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EXECUTIVE SUMMARY

Background and Purpose: Food insecurity means that the food intake of one or more household residents was reduced and their eating patterns disrupted because the household lacked money and other resources for food. In contrast, food secure households have access at all times to enough food for an active, healthy life for all household members. This study developed estimates of food insecurity risk for U.S. counties and examined associations between variables contributing to food insecurity risk, behaviors related to food insecurity risk, and health outcomes that may be affected by food insecurity. The focus was especially on variations in patterns of food insecurity across the rural-urban spectrum. From a policy perspective, this study contributes to the knowledge base regarding food insecurity and its potential contribution to health issues among rural populations, and suggests general policy initiatives to improve food security.

Methods: A literature review was conducted to identify measures, and then a series of correlational analyses were performed to examine food insecurity in relation to health outcomes. The measures chosen were accessible at the county level and were related to a state-level food security score previously developed by the US Department of Agriculture (USDA). The seven selected county measures were: 1) the poverty rate, 2) the ratio of median home value to median household income, 3) percent of low-income population ($\leq 200\%$ of poverty) receiving Supplemental Nutrition Assistance Program (SNAP) benefits, 4) percent of households with no car and more than 1 mile to a grocery store, 5) percent of low income population that is more than 1 mile from a grocery store, 6) grocery stores per 1,000 population, and 7) dollars of direct farm sales per capita.

Every county's score on these measures was expressed on a common scale and summed across measures to obtain one county-level food insecurity risk score. Risk scores were analyzed to examine variation throughout rural-urban areas throughout the nation. Rural-urban counties were defined using the nine-level USDA Rural-Urban Continuum Codes as shown in this table:

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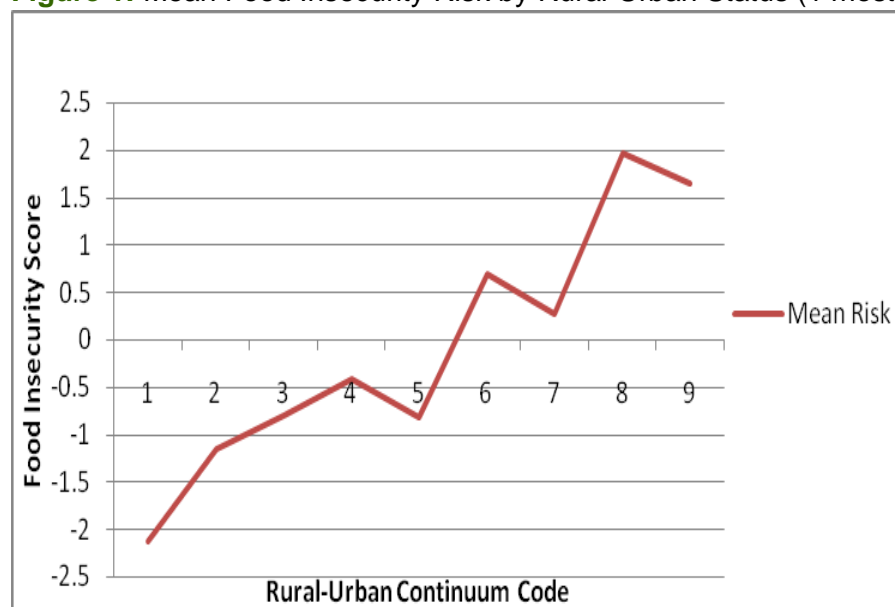
Table 1: Rural-Urban Continuum Code Descriptions*

Rural-Urban Continuum Code	Description
1	County in metro area with 1 million population or more
2	County in metro area of 250,000 to 1 million population
3	County in metro area of fewer than 250,000 population
4	Nonmetro county with urban population of 20,000 or more, adjacent to a metro area
5	Nonmetro county with urban population of 20,000 or more, not adjacent to a metro area
6	Nonmetro county with urban population of 2,500-19,999, adjacent to a metro area
7	Nonmetro county with urban population of 2,500-19,999, not adjacent to a metro area
8	Nonmetro county completely rural or less than 2,500 urban population, adj. to metro area
9	Nonmetro county completely rural or less than 2,500 urban population, not adj. to metro area

*Note that the scale tends to move from more urban to more rural, but is not strictly ranked.

Also computed were linear correlations at the county level between the food insecurity risk score and several health and behavioral outcomes. Three behavioral variables were examined: 1) a diet with less than five servings per day of fruits and vegetables, 2) no leisure-time physical activity and 3) current smoking rate. County-level prevalence estimates were generated using data from the 2000-2005 Behavioral Risk Factor Surveillance System (BRFSS). Five variables representing health outcomes were used. These include diabetes, obesity prevalence, age-adjusted death rates for heart disease, all-site cancers, and stroke. County-level data for the mortality variables were generated using individual death certificate data obtained from the National Center for Health Statistics and population denominators from the US Census.

Figure 1: Mean Food Insecurity Risk by Rural-Urban Status (1 most urban and 9 most rural)

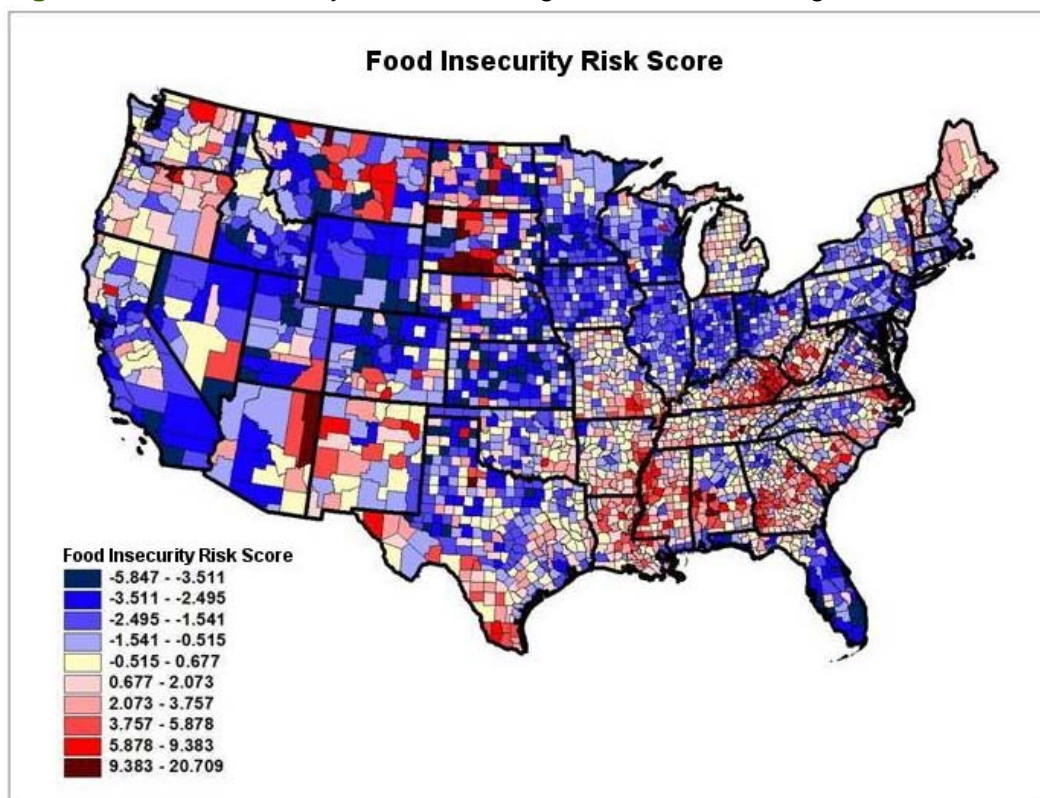


Results: Risk of food insecurity increases from a score below -2 to one above 1.5 as counties become more rural along the rural-urban continuum (refer to Figure 1). Most metropolitan counties (84%) have food insecurity risk scores falling within the five (out of ten) lowest, or most favorable, risk score categories. Much larger percentages of rural counties than major

metropolitan counties are represented in the high food insecurity risk categories. For example, 12.5% of counties with code=9 lie in the two worst food insecurity risk score groups, compared to 0% of counties with code=1 in this range.

Risk of food insecurity is highly variable across U.S. counties although a number of regions show significant clustering (refer to Figure 2). Central Appalachia, the Mississippi Delta, and Southern Crescent regions of the U.S. show generally high risk of food insecurity with large clusters of counties in the high risk range. Upper New England, many parts of the Southwestern U.S. and the Pacific Northwest also have counties in the high food insecurity categories. Several states, including Montana, North Dakota and South Dakota, also show significant gradients among their constituent counties with representation in both the very high risk and very low risk ranges. In contrast, counties in several states (e.g. Florida, Indiana, Illinois, Wyoming, Wisconsin, and Iowa) are almost all within the low risk categories.

Figure 2: Food Insecurity Risk Score. Higher scores indicate greater food insecurity.



Results of the correlational analyses show significant associations ($p < .0001$) between food security risk and diabetes, obesity, no leisure time for physical activity, less than five servings per day of fruits and vegetables, and smoking rate. There were also significant positive associations between food insecurity risk and both obesity and diabetes in some regions. No statistically significant associations were found on a national level between food insecurity risk and death rates for all causes, heart disease, cancer or stroke. However, results from the regional analyses were highly variable and showed significant correlations between food insecurity and mortality in some regions.

Conclusions: Rural counties are disproportionately associated with high food insecurity risk relative to urban counties. Programs and policies may focus on improving food availability and access for rural populations. More research, with multivariate analyses across regions, can

shed additional light on the impact of food insecurity on the health of the population, especially for those living in rural areas.

INTRODUCTION

The high cost of obesity and related chronic diseases is of concern to rural America. Provider care delivery and policy maker decisions for health promotion, health maintenance, and health restoration behaviors must be made in the context of the features of the economic and human-made (or “built”) environments in rural areas. One important piece of the built environment is the availability of high quality food sources. Food insecurity and poor food availability contribute to diminished health and disease risk factors associated with poor diets. This study examines food insecurity, develops a food insecurity risk score for United States (US) counties, analyzes results across rural-urban counties, and explores the relationship between county food insecurity risk scores, and health behaviors and outcomes.

Food insecurity is defined as reduction of food intake of one or more household residents and disruption of their eating patterns because the household lacked finances and other resources for adequate food.¹ In contrast, food secure households have access at all times to enough food for an active, healthy life for all household members. The Current Population Survey (CPS) is conducted monthly with about 50,000 households by the Census Bureau for the Bureau of Labor Statistics.² Once a year, food security supplement questions are included that ask about food expenditures, the use of supplemental food assistance and/or nutrition programs, and any incidence of food insecurity. In 2007, 11.1% of US households were food insecure at least some time during the year; and 4.1% of all US households had very low food security.³ In 2008, the national average had increased to 14.6% of households.

Food insecurity as it is currently assessed is largely an income-dependent measure.⁴ Thus, additional mechanisms of poor nutrition resulting from food insecurity are likely to be similar to those linking low income and poor nutrition. Specifically, poverty may lead to consumption of high “empty or non-nutritive” calorie per dollar foods that are largely full of refined grains, added sugars, and added fats.^{5,6} Further compounding this, rural residents have poor access to low-cost supermarkets, and rural supercenters, compared to small grocery stores, have higher prices for fresh fruits and vegetables, dairy items and less refined/processed food items.^{7,8} These findings depict a rural environment lacking easy access to nutritive-dense healthy, low-cost food. Also within this energy “calorie” imbalance environment, there is little evidence directly linking food insecurity and physical inactivity. Often in rural areas, food is most accessible at convenience stores and fast food outlets. Federal, state and local programs are available to increase funding for food to US families (such as supplemental programs like WIC, Food Stamps); but in rural areas, healthy food sources may not be readily available. Local dependencies on federal “food banks”, which typically provide high fat, refined-processed foods, may exacerbate the obesity problem.

Food Insecurity and Health Outcomes

To the extent that healthy food is not available or easily accessible, one can expect greater health problems such as obesity, diabetes, cardiovascular disease, cancer and other chronic diseases. Obesity prevalence tends to be higher in more rural counties of the US relative to urban counties, particularly in the Eastern and Southeastern regions.⁹ Factors driving obesity prevalence may relate to regional cultural differences in both eating and physical activity patterns and behaviors, such as variation in food preferences in the South, Northeast, Midwest or West.

Pheley et al. found that individuals living in food insecure households in a rural Appalachian Ohio community reported significantly worse functional health status than their food-secure counterparts in the same community.¹⁰ Results from a survey of women in rural

New York suggest that greater food insecurity is associated with reduced consumption of fruits and vegetables and significant increases in eating disorders.¹¹ Food insecurity may affect health in many ways, as summarized below.

Obesity and Diabetes: Diets high in fats increase the prevalence of obesity, leading to increased risk of cardiovascular and cerebrovascular disease. It is well understood that obesity raises the probability of developing type 2 diabetes. Current literature finds an additional linkage that may extend the impact of obesity-to-diabetes to other chronic disease co-morbidities. These findings suggest that type 2 diabetes increases the probability that some cancers will develop.¹⁶ A recent meta-analysis finds that some cancers develop more commonly in patients with type 2 diabetes, with greatest risks (approximately 2-fold or higher) for cancers of the liver, pancreas and endometrium; and lesser risks (1.2-fold to 1.5-fold) for cancers of the colon/rectum, breast and bladder.¹⁷ However, obese men with prostate cancer have higher mortality rates than men with normal weight.¹⁸

Evidence shows that diabetes may also significantly increase mortality in patients who have cancer.¹⁹ In one study, five-year mortality rates were higher in patients diagnosed with both breast cancer and diabetes, than for those diagnosed with only breast cancer.²⁰ Potential risk factors common to both cancer and diabetes include age, sex, obesity, physical activity, diet, alcohol and smoking. Of these risk factors, obesity, physical activity, diet, alcohol and smoking are modifiable. Regarding diet, most studies indicate that diets that are low in red and processed meats, and higher in vegetables, fruits, and whole grains appear to lower the risk of many types of cancers.^{21,22} Studies also indicate that diets low in red and processed meat, and high in monounsaturated fatty acids, fruits, vegetables, whole-grain cereals, and dietary fiber may protect against type 2 diabetes.²³ Diets high in foods with a high glycemic index are associated with increased risk of type 2 diabetes.²⁴ The American Cancer Society recommends limiting consumption of these foods.²² Thus, poor access to healthy foods may contribute to both diabetes and obesity risks.

Psychological Health: Research shows a dramatic increase in the use of the medical system during times of stress.¹² Stress is a factor in many illnesses including headaches, heart disease, immune deficiencies, and digestive problems. Household food insecurity has been linked to mood disorders, lower life satisfaction and higher self-perceived stress.¹³

Children: Food insecurity also impacts children. Parenting practices and parental depression are factors that link household food insecurity to childhood obesity.¹⁴ Smoking by adults in children's homes has recently been found to be highly associated with childhood food insecurity. Households with smokers were 17% food insecure compared to 8.7% in households without smokers, and rates of severe child food insecurity were 3.2% vs. 0.9%, respectively.¹⁵

In this study food insecurity risk for US counties was derived and associations between food insecurity risk, behaviors related to food insecurity risk, and health outcomes that may be affected by food insecurity were examined. This study can inform policy-level decision making by describing how food insecurity is related to health issues in rural areas.

METHODS

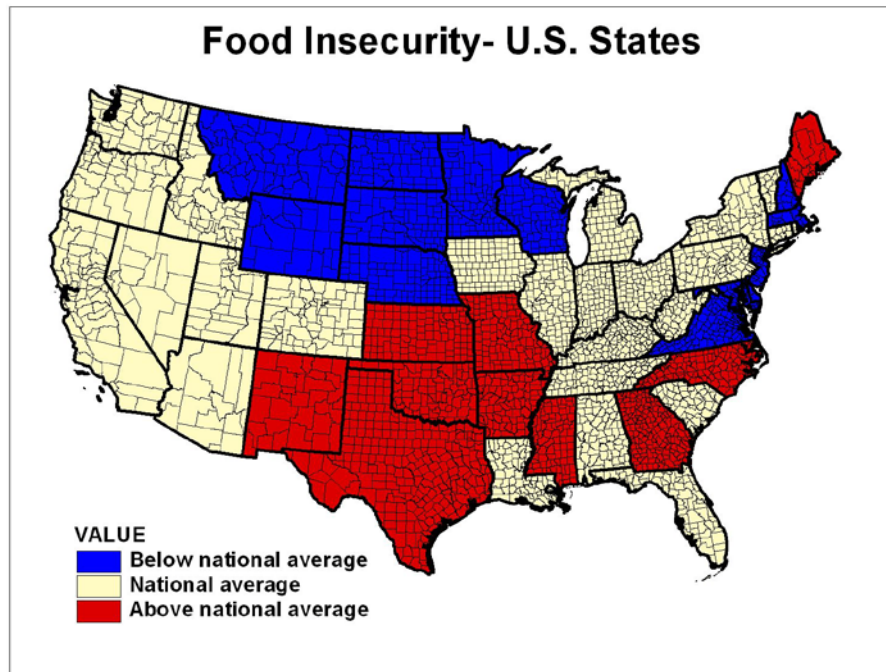
Design and Measures

Rural-urban counties were classified using the nine categories in the US Department of Agriculture's (USDA) Economic Research Service (ERS) rural-urban continuum codes shown in Table 1.²⁵ The term "rural" refers to the non-metropolitan counties (continuum codes 4-9).

Measuring rates of food insecurity is typically done using questionnaires to identify individuals/families that have experienced reduced food intake due to financial limitations or access to food resources.¹ Sample sizes are relatively small in existing surveys and insufficient to derive county-level estimates of food insecurity. Developing and implementing a questionnaire survey was beyond the scope of this study. However, during the course of this

study, ERS released the Food Environment Atlas, which contained state-level data on food security based on the Current Population Survey food insecurity questionnaires.²⁶ See Figure 3. In addition, a broad range of county-level variables were made available through the Food Environment Atlas that included food environment, food access, and related health outcome measures. This made it possible to construct a food insecurity score with N=3,141 counties, strengthening the measurement of food insecurity above the previous state-level measure.

Figure 3: State Food Insecurity



Based on a literature review of factors contributing to food insecurity, including determinants cited in an ERS study of food insecurity,²⁷ a list was developed of seven county variables that were in the Food Environment Atlas and that were correlated to the state-level food security variable. The seven county indicators were:

- Percentage of county residents with household income below the federal poverty threshold based on 2008 US Census data.
- Ratio of median home value to median household income (to reflect variations in the cost-of-living across counties).
- Percentage of people at or below 200% of the federal poverty level who are receiving Supplemental Nutrition Assistance Program, formerly Food Stamp Program benefits based on 2006 data.
- Percentage of housing units in a county that are more than one mile from a supermarket or large grocery store and that have no car. This variable represents 2006 data for stores, and 2000 data for households.
- Percentage of the population that is less than 200% of the federal poverty level for family size and lives more than one mile from a supermarket or grocery store. Again, 2006 data are for stores and 2000 data for households.
- Number of grocery stores per 1,000 population. Store data are from the U.S. Census Bureau, County Business Patterns; and 2007 population data are from the U.S. Census Bureau, Population Estimates. Convenience stores are excluded, as well as large general merchandise stores that also sell food, so that only grocery stores offering the full range of foods including fresh produce, dairy products, and less processed foods are included.
- Direct farm sales in dollars per capita. Market data and population data are for 2007. This variable accounts for food sales directly to individuals from sources such as farmers

markets, community supported agriculture (CSA) operations, farm stands, and/or pick-your-own operations, among others.

Average values for these county variables are summarized in Table 2 and described below.

Table 2: County Variable Averages by State Food Insecurity Status

Variable Average for Food Insecurity Categories								
Food Insecurity Status	Poverty rate	Median home value (\$)	Median household income (\$)	% Low-income receiving SNAP	% Households no car & > 1 mi to store	% Low income & > 1 mi to store	Grocery stores/ 1,000 pop	Direct farm sales per capita (\$)
Below National Average*	11.2	87,183.56	54,192.36	26.3	3.1	16.1	0.29	12.10
National Average	15.0	77,285.37	43,950.65	30.8	4.0	23.3	0.34	7.48
Above National Average	17.1	67,638.58	43,373.52	31.8	3.9	23.7	0.27	7.42

* Below national average is “better” in that higher scores indicate more food insecurity.

The USDA has found that food insecurity is more prevalent in households with income below the poverty line. This study included three measures of income in a county. The first was the percentage of county residents with household income below the federal poverty threshold. This variable is based on 2008 U.S. Census data. The second income-related measure studied was the ratio of median home value to median household income (to reflect variations in the cost-of-living across counties). For this variable, data are from the 2005 Area Resource File, based on 2000 data. The third measure examined was the percentage of low-income people (at or below 200% of the federal poverty level) who are receiving SNAP (Supplemental Nutrition Assistance Program, formerly Food Stamp Program) benefits to enable households to meet at least some of their food needs. The SNAP variable adds information over the poverty measure because of county variability in how effective SNAP programs are in reaching low income populations. This variable is based on 2006 data.

Availability of healthy food through access to grocery stores and supermarkets per capita is another important variable for understanding food insecurity. There may be less access to larger stores in rural areas because of fewer stores at distant locations. The fourth measure examined includes the percentage of housing units in a county that are more than one mile from a supermarket or large grocery store and that have no car. This variable represents 2006 data for stores and 2000 data for households. A store met the definition of a supermarket or large grocery store if it had at least \$2 million in annual sales and contained all the major food departments found in a traditional supermarket, including fresh meat and poultry, dairy, dry and packaged foods, and frozen foods. For each 1-kilometer-square grid cell, the number of housing units was counted and the distance was calculated from the cell’s geographic center to the nearest supermarket. For the housing units within this grid the distance was converted to whether or not the nearest supermarket or large grocery store was more than one mile away. Vehicle access was measured based on a CPS long-form survey question that asks respondents whether the housing unit has access to an automobile, van, or truck of 1-ton-load capacity or less. The study’s fifth variable combines income and food access and measures the percentage of the population in a county that is low income and lives more than one mile from a

supermarket or grocery store. Again, 2006 data are for stores and 2000 data for households. An annual household income less than 200% of federal poverty levels for family size defines low income.

Sixth, grocery stores per 1,000 population were considered. Store data are from the U.S. Census Bureau, County Business Patterns; and 2007 population data are from the U.S. Census Bureau Population Estimates. Grocery stores include supermarkets and smaller grocery stores primarily engaged in retailing a general line of food, such as canned and frozen foods; fresh fruits and vegetables; and fresh and prepared meats, fish, and poultry. Included in this industry are delicatessen-type establishments primarily engaged in retailing a general line of food. Convenience stores are excluded, as well as large general merchandise stores that also sell food.

Another source of food access is the availability of food from local farmers who are selling directly to local consumers. Thus, the seventh measure considered in this study was direct farm sales in dollars per capita. Market data and population data are for 2007. This variable accounts for food sales directly to individuals from sources such as farmers markets, community supported agriculture (CSA) operations, farm stands, and/or pick-your-own operations, and others. It excludes non-edible products such as nursery crops, cut flowers, and wool, but includes livestock sales. Sales of agricultural products by vertically integrated operations through their own processing and marketing operations are also excluded.

The Food Insecurity Risk Score

For each selected variable, means for each state were calculated and compared to the state-level food insecurity categories provided in the ERS study. It was confirmed that the directionality of each variable was the same as the directionality of the state's food insecurity score. For example, the average poverty rate was higher in states that had an above-the-national-average food insecurity score. Similarly, states reporting a below national average food insecurity score also had a lower average poverty rate. This pattern is shown for all measures in Table 2. For three of the measures the order from highest to lowest was only partially present: percent of households with no car and more than one mile to a grocery store, grocery stores per 1,000 population, and direct farm sales per capita.

A standardized county-level food insecurity risk score was then constructed by (1) subtracting the county value for each variable from the national mean for that variable; (2) dividing the result by the standard deviation for the national mean; and (3) multiplying the result by -1. (This last step has the effect of expressing the midrange as 0, where 0 reflects average food insecurity. Positive scores indicated greater food insecurity, and negative scores less food insecurity.) Three variables were reverse-scored in the algorithm so that higher scores on all measures indicate greater food insecurity: grocery stores/1,000 population, direct farm sales per capita, and median home value/household income ratio. The final food insecurity risk score was found by summing the score across all seven indicators.

Analyses

Descriptive analyses explored the food insecurity risk score across all counties and across counties defined by region and by rural-urban continuum code. Next, associations between the food insecurity risk score and health behaviors and outcomes were examined. Three behavioral variables were evaluated: (1) a diet with less than five servings per day of fruits and vegetables, (2) no leisure time for physical activity, and (3) current smoking. These variables were selected to represent major behavioral variables affecting health outcomes. County-level prevalence estimates were generated using data from the 2000-2005 Behavioral Risk Factor Surveillance System (BRFSS).²⁸ As shown in Table 3, rural counties tend to have higher prevalence of obesity and sedentary lifestyles than urban counties. In conjunction with a

high risk of food insecurity, high prevalence of obesity and sedentary lifestyles are likely to exacerbate poor health outcomes among rural counties.

Table 3: Mean Prevalence of Outcome and Behavioral Factors by Rural-Urban Codes.

Rural-Urban Code	Percent Obese Adults	Percent Adults with Diabetes	Percent with No Leisure-Time Physical Activity	Percent who Eat Less Than 5 Servings of Fruits and Vegetables per Day	Percent who Smoke
1	26.7	8.8	25.1	4.6	18.3
2	27.7	9.3	25.8	4.8	18.5
3	28.3	9.4	26.4	5.3	18.7
4	28.5	9.6	27.1	5.1	19.7
5	28.4	8.9	25.8	5.3	18.3
6	29.2	10.1	30.8	5.8	20.2
7	28.6	9.8	29.3	5.7	19.5
8	29.4	10.5	30.3	6.5	20.4
9	28.2	9.8	30.5	5.2	17.4

Five variables representing health outcomes were used. These include diabetes prevalence, obesity prevalence, and age-adjusted death rates for heart disease, all-site cancers, and stroke. These outcomes were chosen because they were expected to be most clearly related to food access and quality (obesity and diabetes) and because they represent common mortality categories that are also related to behaviors including diet. County-level data for the mortality variables were generated using individual death certificate data obtained from the National Center for Health Statistics²⁹ and population denominators from the US Census³⁰. Mortality data were aggregated over the period 1995-2001 to improve the likelihood of generating stable and reliable estimates. If a county had fewer than 20 deaths for any of the three causes of death, a death rate was not calculated and instead was assigned an 'Insufficient Data' value.

Bivariate analyses were performed to assess the level of association between food insecurity risk and each of the health behaviors and outcomes. All analyses are county-level. One analysis uses all counties in the nation, and the other analyses examine regional subsets of counties based on US Census divisions to explore possible regional differences in behavior or built environment features.

RESULTS

Risk of food insecurity increases from a score below -2 to one above 1.5 as counties become more rural along the rural-urban continuum (refer to Figure 1 in the Executive Summary). For each rural-urban continuum code Table 4 lists the number of counties in each food insecurity risk score category. As shown, there are many rural counties represented in high food insecurity risk categories in contrast to the low number of major metropolitan counties with high food insecurity. For example, in the two worst score groups there are 53 counties with code=9 (12.5% of counties with this continuum code), compared to zero counties with code=1 in this range.

Table 4: Percent of Counties within each Rural-Urban Continuum Code by Food Insecurity Risk Score Category. Each row sums to 100% of counties within each rural-urban code.

Rural-Urban Code	Risk Score										Total N
	-5.847 to -3.511	-3.512 to -2.495	-2.496 to -1.541	-1.542 to -0.515	-0.516 to 0.677	0.678 to 2.073	2.074 to 3.757	3.758 to 5.878	5.879 to 9.383	9.384 to 20.709	
1	4.1	17.7	30.5	19.3	14.1	8.4	4.1	1.9	0	0	419
2	7.4	13.6	20.4	27.6	16.1	6.8	4.3	2.2	1.5	0	323
3	6.9	12.3	24.0	20.0	16.6	10.3	6.9	2.3	0.6	0.3	350
4	4.1	11.9	16.9	23.3	24.7	11.9	4.1	2.3	0.9	0	219
5	9.9	21.8	13.9	14.9	22.8	7.9	5.0	2.0	2.0	0	101
6	2.6	6.2	13.1	16.4	18.7	18.9	13.8	7.4	2.5	0.3	609
7	6.1	14.7	14.7	14.5	15.4	14.0	10.6	5.7	3.4	0.9	442
8	0.4	2.2	10.3	9.1	18.1	22.4	16.8	9.9	8.6	2.2	232
9	2.8	6.4	9.2	12.7	15.3	15.3	13.9	11.8	8.5	4.0	424
Total N	140	344	537	545	535	421	298	173	97	29	3119

* A higher score indicates higher, or worse, food insecurity. Note that relatively few counties are in the upper right and lower left corners, indicating that food insecurity generally increases as environments become more rural

Based on the calculated Food Insecurity Risk Score, risk of food insecurity is highly variable across US counties although a number of regions show significant clustering. Central Appalachia, the Mississippi Delta, and Southern Crescent regions of the US show generally high risk of food insecurity (see Figure 2 from the Executive Summary) with large clusters of counties in the high risk range. Upper New England, many parts of the Southwestern US and the Pacific Northwest also have counties in the high food insecurity categories. Several states, including Montana, North Dakota, and South Dakota also show significant gradients among their constituent counties with representation in both the very high risk and very low risk ranges. In contrast, counties in several states (e.g. Florida, Indiana, Illinois, Wyoming, Wisconsin, and Iowa) are almost all within the low risk categories.

Most major metropolitan counties in the US (84%) have favorable food insecurity risk scores (scores falling in the lowest five categories). However, some counties on the fringes of metropolitan areas, particularly in the South, have moderate to high food insecurity risk scores. This may reflect economies-of-scale enjoyed by urban populations that are more likely to have large numbers of large-scale grocery stores that can offer a greater variety of foods and lower prices.^{7,8}

For reference, US Census divisions are shown in Figure 4. Figure 5 shows rural-urban food insecurity scores for each of these Census divisions. Rural-urban differences were not significantly different for New England and Pacific divisions, but for the remaining seven divisions the food insecurity scores were significantly worse in rural areas (rural areas are defined as non-metropolitan codes.) The worst score was 4.05 which was observed in rural areas of the East South Central division. The next two highest unfavorable scores were in rural areas of the South Atlantic (2.54) and West South Central (2.35) divisions. The most favorable scores for rural areas were found in the Pacific (-3.22) and New England (-3.20) divisions.

Figure 4: US Census Divisions

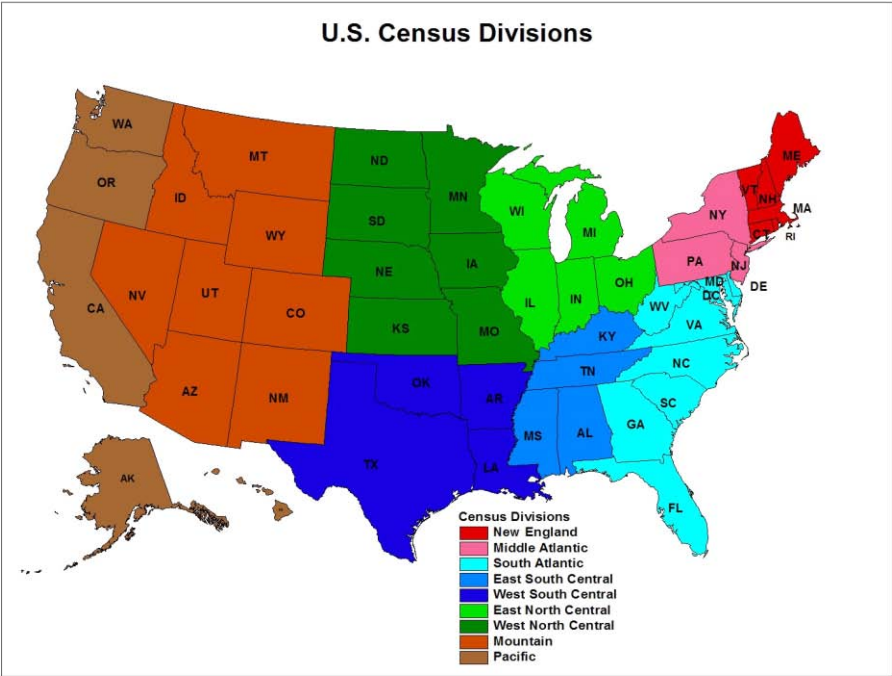
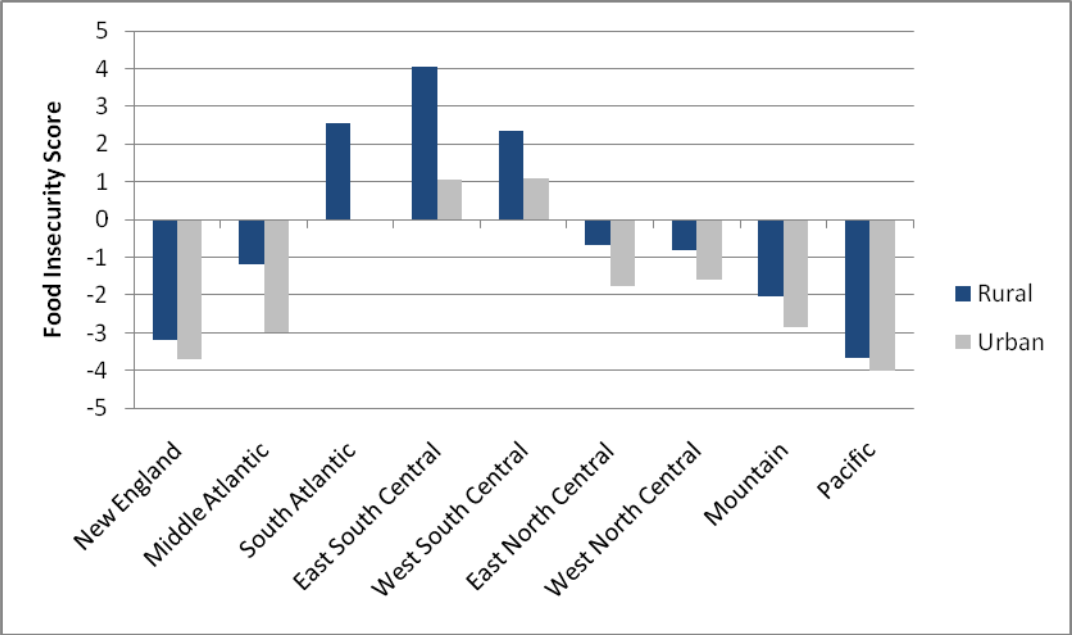


Figure 5: Food insecurity by Census divisions in rural and urban areas.



Results of the national bivariate analyses in Table 5 show statistically significant positive associations ($p < .0001$) between food insecurity risk and diabetes, obesity, no leisure time physical activity, less than five servings per day of fruits and vegetables, and smoking.

Table 5: National regression results

Regression Results Food Insecurity Risk Score with Behavior and Health Outcomes	Food Insecurity Risk Score	
	Estimate (SE)	P<
Percent of Adults with Diabetes	0.83 (0.03)	0.0001
Percent of Obese Adults	0.34 (0.02)	0.0001
Percent of Adults with No Leisure Time Physical Activity	0.15 (.007)	0.0001
Percent of Adults Who Eat Less Than 5 Servings of Fruits and Vegetables a Day	0.16 (.018)	0.0001
Percent of Adults Who Smoke	0.09 (0.009)	0.0001

At the national level, no statistically significant associations were found between food insecurity risk and death rates for all causes, heart disease, cancer or stroke. However, results from the regional analyses were highly variable (Table 6). Significant associations were found between food insecurity risk and all cause death rates in the New England ($p < .0001$), East South Central ($p < .0001$), West South Central ($p < .0001$), and West North Central ($p < .001$) US Census Divisions. (For reference, US Census divisions are shown in Figure 4).

Significant associations ($p < .01$ or better) were found between food insecurity risk and heart disease death rates in all regions except the Middle Atlantic, South Atlantic, and Mountain. Significant associations between food insecurity risk and cancer death rates were only found in the East South Central ($p < .0001$), West South Central ($p < .0001$), and West North Central ($p < .0001$) regions. Associations between food insecurity risk and stroke death rates were only significant in the New England region ($p < .0001$).

Table 6: Regional Regression Results, Association between Food Insecurity Risk Score and Mortality Rates for each US Census Division.

US Census Divisions	All Cause		Heart Disease		Cancer		Stroke	
	Estimate (SE)	P<	Estimate (SE)	P<	Estimate (SE)	P<	Estimate (SE)	P<
New England	10.3 (2.2)	0.0001	3.7 (1.3)	0.01	0.7 (0.6)	0.27	1.7 (0.4)	0.0001
Middle Atlantic	-0.6 (3.2)	0.84	3.9 (2.4)	0.10	-0.5 (1.1)	0.67	-1.3 (0.7)	0.08
South Atlantic	-839.9 (352.0)	0.02	-896.4 (355.7)	0.02	-905.7 (356.2)	0.02	-908.6 (357.2)	0.02
East South Central	19.9 (3.3)	0.0001	9.4 (1.0)	0.0001	3.7 (0.4)	0.0001	-0.4 (0.3)	0.23
West South Central	11.4 (2.9)	0.0001	4.7 (1.3)	0.001	2.7 (0.7)	0.0001	0.6 (0.4)	0.18
East North Central	3.3 (5.7)	0.57	7.9 (1.3)	0.0001	0.05 (0.6)	0.41	127.3 (124.1)	0.31
West North Central	5.0 (1.5)	0.001	4.8 (0.9)	0.0001	1.6 (.3)	0.0001	-0.1 (0.2)	0.64
Mountain	32.9 (120.4)	0.79	35.3 (121.3)	0.77	35.6 (121.4)	0.77	33.8 (121.7)	0.78
Pacific	-16.8 (11.2)	0.14	-5.8 (1.6)	0.001	0.6 (.7)	0.45	1.1 (0.4)	0.01

Table 6: Regional Regression Results (continued)

US Census Divisions	Obesity		Diabetes	
	Estimate (SE)	P<	Estimate (SE)	P<
New England	0.3 (0.1)	0.01	0.1 (0.4)	0.75
Middle Atlantic	-0.3 (0.1)	0.01	-0.4 (0.3)	0.12
South Atlantic	0.6 (.03)	0.0001	1.3 (.06)	0.0001
East South Central	0.6 (.05)	0.0001	1.1 (0.1)	0.0001
West South Central	0.5 (0.1)	0.0001	0.9 (0.1)	0.0001
East North Central	0.4 (0.1)	0.0001	0.7 (.09)	0.0001
West North Central	0.9 (0.1)	0.0001	1.4 (0.1)	0.0001
Mountain	0.1 (.05)	0.08	0.6 (0.1)	0.0001
Pacific	0.1 (.06)	0.02	0.4 (0.2)	0.03

Significant positive associations between food insecurity risk and obesity were found in all regions ($p < .02$ or better) except for the Mountain region. Significant positive associations were also found between food insecurity risk and diabetes prevalence in all regions ($p < .03$ or better) except New England and Middle Atlantic.

SUMMARY AND CONCLUSIONS

Food insecurity is becoming an increasing concern in the United States. Understanding the extent of food insecurity is critical for identifying programs and policies to reduce the adverse effects of food insecurity among affected populations. Poor nutrition has a number of adverse health outcomes particularly when it occurs in conjunction with poor health behaviors.

Estimating the extent of food insecurity is difficult due to the need to survey individual households in order to derive prevalence estimates. In this study an algorithm for estimating food insecurity at the county level was developed. This tool should be of use in targeting high-risk areas relative to food-insecurity and thus enable interventions for improving availability of high quality foods. Access to healthy food should help reduce the burden of chronic health outcomes that result from poor nutrition.

Rural counties relative to urban counties are associated with high food insecurity risk. Programs and policies may focus on improving food availability and access for rural populations. These may include in particular attention to the food infrastructure in rural environments, such as policies to increase local food availability in rural agricultural environments, school- or community-based nutrition education programs, or policies to promote greater availability of healthy food choices through tax incentives or targeted food infrastructure investments to geographic areas of greatest need. Future research, with multivariate analyses across regions can shed additional light on the impact of food insecurity on the health of the population, especially for those living in rural areas, and the nature of regional variations that may be present in rural and urban settings.

Limitations of the study include variables measured at different time points and limits that result from the county-level design. Independent variables were not all available for the same period of time, and the health outcome measures were assessed roughly equivalent in time to the food insecurity measures, when in reality health outcomes such as diabetes and early mortality would be expected to occur after exposure to poor foods. It was assumed that county level measures don't change dramatically from one year to the next, and this seems reasonable as population indicators such as poverty rates, per capita grocery stores, etc. tend to be stable at county scales. Also, the researchers in this study possess only county-level data and no individual data to link food access or consumption behaviors to individual health outcomes. Nevertheless, the derivation of the county-level measure offers a significant advance over the previously available state-level measure for the purposes of planning programs or policies to address food insecurity at finer geographic levels.

Existing policy initiatives such as the White House's Let's Move campaign are designed to reduce childhood obesity.³¹ This effort is multifaceted and includes one component that recognizes the poor access to quality foods that exists in some rural areas, and encourages local governments to "make healthy food affordable and accessible" through a variety of activities. The most recent federal Farm Bill includes provisions for improving food access to underserved populations including those in rural areas.³² Policies such as these can help to address the food insecurity problem in rural environments.

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