



AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search

<http://ageconsearch.umn.edu>

aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*



United States Department of Agriculture

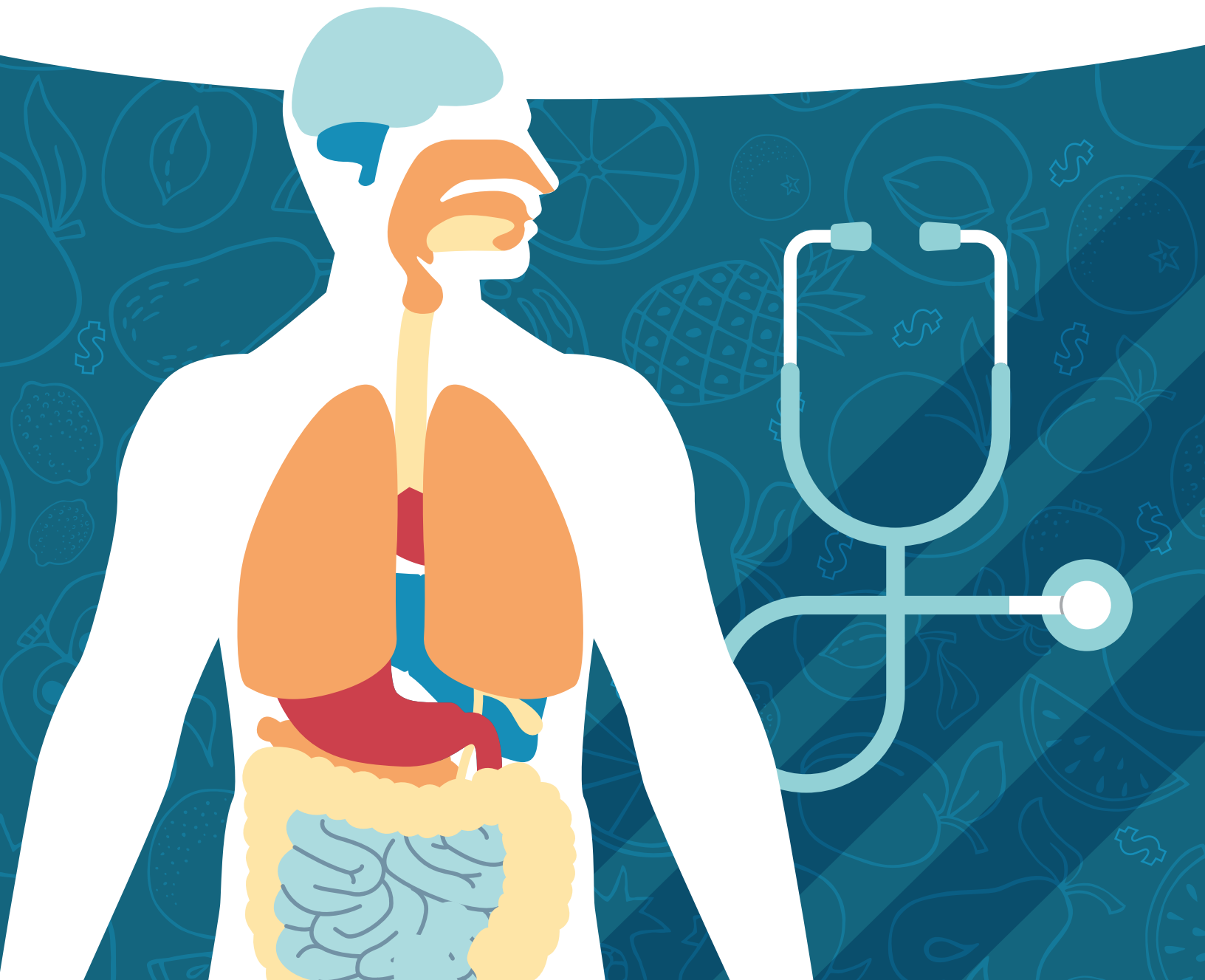
Economic
Research
Service

Economic
Research
Report
Number 235

July 2017

Food Insecurity, Chronic Disease, and Health Among Working-Age Adults

Christian A. Gregory and Alisha Coleman-Jensen





United States Department of Agriculture

Economic Research Service

www.ers.usda.gov

This digital publication is available online at
www.ers.usda.gov/publications/

Recommended citation format for this publication:

Christian A. Gregory, Alisha Coleman-Jensen. *Food Insecurity, Chronic Disease, and Health Among Working-Age Adults*, ERR-235, U.S. Department of Agriculture, Economic Research Service, July 2017.

Cover is a derivative of images from iStock.

Use of commercial and trade names does not imply approval or constitute endorsement by USDA.

To ensure the quality of its research reports and satisfy governmentwide standards, ERS requires that all research reports with substantively new material be reviewed by qualified technical research peers. This technical peer review process, coordinated by ERS' Peer Review Coordinating Council, allows experts who possess the technical background, perspective, and expertise to provide an objective and meaningful assessment of the output's substantive content and clarity of communication during the publication's review.

In accordance with Federal civil rights law and U.S. Department of Agriculture (USDA) civil rights regulations and policies, the USDA, its Agencies, offices, and employees, and institutions participating in or administering USDA programs are prohibited from discriminating based on race, color, national origin, religion, sex, gender identity (including gender expression), sexual orientation, disability, age, marital status, family/parental status, income derived from a public assistance program, political beliefs, or reprisal or retaliation for prior civil rights activity, in any program or activity conducted or funded by USDA (not all bases apply to all programs). Remedies and complaint filing deadlines vary by program or incident.

Persons with disabilities who require alternative means of communication for program information (e.g., Braille, large print, audiotape, American Sign Language, etc.) should contact the responsible Agency or USDA's TARGET Center at (202) 720-2600 (voice and TTY) or contact USDA through the Federal Relay Service at (800) 877-8339. Additionally, program information may be made available in languages other than English.

To file a program discrimination complaint, complete the USDA Program Discrimination Complaint Form, AD-3027, found online at [How to File a Program Discrimination Complaint](#) and at any USDA office or write a letter addressed to USDA and provide in the letter all of the information requested in the form. To request a copy of the complaint form, call (866) 632-9992. Submit your completed form or letter to USDA by: (1) mail: U.S. Department of Agriculture, Office of the Assistant Secretary for Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410; (2) fax: (202) 690-7442; or (3) email: program.intake@usda.gov.

USDA is an equal opportunity provider, employer, and lender.



**Economic
Research
Service**

Economic
Research
Report
Number 235

July 2017

Food Insecurity, Chronic Disease, and Health Among Working-Age Adults

Christian A. Gregory and Alisha Coleman-Jensen

Abstract

This report documents the strong correlation between food security status and chronic health conditions among working-age adults living at or below 200 percent of the Federal poverty line (FPL). In general, lower food security is associated with higher probability of each of the chronic diseases we examine—hypertension, coronary heart disease (CHD), hepatitis, stroke, cancer, asthma, diabetes, arthritis, chronic obstructive pulmonary disease (COPD), and kidney disease. Food security status is also strongly related to the likelihood of chronic disease in general, to the number of chronic conditions afflicting the sufferer, and to self-assessed health. Moreover, looking at the entire range of household food security (high, marginal, low, and very low) is important for understanding individuals' experience of chronic illness and, more generally, health. Indeed, food security status is more strongly predictive of chronic illness in some cases even than income. Income is significantly associated with just 3 of the 10 chronic diseases examined in this report, while food insecurity is associated with all 10.

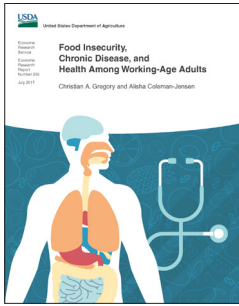
Keywords: Health, chronic illness, food insecurity, self-assessed health, working-age adults, low-income.

Acknowledgments

The authors would like to thank Ed Frongillo, University of South Carolina; Colleen Heflin, University of Missouri; and Linda Kantor, Jean Buzby, Dave Smallwood, and Constance Newman, U.S. Department of Agriculture, Economic Research Service (ERS) for their assistance with this manuscript. Thanks also to ERS editor Dale Simms and designer Ethiene Salgado-Rodriguez.

Contents

Summary	iii
Introduction	1
Related Research	3
Data	5
Methods	10
Results	12
Individual Chronic Conditions	12
Any Chronic Illness, Self-Assessed Health, and Number of Chronic Illnesses	17
Conclusion	20
References	21
Appendix	24



Food Insecurity, Chronic Disease, and Health Among Working-Age Adults

Christian A. Gregory and Alisha Coleman-Jensen

What Is the Issue?

By definition, households that are food secure have access at all times to the kinds and quantities of foods needed for all members to enjoy an active, healthy life. Households that are food insecure have difficulty in consistently obtaining adequate food because of limited economic resources for food. Households that are food insecure also face other challenges—in particular, with respect to health. Extensive literature has examined the associations between food security and health, almost all of it showing the strong correlation between food insecurity and negative health outcomes.

Much of that research is understandably focused on children. Working-age adults have been examined less frequently, and that research has usually focused on a single outcome. Moreover, this research usually highlights differences between food-secure and insecure households; few studies look at health outcomes over the range of food security status—high, marginal, low, and very low. And there are no studies to date that look at health outcomes simultaneously.

In this report, we examine the relationship between food security and health as measured by 10 chronic conditions identified by the Centers for Disease Control and Prevention (CDC) as particularly worthy of research because of their prevalence, cost, morbidity, and preventability. We focus on the role of food security as a predictor of health among working-age adults and the differences in health outcomes across the range of household food security: high, marginal, low, and very low.

What Did the Study Find?

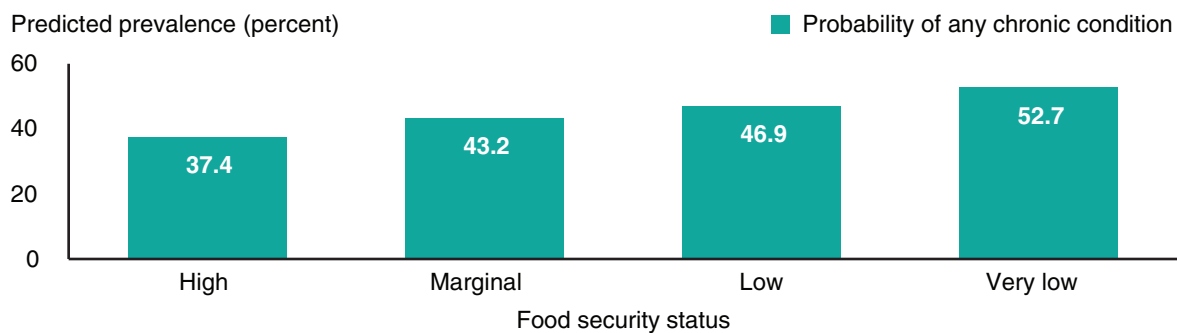
In general, lower food security is associated with higher probability of each of the chronic diseases examined—hypertension, coronary heart disease (CHD), hepatitis, stroke, cancer, asthma, diabetes, arthritis, chronic obstructive pulmonary disease (COPD), and kidney disease. Food security status is also strongly related to the likelihood of chronic disease in general, to the number of chronic conditions reported, and to self-assessed health. Moreover, differences between adults in households with marginal, low, and very low food security are very often statistically significant, which suggests that looking at the entire range of food security is important for understanding chronic illness and potential economic hardship. Indeed, food security status is more strongly predictive of chronic illness in some cases even than income.

ERS is a primary source of economic research and analysis from the U.S. Department of Agriculture, providing timely information on economic and policy issues related to agriculture, food, the environment, and rural America.

Income is only significantly associated with 3 of the 10 chronic diseases—hepatitis, arthritis, and COPD—while food insecurity is significantly associated with all 10. In particular, we find that:

- Adults in households with lower food security status have elevated probabilities of chronic disease diagnosis for all of the conditions we examine. For example, adults in very low food-secure households are 10.5 percentage points more likely than adults in high food-secure households to be diagnosed with hypertension.
- Adults in households with very low food security were 15.3 percentage points more likely to have any chronic illness than adults in households with high food security, as is shown in the figure below. This is a 40-percent increase in overall prevalence.
- Adults in households with marginal food security were 9 percentage points less likely to report excellent health, compared to those in households with high food security, and 1.3 percentage points more likely to report poor health.
- The number of chronic conditions for adults in households with low food security is, on average, 18 percent higher than for those in high food-secure households.

Adults in households with more severe food insecurity are more likely to have a chronic illness



Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015.

How Was the Study Conducted?

The authors used 5 years of data (2011-2015) from the National Health Interview Survey (NHIS), a nationally representative household survey with a complex survey design that is sponsored by the Centers for Disease Control and Prevention's National Center for Health Statistics. The NHIS is the source for national statistics on the health of the U.S. population. Food security is measured using a series of 10 questions about experiences and behaviors of household adults that indicate food insecurity in the 30 days prior to the survey, such as being unable to afford balanced meals, cutting the size of or skipping meals because of too little money for food, or being hungry because of too little money for food. The study sample included non-senior adults (age 19-64) in households below 200 percent of the Federal poverty line. Regression estimates were adjusted to account for the complex survey design of the NHIS. The regression adjustment shows the conditional association—or, correlation—between food security status and health outcomes.

Our main sample includes adults in households with income at or below 200 percent of the Federal poverty line (41,854 total); estimates are regression-adjusted for age, gender, marital status, employment status, number of children (below age 18) in the household, total size of household, race, education, health insurance, and income (as a fraction of the Federal poverty line).

Food Insecurity, Chronic Disease, and Health Among Working-Age Adults

Introduction

Food security status is strongly correlated with measures of health, and there is a known correlation between income, wealth, and health status (Dorling, 2015; Pickett and Wilkinson, 2015). While this correlation has been known on a macroeconomic or aggregate level for some time (Deaton, 2008), and while research on child health and food insecurity has flourished (for a review of literature on food insecurity and children’s health outcomes, see Coleman-Jensen et al., 2013), the links between the health of working-age adults and household food insecurity are less studied.

In most prior research on the correlates of food insecurity, adults are classified as belonging to either food-secure or food-insecure households. This classification scheme, however, obscures distinctions between adults in households reporting no food-insecure conditions (highly food secure) and those reporting only one or two food-insecure conditions (marginally food secure) because these groups are often combined into the food-secure group (see box, “Defining Food Security Status”). At the same time, differences between those with low food security and very low food security, often labeled together as “food insecure,” can be missed by this taxonomy. In this report, we examine the differences in health between working-age adults in these different household food-security situations.

Other studies about food security and health among adults focus on one or at most two health outcomes. We use chronic illness and self-assessed health as general indicators of underlying health, but also look at 10 chronic illnesses—both separately and together—to show how food security status relates to both individual conditions and chronic illness generally. The analyses in this report do not determine causality between food insecurity and chronic conditions. Instead, we focus on understanding to what extent food insecurity and health are associated with one another, separate from income and other factors.

In general, food security status and health outcomes move in tandem across the classification of food security into high, marginal, low, and very low. Most differences in health, we find, are statistically significant, implying large potential differences in expected costs of illness across food security categorizations. Significant differences in health outcomes between households with high and marginal (as well as low and very low) food security—normally characterized together as food secure (food insecure)—suggest that the more exact food-insecurity classification captures important information about economic hardship and how it translates into poorer health outcomes. Moreover, similarity in health outcomes between households with marginal and low food security suggests that the prevailing binary classification (food secure and insecure) can obscure ways that households thought to be food secure are more like those that are food insecure. This is consistent with research showing that the demographic characteristics of marginally food-secure households are more similar to food-insecure households than food-secure households (Coleman-Jensen, 2009); it is also consistent with research suggesting that marginal food security among children is associated with negative health outcomes (Jyoti et al., 2005).

Defining Food Security Status

The food security status of each household lies along a continuum from high food security to very low food security. (See box, “Questions Used To Assess Food Security of Households in the National Health Interview Survey”.) Lack of access is, in all cases, due to lack of monetary resources or the inability to afford adequate food. The food security continuum is characterized as follows:

Two-category food security status:	Food secure		Food insecure	
Four-category food security status:	High food security —Households had no problems or anxiety about consistently accessing adequate food.	Marginal food security —Households had problems, at times, or anxiety about acquiring adequate food, but the quality, variety, and quantity of their food intake were not substantially reduced.	Low food security —At times during the year, households reduced the quality, variety, and desirability of their diets due to a lack of resources for food, but the quantity of food intake and normal eating patterns were not substantially disrupted.	Very low food security —At times during the year, eating patterns of one or more household members were disrupted and food intake reduced because the household lacked money and other resources for food.
Severity of food insecurity	Less severe -----> More severe			

Related Research

Research on the associations with and, more rarely, the causal effects of food security on health outcomes has focused mainly on children. Children are vulnerable to adverse social conditions, and the cumulative costs of food insecurity over a lifetime are presumably high. A recent longitudinal study of childhood health and food insecurity found that episodes of food insecurity in kindergarten were associated with reports of compromised health in eighth grade (Ryu and Bartfeld, 2012). A review of recent research (Coleman-Jensen et al., 2013) found consistent evidence of negative health and developmental consequences associated with food insecurity. In another review of the literature on food insecurity and health, children in households that were food insecure were more likely to suffer from a host of conditions including some birth defects, anemia, cognitive difficulties, aggression, anxiety, asthma, behavioral problems, depression, and poorer oral health (Gundersen and Ziliak, 2015).

Working-age adults have received less attention than children, but there is still extensive literature examining the relationship between food insecurity and their health outcomes. Food insecurity among adults has been found to be associated with depression and adverse mental health conditions, diabetes, hypertension, high cholesterol, and poor sleep outcomes (Gundersen and Ziliak, 2015). Even though Bhattacharya et al. (2004) found no nutritional differences between food-insecure and food-secure children, they did find nutritional differences among adults.

Many studies emphasize the tradeoffs that low-income households have to make between food and other necessities. Bhattacharya and colleagues (2003) found that poor households often spend less on and eat less food during cold weather shocks. Recent studies using the same National Health Interview Survey (NHIS) data source used in this report have found that food insecurity is a risk factor for underuse of medication (due to cost) among adults with chronic disease (Berkowitz et al., 2014), among all working-age adults (Herman et al., 2015), and among elderly adults (Afulani et al., 2015). Such occurrences include not being able to afford prescriptions due to cost or skipping doses/taking less medication than prescribed in order to save money. Food-insecure older adults (age 60+) in Georgia were almost three times more likely to engage in cost-related medication budgeting than those who were food secure (Bengle et al., 2010).

Few studies have looked at causal relationships between food security and health outcomes. However, one pathway between food insecurity and healthcare use is suggested by a series of studies that link diabetes, glycemic control, and hypoglycemia to food insecurity (Seligman et al., 2010; Seligman et al., 2011; Seligman, et al., 2010). In general, for persons with low tolerance for variation in blood glucose—diabetics—food insecurity is more likely to prompt trips to the emergency room. Another approach has been suggested by Gundersen and Kreider (2009), who address the issues about measurement and confounding bias by using bounding methods. Under relatively weak assumptions, they find that food security has a positive effect on child health.

This report examines 10 chronic conditions that have been singled out by the Centers for Disease Control and Prevention as being particularly important to population health (see box, “Chronic Conditions”) and worthy of research (Goodman et al., 2013). We examine these conditions both separately and together and focus on the correlation between different chronic health conditions and severity of food insecurity. We highlight the differences in health outcomes between adults in high, marginal, low, and very low food-secure households, whereas most other studies use the more general food secure/insecure distinction.

Chronic Conditions

Chronic conditions are those that last for a year or more, result in limitations (to mobility or functioning), and/or require ongoing medical treatment. Chronic conditions or diseases are costly both in terms of human life and in terms of financial costs.¹ In 2012, 48 percent of U.S. adults had 1 or more chronic condition; 25 percent had multiple chronic conditions (Ward et al., 2014). Chronic conditions can impair quality of life, affect employment and other life activities, and even hasten death. Of the top 10 causes of death in 2014, 7 were chronic diseases. In 2010, 86 percent of healthcare spending was for adults with 1 or more chronic conditions. Per-person healthcare spending for people with 1 chronic condition was 2.5 times more than spending for people with no chronic conditions; per-person healthcare spending increases with each additional chronic condition (Gerteis et al., 2014).

Some of the human and monetary costs associated with chronic conditions could be reduced because many such conditions are preventable. Poor nutrition can play a role in the development of diabetes, cancer, heart disease, and stroke.

We examine whether, and to what extent, food insecurity is associated with 10 chronic diseases, all targeted by the CDC as warranting research in order to mitigate the conditions and reduce associated costs. Given the growing significance of chronic disease in the U.S. population's health, the CDC has recommended consistent definitions and classifications of chronic disease to improve research and monitoring. The 10 chronic diseases examined here are self-reported in the National Health Interview Survey (Goodman et al., 2013)². They include:

1. Hypertension/high blood pressure
2. Coronary heart disease (CHD)
3. Hepatitis
4. Stroke
5. Cancer
6. Asthma
7. Diabetes
8. Arthritis
9. Chronic obstructive pulmonary disease (COPD)
10. Chronic kidney disease.

¹Throughout this report, we use the terms “chronic condition,” “chronic disease,” and “chronic illness” interchangeably.

²Goodman and colleagues identify 20 chronic diseases as being important for research, monitoring, and prevention, but we only examine the 10 of these that are reported in NHIS. The other 10 are congestive heart failure, autism, cardiac arrhythmias, hyperlipidemia, dementia, depression, HIV, osteoporosis, schizophrenia, and substance abuse disorders.

Data

Data are from the National Health Interview Survey (NHIS), 2011-15. Sponsored by the Centers for Disease Control and Prevention's National Center for Health Statistics, the NHIS is a nationally representative survey of roughly 40,000 U.S. households with an oversample of Black, Hispanic, and Asian households. It contains health information on each person living in sampled households, with more extensive information collected from one sample adult and one sample child (if children are present) per household. Surveys are conducted in person. We concentrate on information given by the sample adult, who is randomly chosen from within a sampled household. The sample adult responds to all of the health questions for him/herself, whereas information about other adults may be given by another adult in the household. Questions about the household, including food security questions, are answered by an adult household representative who may or may not be the same person as the sample adult for that family.

We begin with a sample of 172,465 unweighted observations, which includes all sample adults across 2011-15. We limit the sample to households for whom the sample person is a working-age adult (18-64)¹ (excluding 39,038 observations), is not a pregnant woman (excluding 1,648 observations), has valid responses to the food security module questions (excluding 23 observations), is not missing information on chronic conditions (excluding 2,176 observations), and lives in households that have income less than or equal to 200 percent of the Federal poverty line (FPL) (excluding 87,726 observations).² The final sample used for estimation and analysis consists of 41,854 sample adults.³

The NHIS began administering the 10-item, 30-day food security module in 2011. The 10 items include 3 questions about food conditions of the household as a whole and 7 questions about food conditions for adults alone. Food security status is determined by the answers to the 10 questions (see box, "Questions Used To Assess the Food Security of Households in the National Health Interview Survey"). Each question asks about conditions or behaviors that characterize households when they are having difficulty meeting their basic food needs and stipulates that the reason for the difficulty was a lack of money or other resources.⁴ Affirmative responses ("often," "sometimes," and "yes") to the food security questions were summed for all households. Answers to questions about the frequency of behaviors (cut or skip meals, not eat for a whole day in the previous 30 days) that were greater than or equal to 3 days were counted as affirmative.

Households that affirmed none of the food-insecure conditions were categorized as having high food security, while those with one or two affirmatives were counted as having marginal food security.

¹We restrict our sample to working-age adults to avoid conclusions that conflate difference in time allocation, health insurance, and income that are, on average, different for retired persons.

²We wanted to capture a sample of adults from households where there was a reasonable chance of having high food security (no affirmative responses to the food security module questions) but with some resource constraints. The average income-to-poverty ratio for adults who report at least one affirmative is 165 percent, so we wanted to go a little above that; 200 percent of the Federal poverty line gave us both good sample size and variation in food security status.

³For estimation purposes, we use two strategies to get correct inferences on the estimation subsample. First, we retain the entire sample but zero-weight observations that are not in our desired subsample in order to get correct inferences, as suggested in Korn and Graubard (1999). Second, we use Stata's `subpop` subcommand to specify the estimation sample. See West et al. (2008).

⁴Most USDA food security statistics rely on questions that ask about food security during the previous 12 months. The NHIS only asks about food insecurity experienced in the 30 days prior to the survey. The 30-day reference period was used in the NHIS to enable research linking current health conditions to current food security status.

(Often, especially for the purposes of estimating food insecurity prevalence, households with high and marginal food security are classified together as food secure.) Households that affirm three to five conditions are counted as having low food security, while those affirming six or more conditions are counted as having very low food security. (Households with low or very low food security are also frequently called food insecure.)

Questions Used To Assess Food Security of Households in the National Health Interview Survey (NHIS)

1. “We worried whether our food would run out before we got money to buy more.” Was that often, sometimes, or never true for you in the last 30 days?
2. “The food that we bought just didn’t last and we didn’t have money to get more.” Was that often, sometimes, or never true for you in the last 30 days?
3. “We couldn’t afford to eat balanced meals.” Was that often, sometimes, or never true for you in the last 30 days?
4. In the last 30 days, did you or other adults in the household ever cut the size of your meals or skip meals because there wasn’t enough money for food? (Yes/No)
5. (If yes to question 4) In the last 30 days, how many days did this happen?
6. In the last 30 days, did you ever eat less than you felt you should because there wasn’t enough money for food? (Yes/No)
7. In the last 30 days, were you ever hungry, but didn’t eat, because there wasn’t enough money for food? (Yes/No)
8. In the last 30 days, did you lose weight because there wasn’t enough money for food? (Yes/No)
9. In the last 30 days did you or other adults in your household ever not eat for a whole day because there wasn’t enough money for food? (Yes/No)
10. (If yes to question 9) In the last 30 days, how many days did this happen?

Table 1 shows descriptive statistics for sampled adults and, below, their households categorized by food security status. Sampled adults in very low food-secure households are older than those in all other households. Women make up a little more than half of the sample and a little more than half of each of the food insecurity categories. As severity of food insecurity worsens, the proportion of sample adults who are employed decreases, from 57 percent in high food-secure households to 38 percent in households suffering very low food security. As food insecurity worsens, a smaller proportion of sample adults are married.

Table 1
Sample means

	Food security status				
	All	High	Marginal	Low	Very low
	Characteristics of sampled adult				
Age	37.45 (0.154)	36.74 (0.214)	37.02 (0.257)	38.65 (0.230)	39.56 (0.250)
Female	0.531 (0.004)	0.516 (0.004)	0.550 (0.009)	0.565 (0.008)	0.538 (0.009)
Employed	0.524 (0.004)	0.570 (0.005)	0.529 (0.009)	0.474 (0.009)	0.377 (0.009)
Married	0.362 (0.004)	0.380 (0.006)	0.373 (0.009)	0.358 (0.009)	0.277 (0.008)
Non-Hispanic White	0.483 (0.006)	0.506 (0.007)	0.436 (0.010)	0.412 (0.010)	0.513 (0.009)
Non-Hispanic Black	0.175 (0.004)	0.145 (0.004)	0.205 (0.008)	0.213 (0.008)	0.226 (0.008)
Hispanic	0.267 (0.006)	0.263 (0.006)	0.297 (0.009)	0.310 (0.009)	0.205 (0.007)
Asian	0.047 (0.002)	0.061 (0.003)	0.038 (0.003)	0.027 (0.003)	0.018 (0.002)
Other race	0.028 (0.001)	0.024 (0.002)	0.024 (0.003)	0.038 (0.004)	0.039 (0.004)
Insured	0.652 (0.005)	0.680 (0.006)	0.627 (0.009)	0.597 (0.009)	0.619 (0.009)
	Characteristics of household				
Highest education: High school dropout	0.148 (0.003)	0.125 (0.003)	0.167 (0.006)	0.192 (0.007)	0.174 (0.006)
Highest education: High school graduate	0.295 (0.004)	0.277 (0.005)	0.316 (0.008)	0.321 (0.008)	0.320 (0.009)
Highest education: Some college	0.400 (0.005)	0.403 (0.007)	0.392 (0.009)	0.390 (0.009)	0.412 (0.010)
Highest education: College graduate	0.156 (0.003)	0.194 (0.005)	0.124 (0.006)	0.096 (0.006)	0.095 (0.006)
Number of children	1.093 (0.014)	1.065 (0.018)	1.295 (0.025)	1.165 (0.026)	0.907 (0.027)
Family size	3.154 (0.023)	3.092 (0.031)	3.450 (0.039)	3.310 (0.037)	2.911 (0.042)
Household income-to-poverty ratio	1.080 (0.006)	1.123 (0.009)	1.075 (0.009)	1.026 (0.009)	0.969 (0.009)
N	41,854	23,799	5,967	6,286	5,802

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Standard errors in parenthesis. All estimates account for complex survey design. N = number of unweighted observations.

Sample adults in households that have high food security are less likely to be non-Hispanic Black or Hispanic than those with marginal, low, or very low food security. Asian adults comprise a little less than 5 percent of the sample (column 1), but are overrepresented in the high food security category and underrepresented in the lower food security groups.⁵ Adults in very low food-secure households are also less likely to have health insurance than those in high food-secure households.

The highest level of education by anyone in households characterized as having very low food security is generally lower than the highest level of education in households with high food security and marginal food security—cohorts typically categorized together as food secure. Only 12.4 percent of marginally food-secure households have someone who graduated from college versus 19.4 percent of households with high food security. In terms of household composition, while households with marginal and low food security have more children and more persons overall, the differences between households with very low food security and high food security are small. Finally, households with better food security have higher incomes relative to the poverty line.⁶

The prevalence of the 10 chronic conditions is similar in the population as a whole and among our low-income sample. It is not until we begin to stratify by food security status that clearer distinctions emerge (table 2). There is a statistically significant increase in the prevalence of chronic health conditions as food security worsens. For example, the prevalence of hypertension for adults in households with high, marginal, low, and very low food security is 19.7, 23.6, 28.0, and 36.1 percent, respectively. Similarly, the prevalence for chronic obstructive pulmonary disease (COPD) is 4.9, 7.2, 8.9, and 15.0 percent across worsening food security status.

⁵The “other race” category contains multi-race individuals as well as those who do not self-identify in one of the specified categories, and so it is difficult to make meaningful interpretations for this group.

⁶NHIS imputes income data for families that either report it in terms of categories (more than X, less than Y) or do not report it at all. Among sample adults, roughly 85 percent report their income, 3 percent give no information, and 12 percent give income information in categories. Among the estimation sample (200 percent of the FPL or below), all of the sample adults live in households that report income information; none live in households that have imputed income information.

Table 2

Proportion of adults with chronic illnesses

Condition	Population	< 200% FPL	Food security status			
			High	Marginal	Low	Very low
Hypertension	0.229 (0.002)	0.237 (0.003)	0.197 (0.004)	0.236 (0.008)	0.280 (0.008)	0.361 (0.009)
CHD	0.022 (0.001)	0.029 (0.001)	0.020 (0.001)	0.029 (0.003)	0.037 (0.003)	0.056 (0.005)
Hepatitis	0.025 (0.001)	0.031 (0.001)	0.026 (0.001)	0.028 (0.003)	0.038 (0.003)	0.050 (0.004)
Stroke	0.015 (0.000)	0.024 (0.001)	0.016 (0.001)	0.020 (0.002)	0.034 (0.003)	0.050 (0.004)
Cancer	0.049 (0.001)	0.039 (0.001)	0.033 (0.002)	0.038 (0.004)	0.047 (0.003)	0.058 (0.004)
Asthma	0.077 (0.001)	0.095 (0.002)	0.074 (0.002)	0.096 (0.005)	0.115 (0.006)	0.165 (0.006)
Diabetes	0.067 (0.001)	0.086 (0.002)	0.068 (0.002)	0.087 (0.005)	0.111 (0.005)	0.140 (0.006)
Arthritis	0.167 (0.002)	0.175 (0.003)	0.135 (0.003)	0.172 (0.007)	0.216 (0.007)	0.300 (0.008)
COPD	0.047 (0.001)	0.072 (0.002)	0.049 (0.002)	0.072 (0.005)	0.089 (0.005)	0.150 (0.007)
Kidney disease	0.012 (0.000)	0.021 (0.001)	0.013 (0.001)	0.020 (0.002)	0.026 (0.002)	0.050 (0.004)
N	129,580†	41,854	23,799	5,967	6,286	5,802

CHD = coronary heart disease; COPD = chronic obstructive pulmonary disease. N = number of unweighted observations. Standard errors in parentheses. All estimates account for complex survey design. For each condition, all pairwise differences between adults in households with respective levels of food insecurity are significant at $p = .10$. † Estimates for the full adult sample applied all exclusions outlined in the text except for the exclusion based on income/poverty ratio.

Source: USDA, Economic Research Service calculations using National Health Interview Survey data, 2011-2015.

Methods

We estimate logistic regressions to determine the conditional association of food insecurity with each of the chronic conditions examined (tables 3 and 4). We also estimate a logistic regression of the conditional association of food insecurity with the presence of any chronic condition (table 6, column 1). In very general terms, these models belong to a latent variable framework, where

$$y_i^* = x_i\beta + \varepsilon_i$$

expresses the relationship between an unobserved latent variable, y_i^* , and the observed regressors x , which include food security status. The latent variable represents the propensity to have one of the conditions in question, or any of the conditions in question, depending on the specification. The variable we observe, y , takes a value of zero or one. We assume that ε has an extreme value distribution and that

$$y_i^* = 1 \quad \text{if} \quad x_i\beta + \varepsilon_i > 0.$$

This set of assumptions allows us to characterize the probability that we observe that $y = 1$:

$$P(y = 1) = P(y_i^* > 0) = P(-x_i\beta < \varepsilon_i) = F(x_i\beta),$$

where F is the extreme value (logistic) cumulative distribution function (CDF).

For estimates of the conditional association of food security status and self-assessed health, we used an ordered logistic regression, which also falls in the latent variable framework. However, our observed variable takes k values, $1, 2, \dots, k$. So,

$$y_i = k \quad \text{if} \quad \mu_{k-1} \leq x_i\beta < \mu_k,$$

where μ_1, \dots, μ_{k-1} are threshold parameters estimated by the model. The thresholds and other parameters characterize the probabilities as:

$$P(y_i = k) = P(\mu_{k-1} < x_i\beta < \mu_k) = F(\mu_k - x_i\beta) - F(\mu_{k-1} - x_i\beta),$$

where once again F is the extreme value CDF.

Finally, for specifications estimating the conditional association of food security status with the **number** of conditions (table 6, column 2), we use a negative binomial regression. This is a simple generalized linear model where it is assumed that the distribution of the outcome is very skewed—for example, with a lot of zeros. The density for the count of affirmed conditions can be modeled as:

$$h(Y_i | X_i, \alpha) = \frac{\Gamma(\alpha^{-1} + y_i)}{\Gamma(\alpha^{-1})\Gamma(y_i + 1)} \left(\frac{\alpha^{-1}}{\alpha^{-1} + \mu_i} \right)^{\alpha^{-1}} \left(\frac{\mu_i}{\alpha^{-1} + \mu_i} \right)^{y_i}$$

Here, α is a parameter that characterizes heterogeneity on the observation level; $\mu_i = \exp(X_i\beta)$ with $X_i\beta$ defined as above, and Γ is the gamma function.⁷

For all of these models, we are most interested in marginal changes in the expected value of the outcome with a change in food security status. In all cases, although the specific calculations will differ based on the functional forms used, this change can be expressed as:

$$E(y | FS = j) - E(y | FS = High),$$

where $j =$ Marginal, Low, or Very Low. Standard errors for these quantities are calculated by the delta method.⁸

⁷We modeled this count variable using poisson, negative binomial, and ordered probit models. Using Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) criteria, the ordered probit was very weakly preferred to the negative binomial, but both were strongly preferred to the poisson. We present the results from the negative binomial to ease exposition of the marginal changes by food security status, but they are qualitatively the same as the ordered outcomes model. For more on the negative binomial model, see Cameron and Trivedi (2013).

⁸We use Stata 14 for all of these calculations. We invoke the margins command to calculate marginal changes and standard errors. Both sets of calculations were checked by hand by deriving the quantities analytically and programming them independently of packaged routines.

Results

Individual Chronic Conditions

Table 3 shows the regression parameters for each of the 10 chronic health conditions using logistic regression. Because the logistic regression is nonlinear, the magnitudes of the coefficients are not informative about the size of marginal changes in the probability of illness associated with the variables in question. However, the signs of the coefficients and their significance do indicate if they were significant predictors of chronic illness: negative signs indicate that the variable (e.g., female, very low food security) reduces the probability of that condition, while positive signs indicate a marginal increase associated with that variable.⁹ For the most part, marginal, low, and very low food security status are strongly associated with chronic disease, relative to high food security (the reference group). For each condition, as food insecurity worsens, the likelihood of having the condition increases. While marginal food security is not significantly more closely associated with hepatitis, stroke, or cancer, it is significantly associated with each of the other chronic diseases.

For sampled adults in these regressions (second panel from the top, table 3), age is positively (and predictably) associated with the probability of chronic illnesses.¹⁰ Women are less likely than men to report hypertension, CHD, and hepatitis, but more likely to report cancer, asthma, arthritis, and COPD. Marital status, for the most part, is not associated with chronic illness. Hispanic and Asian adults are less likely to have one of these chronic conditions, while non-Hispanic Black adults are more likely to report some conditions and less likely to report others, relative to Whites (the reference group). For example, non-Hispanic Blacks are less likely to report hepatitis, cancer, arthritis, and COPD than Whites, but more likely to report stroke or diabetes. Hispanics are less likely to report hypertension, CHD, stroke, cancer, asthma, arthritis, and COPD, and more likely to report diabetes than Whites. Asian adults are significantly less likely than Whites to report hypertension, CHD, cancer, asthma, arthritis, and COPD.

Persons who are employed are less likely to report chronic illness than those who are not employed. Persons who are insured are more likely to report these conditions, all else being equal. Although this result seems counterintuitive (having health insurance is associated with higher income), it reflects the higher probability that low-income people with health insurance will visit the doctor and thus receive a diagnosis. It also suggests that what is being measured in the negative correlation of employment with chronic illness is related to unobserved characteristics associated with attachment to the labor market.

Adults in households that include a college graduate are less likely to report chronic health conditions than adults in households with no high school graduate: particularly significant in this regard are the associations with hypertension, CHD, stroke, diabetes, arthritis, COPD, and kidney disease (table 3, last panel). Also of note, adults in households with more children are more likely to report cancer, and less likely to report asthma, diabetes, COPD, and kidney disease.

⁹A more rigorous statement about the relationship between these coefficients and the marginal changes in probability would be the following: although it is true that there is no linear mapping of the size of the coefficients to the size of the marginal changes in probability, larger coefficients generally mean larger effects.

¹⁰Results are the same whether we include age as a continuous or categorical measure with three or four categories.

Table 3

Regression parameters, logistic regression for probability of chronic illness

Variable	Hyper-tension	CHD	Hepatitis	Stroke	Cancer	Asthma	Diabetes	Arthritis	COPD	Kidney
Food security status										
Marginal food security	0.229*** (0.052)	0.353*** (0.115)	0.107 (0.110)	0.185 (0.138)	0.170 (0.119)	0.288*** (0.067)	0.250*** (0.073)	0.339*** (0.060)	0.405*** (0.080)	0.384*** (0.133)
Low food security	0.345*** (0.048)	0.433*** (0.116)	0.305*** (0.103)	0.520*** (0.104)	0.295*** (0.084)	0.431*** (0.067)	0.363*** (0.068)	0.500*** (0.056)	0.491*** (0.075)	0.496*** (0.118)
Very low food security	0.641*** (0.048)	0.761*** (0.122)	0.508*** (0.101)	0.784*** (0.105)	0.339*** (0.080)	0.734*** (0.058)	0.575*** (0.064)	0.850*** (0.052)	0.945*** (0.066)	1.050*** (0.117)
Characteristics of sample adult										
Age	0.074*** (0.001)	0.089*** (0.004)	0.051*** (0.003)	0.076*** (0.004)	0.060*** (0.003)	0.004** (0.002)	0.077*** (0.002)	0.075*** (0.002)	0.045*** (0.002)	0.044*** (0.004)
Female	-0.132*** (0.037)	-0.574*** (0.082)	-0.275*** (0.070)	-0.090 (0.084)	0.539*** (0.070)	0.580*** (0.045)	-0.073 (0.048)	0.408*** (0.041)	0.318*** (0.054)	0.075 (0.090)
Employed	-0.471*** (0.036)	-0.912*** (0.111)	-0.307*** (0.085)	-1.118*** (0.109)	-0.514*** (0.073)	-0.431*** (0.050)	-0.557*** (0.053)	-0.592*** (0.042)	-0.551*** (0.065)	-1.079*** (0.107)
Married	0.091** (0.044)	0.070 (0.103)	-0.205** (0.102)	0.166 (0.106)	0.020 (0.090)	-0.152*** (0.057)	0.105* (0.056)	0.042 (0.048)	-0.102 (0.075)	0.089 (0.119)
Black	0.504*** (0.044)	-0.057 (0.095)	-0.473*** (0.100)	0.371*** (0.087)	-0.983*** (0.101)	-0.037 (0.059)	0.325*** (0.063)	-0.393*** (0.052)	-0.499*** (0.065)	0.085 (0.101)
Hispanic	-0.302*** (0.048)	-0.329*** (0.121)	0.007 (0.106)	-0.179 (0.122)	-0.824*** (0.112)	-0.528*** (0.067)	0.280*** (0.068)	-0.985*** (0.058)	-1.071*** (0.088)	0.160 (0.101)
Asian	-0.483*** (0.090)	-0.580*** (0.214)	0.118 (0.184)	-0.497* (0.282)	-1.332*** (0.301)	-0.841*** (0.148)	-0.012 (0.115)	-1.239*** (0.126)	-1.247*** (0.168)	-0.136 (0.246)
Other race	0.195* (0.102)	-0.014 (0.191)	0.323 (0.200)	0.531** (0.227)	-0.195 (0.155)	0.266** (0.119)	0.240* (0.129)	-0.099 (0.121)	-0.064 (0.141)	0.289 (0.217)
Has insurance	0.430*** (0.042)	0.491*** (0.121)	0.216** (0.089)	0.797*** (0.104)	0.428*** (0.087)	0.519*** (0.060)	0.619*** (0.058)	0.574*** (0.043)	0.527*** (0.084)	0.580*** (0.113)
Characteristics of household										
High school graduate	-0.003 (0.046)	-0.051 (0.094)	0.106 (0.107)	-0.156 (0.108)	0.102 (0.093)	-0.015 (0.068)	-0.082 (0.072)	0.032 (0.053)	-0.029 (0.069)	-0.332*** (0.125)
Some college	-0.046 (0.048)	-0.122 (0.097)	0.049 (0.102)	-0.048 (0.103)	0.127 (0.101)	0.019 (0.069)	-0.147** (0.072)	0.117** (0.053)	-0.129* (0.078)	-0.099 (0.115)
College graduate	-0.312*** (0.061)	-0.296** (0.150)	-0.026 (0.132)	-0.410*** (0.151)	0.001 (0.123)	0.001 (0.090)	-0.473*** (0.089)	-0.266*** (0.075)	-0.539*** (0.103)	-0.447** (0.183)
Number of children	-0.016 (0.025)	-0.000 (0.091)	-0.040 (0.071)	0.000 (0.073)	0.198*** (0.074)	-0.135*** (0.040)	-0.083** (0.039)	0.031 (0.038)	-0.194*** (0.049)	-0.150* (0.082)
Family size	-0.008 (0.019)	-0.000 (0.062)	0.016 (0.061)	-0.070 (0.052)	-0.205*** (0.056)	0.040 (0.031)	0.078*** (0.030)	-0.031 (0.028)	0.115*** (0.039)	0.049 (0.071)
Household income-to-poverty ratio	0.006 (0.036)	-0.097 (0.085)	-0.088 (0.084)	-0.176** (0.078)	0.005 (0.071)	-0.149*** (0.046)	-0.029 (0.048)	-0.038 (0.039)	-0.191*** (0.058)	-0.140 (0.096)
Constant	-4.348*** (0.098)	-7.371*** (0.308)	-5.362*** (0.245)	-7.234*** (0.277)	-5.715*** (0.209)	-2.806*** (0.126)	-6.299*** (0.164)	-4.886*** (0.119)	-4.687*** (0.159)	-5.847*** (0.252)
N	41,854									

Notes: Parameters from logistic regressions for individual conditions. Standard errors in parentheses. Coefficients on year dummies not shown. All models account for complex survey design. *p<.1, **p<.05, ***p<.01.

The marginal increases in the probability of each chronic illness for each level of food security are shown in table 4. These are increases in the probability of each illness, relative to those in high food-secure households. For each condition, the increase associated with marginal, low, and very low food security is shown in the marked rows, and the prevalence among those with high food security is shown in the last row marked “Prevalence”). For hypertension, CHD, asthma, diabetes, arthritis, COPD, and kidney disease, adults in households with marginal, low, and very low food security have increased risk of chronic illness relative to those in high food-secure households. For hepatitis, stroke, and cancer, adults in households with low and very low food security have increased risk of chronic illness.

The magnitude of changes in the risk of disease associated with food security may seem small. However, when compared to the prevalence of chronic disease among those with high food security, the food security-related changes in the occurrence of these diseases begin to look decidedly larger. For example, the results for changes in hypertension associated with marginal food security suggest an increase of about 21 percent ($.035/.168 = .208$); for conditions such as COPD and asthma, the associated increase (with marginal food security) is at or over 100 percent of prevalence among adults in high food-secure households (COPD: $.017/.011 = 1.54$; asthma: $.017/.012 = 1.41$). For diabetes, the increase in occurrence with marginal food security is roughly 60 percent ($.017/.028$).

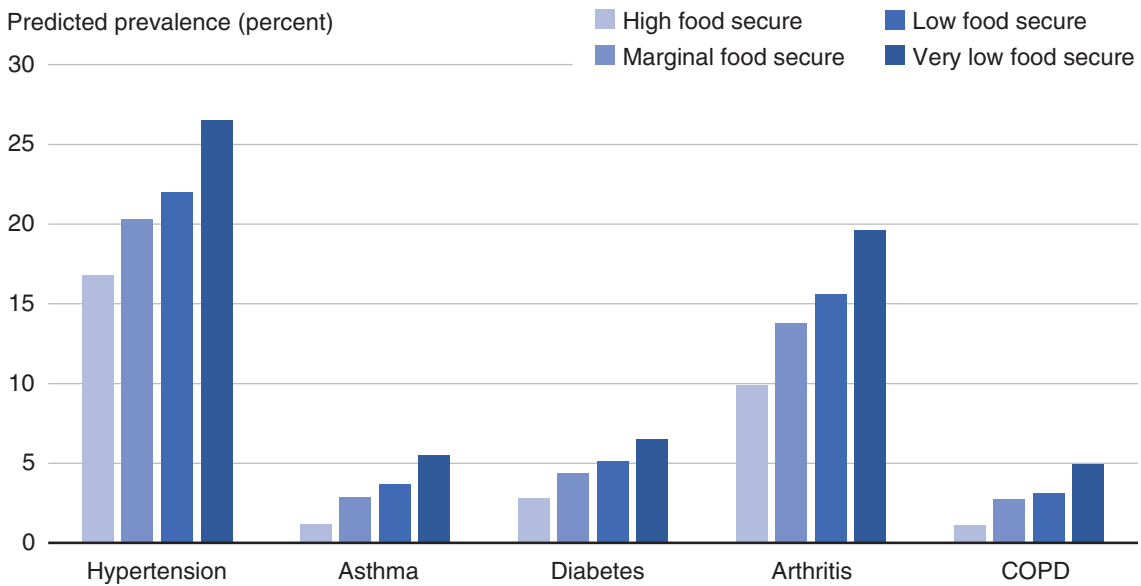
However, for adults in households with very low food security, the relative probability of chronic disease increases dramatically. For example, the increased risk of hypertension associated with very low food security is roughly 66 percent of prevalence (relative to high food-secure households); for asthma and COPD, the risk of occurrence increases roughly 400 percent. Very low food security is also associated with an increase of over 100 percent in the prevalence of arthritis and diabetes, compared with adults from high food-secure households.

The predicted percent of low-income working-age adults that have a chronic illness is shown in figures 1 and 2. Figure 1 shows the five chronic conditions with the highest prevalence rates, while figure 2 shows the five chronic conditions that are less common and have lower prevalence rates. These prevalence estimates are based on the quantities shown in table 4. Large differences in the prevalence of chronic conditions are apparent across the range of household food security. The prevalence of hypertension ranges from 16.8 percent for low-income adults in high food-secure households to 27.3 percent for low-income adults in households with very low food security (figure 1). While the overall prevalence of coronary heart disease is much lower than hypertension, the relative difference in prevalence by food security status is different. An estimated 0.3 percent of low-income working-age adults in high food-secure households had CHD versus 1.8 percent of adults in households with very low food security (figure 2).

While the differences in chronic disease between adults in households with marginal, low, and very low food security relative to those with high food security are large, adults in each of these different kinds of households differ **from each other** in the prevalence of chronic illness. Table 5 shows significance tests for differences between adults in households with marginal, low, and very low food security for each of the health outcomes. The three rightmost columns in the table show comparisons between adults in marginal and low, marginal and very low, and low and very low food-secure households, respectively. For each condition listed, the first line in the panel shows the value of the F-test statistic for the equivalence of the estimates, and the second row shows the p-value of the test statistic.

Figure 1

Predicted prevalence of more common chronic diseases by food security status, adults in low-income households

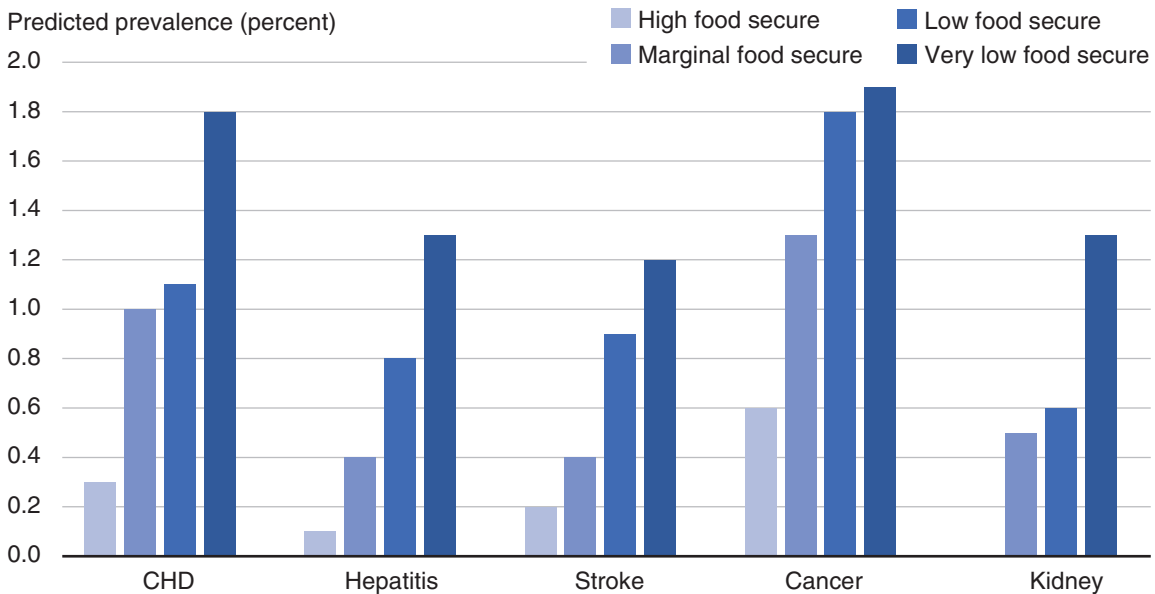


COPD = chronic obstructive pulmonary disease.

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Predicted prevalence estimates are adjusted for: survey year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, and household income-to-poverty ratio. Sample includes working-age adults in households at or below 200 percent of the Federal poverty line.

Figure 2

Predicted prevalence of less common chronic diseases by food security status, adults in low-income households



CHD = coronary heart disease.

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Predicted prevalence estimates are adjusted for: survey year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, and household income-to-poverty ratio. Sample includes working-age adults in households at or below 200 percent of the Federal poverty line.

Table 4

Predicted increases in risk of chronic disease by household food security status

	Hypertension	CHD	Hepatitis	Stroke	Cancer	Asthma	Diabetes	Arthritis	COPD	Kidney
Marginal	0.035*** (0.008)	0.007** (0.003)	0.003 (0.003)	0.002 (0.002)	0.007 (0.005)	0.017*** (0.005)	0.017*** (0.005)	0.040*** (0.008)	0.017*** (0.004)	0.004** (0.002)
Low	0.054*** (0.008)	0.009*** (0.003)	0.008** (0.003)	0.007*** (0.002)	0.013*** (0.004)	0.027*** (0.005)	0.025*** (0.005)	0.061*** (0.008)	0.021*** (0.004)	0.006*** (0.002)
Very low	0.105*** (0.009)	0.018*** (0.005)	0.014*** (0.004)	0.013*** (0.003)	0.015*** (0.005)	0.052*** (0.006)	0.043*** (0.006)	0.112*** (0.009)	0.049*** (0.006)	0.017*** (0.004)
Prevalence	0.168	0.003	0.001	0.002	0.006	0.012	0.028	0.099	0.011	0.000
N	41,854									

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Regressions also include survey year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, smoking indicator, body mass index and household income-to-poverty ratio. Sample includes working-age adults in households at or below 200% of the Federal poverty level. Standard errors in parenthesis, calculated by the delta method. N = unweighted observations. *p<.1, **p<.05, ***p<.01.

Tests for differences between marginal and low food security show significant differences ($p<.10$) for hypertension, stroke, asthma, and arthritis (table 5). Tests for differences between adults in households with marginal and very low food security are significant for all conditions; the same is true for differences between households with low and very low food security. These differences indicate that detailed food security status provides more nuanced information about the prevalence of chronic health conditions across working-age low-income households. By comparison, the income-to-poverty ratio (table 3) is predictive for only 3 of the 10 chronic health conditions examined.¹¹

Table 5

Significance tests of differences between marginal, low, and very low food security status in regression models

		Marginal-Low	Marginal-Very low	Low-Very low
Hypertension	Test	3.277	37.990	28.742
	p-value	(0.071)	(0.000)	(0.000)
CHD	Test	0.318	8.330	6.360
	p-value	(0.573)	(0.004)	(0.012)
Hepatitis	Test	2.359	9.514	3.184
	p-value	(0.126)	(0.002)	(0.075)
Stroke	Test	4.972	17.396	4.769
	p-value	(0.027)	(0.000)	(0.030)
Cancer	Test	1.041	1.815	0.215
	p-value	(0.309)	(0.179)	(0.643)
Asthma	Test	3.157	37.030	17.015
	p-value	(0.077)	(0.000)	(0.000)

continued

¹¹We estimated all of the regressions with body mass index and smoking indicators included. While each of these is significant for some of the conditions, their inclusion does not affect the marginal changes significantly or the gradient of food insecurity with respect to health.

Table 5

Significance tests of differences between marginal, low, and very low food security status in regression models - *continued*

		Marginal-Low	Marginal-Very low	Low-Very low
Diabetes	Test	1.892	14.235	7.531
	p-value	(0.170)	(0.000)	(0.006)
Arthritis	Test	6.289	58.454	31.141
	p-value	(0.013)	(0.000)	(0.000)
COPD	Test	0.748	41.505	26.605
	p-value	(0.388)	(0.000)	(0.000)
Kidney disease	Test	0.552	22.084	19.108
	p-value	(0.458)	(0.000)	(0.000)
Number of conditions	Test	12.605	131.459	78.088
	p-value	(0.000)	(0.000)	(0.000)
Self-assessed health	Test	44.554	299.620	88.771
	p-value	(0.000)	(0.000)	(0.000)

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. All regressions include year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, and household income-to-poverty ratio. P-values of tests in parenthesis.

Any Chronic Illness, Self-Assessed Health, and Number of Chronic Illnesses

Table 6 and figure 3 show the marginal increase in the probability of any chronic illness associated with food insecurity (first column)¹² and the associations of food security with the number of chronic conditions reported (above the number reported by adults in highly food-secure households). As for individual chronic conditions (table 5), these results confirm that food insecurity has a strong association with increased risk of any chronic condition and with the number of chronic conditions reported. The increased risks of any chronic condition associated with marginal, low, and very low food security are 90-200 percent of the baseline probability for adults in high food-secure households. Marginal, low, and very low food security are also associated with increases in the expected number of conditions. These marginal changes are not only different from baseline prevalence (high food-secure adults) or the mean, but they are statistically different from each other as well (table 5).

As in most health surveys, the NHIS poses the question, “How good would you say your health is ...” in terms of a 5-point scale: excellent, very good, good, fair, or poor. For all levels of food insecurity, the probability of reporting excellent health is much lower than for adults in high food-secure households, while the probabilities of reporting good, fair, or poor health are higher (table 7).¹³ Test statistics from table 5 indicate that differences in self-assessed health between adults in marginal and low, marginal and very low, and low and very low food-secure households are all statistically significant.

¹²Parameter estimates for the regressions discussed in this section are shown in Appendix Table 1. We also estimated models that adjust for the correlation between responses for a given person, such as those discussed in DeBoeck and Wilson (2004) and Skrondal and Rabe-Hesketh (2004). The intuition conveyed by these model results is the same as presented here: there is a steep food security gradient in health outcomes.

¹³Test statistics from table 5 indicate that differences in self-assessed health between adults in marginal and low, marginal and very low, and low and very low food secure households are all statistically significant.

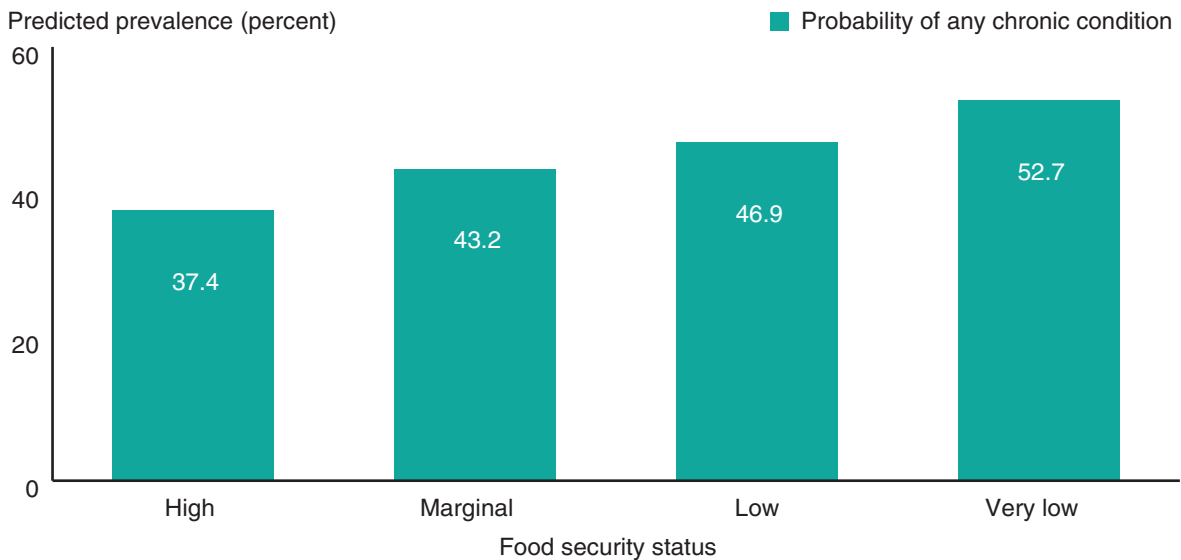
Table 6

Marginal changes in chronic health conditions associated with food security status

Food security status	Any chronic condition	Number of conditions
Marginal	0.053*** (0.009)	0.204*** (0.031)
Low	0.088*** (0.009)	0.329*** (0.031)
Very Low	0.142*** (0.010)	0.620*** (0.045)
High: Prevalence/mean	0.378	1.139
N	41,854	

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Regressions also include year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, and household income-to-poverty ratio. Sample includes working-age adults in households at or below 200% of the Federal poverty level. Standard errors in parenthesis, calculated by the delta method. N = unweighted observations. *p<.1, **p<.05,***p<.01.

Figure 3

Adults in households with more severe food insecurity are more likely to have a chronic illness

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Predicted prevalence estimates are adjusted for: survey year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, and household income-to-poverty ratio. Sample includes working-age adults in households at or below 200 percent of the Federal poverty line.

Table 7

Marginal changes in self-assessed health associated with food security status

Self-assessed health	Food security status		
	Marginal	Low	Very low
Excellent	-0.091*** (0.006)	-0.137*** (0.006)	-0.199*** (0.007)
Very Good	-0.006** (0.003)	-0.018*** (0.005)	-0.047*** (0.007)
Good	0.047*** (0.003)	0.070*** (0.003)	0.095*** (0.003)
Fair	0.037*** (0.003)	0.062*** (0.004)	0.106*** (0.005)
Poor	0.013*** (0.001)	0.023*** (0.002)	0.045*** (0.003)
N	41,854		

Source: USDA, Economic Research Service calculations using National Health Interview Survey data 2011-2015. Regressions also include year indicators, age, gender, employment, marital status, race/ethnicity, insurance status, highest education of any adult in household, number of children, family size, and household income-to-poverty ratio. Sample includes working-age adults in households at or below 200% of the Federal poverty level. Standard errors in parenthesis, calculated by the delta method. N = unweighted observations. *p<.1, **p<.05, ***p<.01.

Conclusion

This report documents the strong correlation between food security status and chronic health conditions among working-age adults living at or below 200 percent of the Federal poverty line. The goal of this analysis is not simply to understand how 10 chronic diseases relate to food insecurity, but to understand how health itself (including self-assessed health) relates to food security and to document the empirical association of food insecurity with health outcomes.

In general, lower food security is associated with higher probability of each of the chronic diseases examined—hypertension, coronary heart disease (CHD), hepatitis, stroke, cancer, asthma, diabetes, arthritis, chronic obstructive pulmonary disease (COPD), and kidney disease. Food security status is also strongly related to the likelihood of chronic disease in general, to the number of chronic conditions reported, and to self-assessed health. Moreover, differences between adults in households with marginal, low, and very low food security are very often statistically significant, which suggests that looking at the entire range of food security is important for understanding chronic illness and potential economic hardship. Indeed, food security status is more strongly predictive of chronic illness in some cases even than income. Income is significantly associated with only 3 of the 10 chronic diseases—hepatitis, arthritis, and COPD—while food insecurity is significantly associated with all 10.

The magnitude of the higher probabilities of chronic illness associated with food insecurity is striking. Even for adults in marginally food-secure households—which are normally classified as food secure and typically endure relatively mild food hardships—the associated increases in the probability of hypertension, diabetes, and COPD are 20, 59, and 158 percent, respectively, compared to the (baseline) prevalence of those diseases in low-income, high food-secure households. The gaps in relative health risks associated with low versus very low food security are even larger.

Understanding the associations between food insecurity and chronic illness is important not only for monetary reasons. Chronic diseases have short- and long-term effects on both quality of life and morbidity; food insecurity may be one of many factors contributing to the impact of these chronic conditions on low-income adults. For example, low or very low food insecurity could make it that much more difficult to live with cancer or diabetes, all other things being equal. The effort to understand these correlations is also an effort to understand the extra challenges faced by low-income adults with any degree of food insecurity.

References

- Afulani, P., D. Herman, A. Coleman-Jensen, and G.G. Harrison. 2015. "Food Insecurity and Health Outcomes Among Older Adults: The Role of Cost-Related Medication Underuse," *Journal of Nutrition in Gerontology and Geriatrics* 34(3): 319-342. doi:10.1080/21551197.2015.1054575
- Bengle, R., S. Sinnett, T. Johnson, M.A. Johnson, A. Brown, and J.S. Lee. 2010. "Food Insecurity Is Associated with Cost-Related Medication Non-Adherence in Community-Dwelling, Low-Income Older Adults in Georgia," *Journal of Nutrition For the Elderly* 29(2): 170-191. doi:10.1080/01639361003772400
- Berkowitz, S.A., H.K. Seligman, and N.K. Choudhry. 2014. "Treat or Eat: Food Insecurity, Cost-related Medication Underuse, and Unmet Needs," *The American Journal of Medicine* 127(4): 303-310.e303. doi:http://dx.doi.org/10.1016/j.amjmed.2014.01.002
- Bhattacharya, J., J. Currie, and S. Haider. 2004. "Poverty, food insecurity, and nutritional outcomes in children and adults," *Journal of Health Economics* 23(4): 839-862. doi:10.1016/j.jhealeco.2003.12.008
- Bhattacharya, J., T. DeLeire, S. Haider, and J. Currie. 2003. "Heat or Eat? Cold-Weather Shocks and Nutrition in Poor American Families," *American Journal of Public Health* 93(7): 1149-1154.
- Cameron, A.C., and P.K. Trivedi. 2013. *Regression Analysis of Count Data*. New York: Cambridge UP.
- Centers for Disease Control and Prevention. 2008. "National Diabetes Fact Sheet: General Information and National Estimates on Diabetes in the United States." 2007.
- Coleman-Jensen, A., W. McFall, and M. Nord. 2013. *Food Insecurity in Households with Children*. EIB-113. U.S. Dept. of Agriculture, Economic Research Service.
- Coleman-Jensen, A., M. Rabbitt, C.A. Gregory, and A. Singh. 2015. *Household Food Security in the United States in 2014*. ERR-194, U.S. Department of Agriculture, Economic Research Service, Sept.
- Coleman-Jensen, A.J. 2009. "U.S. Food Insecurity Status: Toward a Refined Definition," *Social Indicators Research* 95(2): 215-230. doi:10.1007/s11205-009-9455-4
- De Boeck, P., and M. Wilson. 2004. *Explanatory Item Response Models: A Generalized Linear and Non-Linear Approach*. New York: Springer.
- Deaton, A. 2008. "Income, Health, and Well-Being Around the World: Evidence from the Gallup World Poll," *Jouranal of Economic Perspectives* 22(2): 53-72.
- Dorling, D. 2015. "The mother of underlying causes – Economic ranking and health inequality," *Social Science & Medicine* 128: 327-330. doi:http://dx.doi.org/10.1016/j.socscimed.2015.01.008
- Gerteis, J., D. Izrael, D. Deitz, L. LeRoy, R. Ricciardi, T. Miller, and J. Basu. 2014. "Multiple chronic conditions chartbook." Rockville, MD: Agency for Healthcare Research and Quality (AHRQ) Publications.

- Goodman, R.A., S.F. Posner, E.S. Huang, A.K. Prekh, and H.K. Koh. 2013. *Defining and Measuring Chronic Conditions: Imperatives for Research, Policy, Program, and Practice*.
- Greene, William A., and David A. Hensher. 2010. *Modeling Ordered Choices*. Oxford: Cambridge.
- Gundersen, C., and B. Kreider. 2009. "Bounding the effects of food insecurity on children's health outcomes," *Journal of Health Economics* 28(5): 971-983. doi:10.1016/j.jhealeco.2009.06.012
- Gundersen, C., and J.P. Ziliak. 2015. "Food Insecurity And Health Outcomes," *Health Affairs* 34(11): 1830-1839. doi:10.1377/hlthaff.2015.0645
- Herman, D., P. Afulani, A. Coleman-Jensen, and G.G. Harrison. 2015. "Food Insecurity and Cost-Related Medication Underuse Among Nonelderly Adults in a Nationally Representative Sample," *American Journal of Public Health* 105(10): e48-e59. doi:10.2105/AJPH.2015.302712.
- Jyoti, D.F., E.A. Fongillo, and S.J. Jones. 2005. "Food Insecurity Affects School Children's Academic Performance, Weight Gain, and Social Skills," *Journal of Nutrition* 135: 2831-2839.
- Korn, Edward L., and Barry I. Graubard. 1999. *Analysis of Health Surveys*. New York: Wiley.
- Nord, M., A. Coleman-Jensen, and C.A. Gregory. 2014. *Prevalence of U.S. Food Insecurity Is Related to Changes in Unemployment, Inflation, and the Price of Food*. ERR-167, U.S. Department of Agriculture, Economic Research Service, June.
- Pagliara, A.S., R.H. Caplan, C.B. Gundersen, G.G. Wickus, and A.C. Elston, 3rd. 1983. "Peripheral resistance to thyroid hormone in a family: heterogeneity of clinical presentation," *Journal of Pediatrics* 103(2): 228-232.
- Pickett, K.E., and R.G. Wilkinson. 2015. "Income inequality and health: A causal review," *Social Science & Medicine* 128: 316-326. doi:http://dx.doi.org/10.1016/j.socscimed.2014.12.031
- Ryu, J.-H., and J. Bartfeld. 2012. "Household Food Insecurity During Childhood and Subsequent Health Status: The Early Childhood Longitudinal Study-Kindergarten Cohort," *American Journal of Public Health* 102(11): 50-55.
- Seligman, H.K., A.B. Bindman, E. Vittinghoff, A. Kanaya, and M. Kushel. 2010. "Food Insecurity is Associated with Diabetes Mellitus: Results from the National Health Examination and Nutrition Survey (NHANES) 1999-2002," *Journal of General Internal Medicine* 22(7): 1018-1023. doi:10.1007/s11606-007-0192-6
- Seligman, H.K., E.A. Jacobs, L. Andrea, U. Sarkar, J. Tschann, and A. Fernandez. 2011. "Food Insecurity and Hypoglycemia Among Safety Net Patients with Diabetes," *Archives of Internal Medicine* 171(13): 1204-1206. doi:10.1001/archinternmed.2011.287.
- Seligman, H.K., B.A. Laraia, and M.B. Kushel. 2010. "Food Insecurity Is Associated with Chronic Disease Among Low-Income NHANES Participants," *The Journal of Nutrition* 140(2): 304-310. doi:10.3945/jn.109.112573
- Skronidal, A., and S. Rabe-Hesketh. 2004. *Generalized Latent Variable Modeling*. Boca Raton, FL: CRC Press.

Ward, B., J. Schiller, and R. Goodman. 2014. "Multiple Chronic Conditions Among US Adults: A 2012 Update," *Preventing Chronic Disease*.

West, B.T., P. Berglund, and S. Heeringa. 2008. "A Closer Examination of Subpopulation Analysis of Complex-Sample Survey Data," *The Stata Journal* 8 (4): 520-531.

Appendix

Appendix table 1

Parameter estimates for supplementary regressions

	Number of conditions	Self-assessed health	Any chronic condition
Age	0.049*** (0.001)	0.052*** (0.001)	0.071*** (0.001)
Female adult	0.100*** (0.018)	0.059** (0.024)	0.201*** (0.030)
Employed	-0.429*** (0.018)	-0.635*** (0.026)	-0.501*** (0.033)
Married	0.025 (0.024)	-0.062** (0.030)	-0.034 (0.040)
Black	-0.033 (0.021)	-0.072** (0.035)	0.004 (0.041)
Hispanic	-0.419*** (0.025)	-0.114*** (0.031)	-0.584*** (0.043)
Asian	-0.609*** (0.054)	-0.142** (0.065)	-0.838*** (0.076)
Other race	0.061 (0.049)	0.057 (0.067)	0.093 (0.091)
Has insurance	0.392*** (0.024)	0.268*** (0.027)	0.527*** (0.033)
High school grad	-0.005 (0.023)	-0.165*** (0.038)	0.059 (0.046)
Some college	0.000 (0.025)	-0.357*** (0.039)	0.063 (0.047)
College graduate	-0.213*** (0.033)	-0.827*** (0.048)	-0.254*** (0.058)
Number of children	-0.034** (0.016)	-0.131*** (0.020)	-0.067*** (0.025)
Family size	0.007 (0.012)	0.065*** (0.016)	0.000 (0.021)
Household income-to-poverty ratio	-0.060*** (0.018)	-0.139*** (0.025)	-0.015 (0.028)
Marginal food security	0.218*** (0.027)	0.486*** (0.032)	0.300*** (0.047)
Low food security	0.329*** (0.022)	0.763*** (0.036)	0.490*** (0.043)
Very low food security	0.555*** (0.025)	1.203*** (0.042)	0.787*** (0.049)
Cut1		0.272*** (0.076)	
Cut2		1.664*** (0.078)	

continued

Appendix table 1

Parameter estimates for supplementary regressions - continued

	Number of conditions	Self-assessed health	Any chronic condition
Cut3		3.362*** (0.079)	
Cut4		5.138*** (0.081)	
Constant	-2.415*** (0.053)		-3.135*** (0.086)
N	41,854		

Standard errors in parentheses. N = unweighted observations. *p < 0.1, **p < 0.05, ***p < 0.01.

Source: USDA, Economic Research Service using National Health Information Survey data 2011-2105.