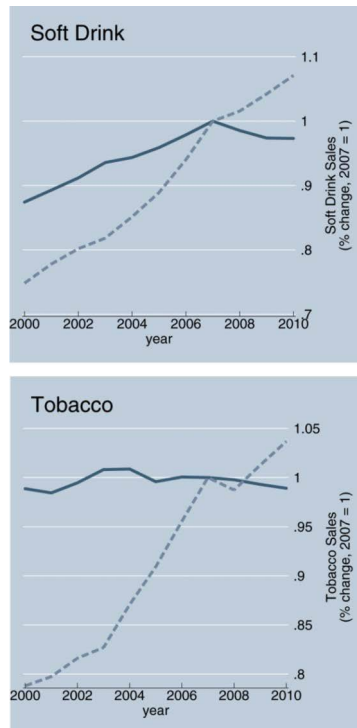


FIGURE 13.1 Growth of Big Food and Big Tobacco sales in developing countries: An example. Shaded blue line is developed countries, dashed grey line is developing countries. Source: Passport Global Market Information Database: EuroMonitor International, 2011 [12].

Big Food is a driving force behind the global rise in consumption of sugar-sweetened beverages (SSBs) and processed foods enriched in salt, sugar, and fat [13]. Increasing consumption of Big Food's products tracks closely with rising levels of obesity and diabetes [18]. Evidence shows that SSBs are major contributors to childhood obesity [19],[20], as well as to long-term weight-gain, type 2 diabetes, and cardiovascular disease [21],[22]. Studies also link frequent consumption of highly processed foods with weight gain and associated diseases [23].

Of course, Big Food may also bring benefits—improved economic performance through increased technology and know-how and reduced risks of undernutrition—to local partners [24]. The extent of these benefits is debatable, however, in view of negative effects on farmers and on domestic producers and food prices [25].

13.2 PUBLIC HEALTH RESPONSE TO BIG FOOD: A FAILURE TO ACT

Public health professionals have been slow to respond to such nutritional threats in developed countries and even slower still in developing countries. Thanks to insights from tobacco company documents, we have learned a great deal about how this industry sought to avoid or flout public health interventions that might threaten their profits. We now have considerable evidence that food and beverage companies use similar tactics to undermine public health responses such as taxation and regulation [26],[27],[28],[29], an unsurprising observation given the flows of people, funds, and activities between Big Tobacco and Big Food. Yet the public health response to Big Food has been minimal.

We can think of multiple reasons for the failure to act [30]. One is the belated recognition of the importance of obesity to the burden of disease in LMICs [13]. The 2011 Political Declaration of the United Nations High-Level Meeting on Prevention and Control of Non-communicable Diseases (NCDs) recognized the urgent case for addressing the major avoidable causes of death and disability [31], but did not even mention the roles of agribusiness and processed foods in obesity. Despite evidence to the contrary, some development agencies continue to view obesity as a “disease of affluence” and a sign of progress in combating undernutrition [32].

A more uncomfortable reason is that action requires tackling vested interests, especially the powerful Big Food companies with strong ties to and influence

over national governments. This is difficult terrain for many public health scientists. It took five decades after the initial studies linking tobacco and cancer for effective public health policies to be put in place, with enormous cost to human health. Must we wait five decades to respond to the similar effects of Big Food?

If we are going to get serious about such nutritional issues, we must make choices about how to engage with Big Food. Whether, and under what circumstances, we should view food companies as “partners” or as part of the solution to rising rates of obesity and associated chronic diseases is a matter of much current debate, as indicated by the diverse views of officials of PepsiCo and nutrition scientists [24],[27],[28],[33],[34].

13.3 ENGAGING WITH BIG FOOD—THREE VIEWS

We see three possible ways to view this debate. The first favors voluntary self-regulation, and requires no further engagement by the public health community. Those who share this view argue that market forces will self-correct the negative externalities resulting from higher intake of risky commodities. Informed individuals, they say, will choose whether to eat unhealthy foods and need not be subjected to public health paternalism. On this basis, UN secretary-general Ban Ki Moon urged industry to be more responsible: “I especially call on corporations that profit from selling processed foods to children to act with the utmost integrity. I refer not only to food manufacturers, but also the media, marketing and advertising companies that play central roles in these enterprises” [35]. Similarly, the UK Health Minister recently said: “the food and drinks industry should be seen, not just as part of the problem, but part of the solution... An emphasis on prevention, physical activity and personal and corporate responsibility could, alongside unified Government action, make a big difference” [36].

The second view favors partnerships with industry. Public health advocates who hold this view may take jobs with industry in order to make positive changes from within, or actively seek partnerships and alliances with food companies. Food, they say, is not tobacco. Whereas tobacco is demonstrably harmful in all forms and levels of consumption, food is not. We can live without tobacco, but we all must eat. Therefore, this view holds that we must work with Big Food to make healthier products and market them more responsibly.

The third approach is critical of both. It recognizes the inherent conflicts of interest between corporations that profit from unhealthy food and public health collaborations. Because growth in profit is the primary goal of corporations, self-regulation and working from within are doomed to fail. Most proponents of this

viewpoint support public regulation as the only meaningful approach, although some propose having public health expert committees set standards and monitor industry performance in improving the nutritional quality of food products and in marketing the products to children.

We support the critical view, for several reasons. First, we find no evidence for an alignment of public health interest in curbing obesity with that of the food and beverage industry. Any partnership must create profit for the industry, which has a legal mandate to maximize wealth for shareholders. We also see no obvious, established, or legitimate mechanism through which public health professionals might increase Big Food's profits.

Big Food attains profit by expanding markets to reach more people, increasing people's sense of hunger so that they buy more food, and increasing profit margins through encouraging consumption of products with higher price/cost surpluses [28]–[31],[37]. Industry achieves these goals through food processing and marketing, and we are aware of no evidence for health gains through partnerships in either domain. Although in theory minimal processing of foods can improve nutritional content, in practice most processing is done so to increase palatability, shelf-life, and transportability, processes that reduce nutritional quality. Processed foods are not necessary for survival, and few individuals are sufficiently well-informed or even capable of overcoming marketing and cost hurdles [38]. Big Food companies have the resources to recruit leading nutritional scientists and experts to guide product development and reformulation, leaving the role of public health advisors uncertain.

To promote health, industry would need to make and market healthier foods so as to shift consumption away from highly processed, unhealthy foods. Yet, such healthier foods are inherently less profitable. The only ways the industry could preserve profit is either to undermine public health attempts to tax and regulate or to get people to eat more healthy food while continuing to eat profitable unhealthy foods [33],[39]. Neither is desirable from a nutritional standpoint. Whereas industry support for research might be seen as one place to align interests, studies funded by industry are 4- to 8-fold more likely to support conclusions favorable to the industry [40].

Our second reason to support the critical view has to do with the "precautionary principle" [41]. Because it is unclear whether inherent conflicts of interest can be reconciled, we favor proceeding on the basis of evidence. As George Orwell put it, "saints should always be judged guilty until they are proved innocent." We believe the onus of proof is on the food industry. If food companies can rigorously and independently establish self-regulation or private–public

partnerships as improving both health and profit, these methods should be extended and replicated. But to date self-regulation has largely failed to meet stated objectives [42],[43],[44],[45],[46],[47], and instead has resulted in significant pressure for public regulation. Kraft's decision to ban trans fats, for example, occurred under pressure of lawsuits [48]. If industry believed that self-regulation would increase profit, it would already be regulating itself.

We believe the critical view has much to offer. It is a model of dynamic and dialectic engagement. It will increase pressures on industry to improve health performance, and it will encourage those who are sympathetic to the first or second views to effect change from within large food and beverage companies.

Public health professionals must recognize that Big Food's influence on global food systems is a problem, and do what is needed to reach a consensus about how to engage critically. The Conflicts of Interest Coalition, which emerged from concerns about Big Food's influence on the U.N. High-Level Meeting on NCDs, is a good place to start [29],[49]. Public health professionals must place as high a priority on nutrition as they do on HIV, infectious diseases, and other disease threats. They should support initiatives such as restrictions on marketing to children, better nutrition standards for school meals, and taxes on SSBs. The central aim of public health must be to bring into alignment Big Food's profit motives with public health goals. Without taking direct and concerted action to expose and regulate the vested interests of Big Food, epidemics of poverty, hunger, and obesity are likely to become more acute.

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