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Examining the Nexus of Obesity, Mental Health and Rural County Level Food Access: Testing the Enduring Role of Persistent Poverty

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This study investigates the nexus between obesity, mental health, and food access across counties in the state of Mississippi. Recent research suggests that food access and poor nutrition may not only lead to poor physical health, but may also increase depression. Data from the USDA and the CDC were used to estimate obesity and mental health rates across counties. Analyses revealed that poverty was the key factor influencing on obesity and mental health at the county level. More specifically, county level per capita SNAP benefits and status of persistent poverty were predictors of obesity and mental health. Findings are discussed in light of identifying the community determinants of food access and their impact on health.

Keywords: Mental health, obesity, food access, population health, poverty

Introduction

The Deep South, and Mississippi in particular, ranks among the highest and lowest on most social indicators: highest poverty and persistent poverty, highest food insecurity, lowest educational attainment, lowest life expectancy and highest obesity rates. Mississippi is consistently ranked the poorest state in the United States with a 23 percent poverty rate compared to national rate of 14.5 percent (U.S. Census Bureau, 2014). Mississippi also has the greatest number of persistent poverty counties, with 61 percent of its counties considered persistently poor. Persistent poverty is a United States Department of Agriculture (USDA) measure that captures the dimension of time, meaning these are counties that have had poverty rates over 20 percent over the last 30 years (Farrigan, 2017). These counties are more likely than other counties to lack basic necessities such as public services, quality food supplies, and health care services (Bennett, Probst, & Pumkam, 2011). Given the number of persistent poverty counties throughout the state, the importance of place has major implications for determining whether residents have access to healthy, affordable food, which ensures a healthy, active life.

In the state of Mississippi, food access is of significant concern. The majority of Mississippians live in rural areas and face unique challenges in relationship to health and food access. Food deserts are areas that have limited or no access to fresh food (Morton, Bitto, Oakland, & Sand, 2005). In Mississippi counties characterized by food deserts there may be convenience stores, gas stations and fast food chains that sell calorie-dense foods; however, these areas lack supermarkets or grocery stores that sell fresh fruits, vegetables, and lean meats. Limited healthy food options coupled with increased high caloric, high sugar foods, and frequent fast food consumption influences residents' health and quality of life. Consequently, Mississippians living in food deserts consume more calories than they need but do not get adequate nutrients for their bodies (Dai & Wang, 2011; UMMC Center for Bioethics and Medical Humanities, 2016) nutritious, and good-quality food may lead to poor diet and increase the risks of health problems such as obesity, diabetes, and cardiovascular diseases. This research advances the popular two-step

floating catchment area (2SFCA). Living in a food desert can also be challenging for individuals who have to manage chronic health conditions. For example, low income residents in rural areas reported difficulty complying with dietary restrictions required for managing obesity and other health-related problems (Smith & Morton, 2009).

Research also suggests that the consumption of high calorie and nutritionally inadequate food could be a function of the dietary practices of Mississippians. For instance, a typical Southern diet for Mississippians may include fried foods, such as chicken, fish, vegetables (often fried), cornbread and desserts that are eaten regularly and in high quantities (Judd et al., 2013; White et al., 2017)

In addition to low food access and residents' poor dietary practices, Mississippi has the highest food insecurity rate in the nation (18.7 percent), which is well above the national average of 13 percent (Coleman-Jensen, Rabbitt, Gregory, & Singh, 2016). (The state rates of food insecurity are based upon the combination of three-year estimates [2014–2016] in order to provide more reliable state-level statistics). Food insecurity is often associated with living in a food desert. Food insecurity is a USDA measure defined as a lack of access to enough food at all times for all members of the household to be healthy and active (Coleman-Jensen et al., 2016).

While food deserts may not directly cause food insecurity, they are good indicators of areas where food insecurity is more likely (Hossfeld, Kelly, & Waity, 2018; Morton et al., 2005). Mississippians are more likely to have problems putting food on the table, due to insufficient income to meet basic needs (Wenger, 2012). A potential consequence of food insecurity is a high prevalence of diet-related disease and obesity (Dinour, Bergen, & Yeh, 2007; Franklin et al., 2012). Since 1990, Mississippi's adult obesity rate has increased from 15 percent to the current rate of 35.6 percent (Segal, Rayburn, & Martin, 2016). Likewise, the state's food insecurity rate has continued to increase. Numerous studies have found that low-income, single-female headed households, racial and ethnic minorities, and individuals with lower education levels are the key populations most likely to experience food insecurity and subsequently the likelihood of

being overweight (Champagne et al., 2007; Drewnowski, 2009; Franklin et al., 2012; Holben, Barnett, & Holcomb, 2007)

Another consequence of the state's lack of access to healthy, affordable food and high rates of food insecurity is the potential impact on mental health outcomes for Mississippians. Researchers have found that low food access and food insecurity were significantly associated with poor or fair self-reported mental health, depression, and mental disorders (Muldoon, Duff, Fielden, & Anema, 2013; Tarasuk, Mitchell, McLaren, & McIntyre, 2013). Stress and anxiety can occur as a consequence of low food access and food insecurity, which may induce hypertension and produce hormonal imbalances that can stimulate weight gain and obesity (Laraia, Vinikoor-Imler, & Siega-Riz, 2015; Mokdad et al., 1999; Stuff et al., 2004)

There are multiple factors that influence how food access contributes to poorer physical and mental health among Mississippians and we intend to examine these associations within this study. This paper contributes to the literature concerning obesity and mental health rates among residents of persistent and non-persistent poverty counties. In the next section, we discuss the data used in the analysis followed by a presentation of the models we use to estimate obesity and mental health rates across Mississippi counties. Then we discuss the results of these empirical models, present the conclusions and the policy implications associated with this work.

Methods

We use data from several publically available state and federal databases including the Center for Disease Control and Prevention (CDC), USDA, Mississippi Department of Agriculture and Commerce (MDAC), and the United States Census Bureau to explore the relationship between county-level food access and physical and mental health.

Dependent Variables

Health indicator variables came from two data sources and were aggregated to the county level. Adult obesity rates were obtained from the CDC Prevention and Health Promotion 2010

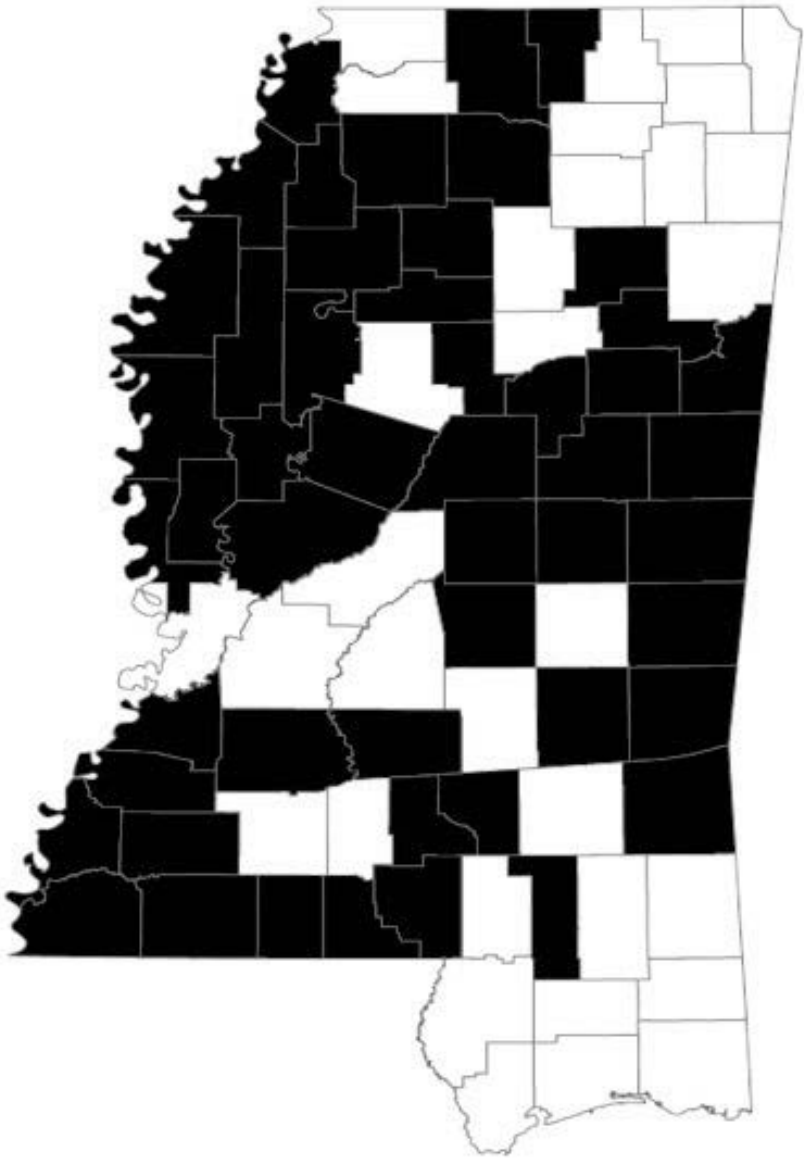
survey. Obesity rates were measured by percent of adults in a county that reported a Body Mass Index (BMI) of 30 or greater. Poor mental health days were aggregated to the county level from the Behavioral Risk Factor Surveillance survey (2006–2012) from adults 20 years or older response to the question, "Thinking about your mental health, which includes stress, depression, and problems with emotions, for how many days during the past 30 days was your mental health not good?" The use of self-reported unhealthy mental days has been widely used and is considered a valid measure (Jia, Muennig, Lubetkin, & Gold, 2004; Robert Wood Johnson Foundation, 2011).

Independent Variables

Persistent poverty. The USDA persistent poverty definition was used to categorize Mississippi countries into persistent poverty counties and non-persistent poverty counties. A county is designated as "persistent poverty" if 20 percent or more of its population is below the poverty level in 1980, 1990, and 2000 decennial censuses and 2007–2011 American Community Survey 5-year estimate (Farrigan, 2017). Figure 1 is a map of Mississippi with the persistent poverty counties in black.

Food access and availability. Food access and availability measures were obtained from the USDA Food Environment Atlas (FEA) and MDAC. We gathered information about markets from the MDAC website. The variable "farmer's market" is coded 1 if a county had at least one farmer's market. Variables drawn from the FEA include: (1) number of grocery stores per 1,000 county residents; (2) number of fast food restaurants per 1,000 county residents; (3) number of full-service restaurants; (4) number of convenience stores per 1,000 county residents; (5) percentage of household without a personal vehicle and more than one mile to the nearest store; and (6) SNAP benefits per capita. These store and restaurant variables were created by FEA from 2007 County Business Patterns and U.S. Census Bureau Population Estimates. The SNAP benefits per capita and percentage of households with a personal vehicle were derived from data from 2010.

Figure 1. Persistent poverty counties of Mississippi in black



Control Variables

We include a number of county-level controls that influence obesity and mental well-being based on theory and research. Covariates come from the 2010 U.S. Census and the FEA. Health control variables from the FEA include the number of primary care doctors per 1,000 county residents and percent with access to exercise opportunities per capita (both private and public opportunities). From the CDC public dataset, we obtained age-adjusted mortality per (excluding accidents and intentional deaths) 100,000 based on the World Health Organization's 10th revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10) categories for the years 2009–2010 (CDC, 2016).

We also include county demographic characteristics including percent 65 years of age and older, percent female (dummied in analysis with 0 = less than 51%), percent unemployed, percent African American, percent Native American, percent Hispanic, percent Asian American, percent White, and population per square mile (logged in analysis).

Analysis

We used Stata 14 to complete the analysis (StataCorp, 2015). First, we describe the sample and then conduct t-test of equivalent means for variables of interest by county persistent poverty status. Next, we conduct univariate regression for both dependent variables to inform our multiple linear regression analyses. Finally, we conduct multiple linear regression analyses. We investigate Pearson's r correlation coefficient to test for possible multicollinearity (See Appendix for correlation table). We found several pair-wise correlations above r = .71, including percent African American, percent White Non-Hispanic, percent unemployed and per capita SNAP benefits. We further test for multicollinearity by investigating the variance inflation factor (VIF) of our multiple linear regression models. We found race to be highly correlated to both dependent variables with a VIF well over 10. Due to the multicollinearity that exists among the variables, we decided to not control for race in the multiple linear regression.

Results

Table 1 displays a descriptive summary of Mississippi counties' health, food environment, and demographic characteristics. On average, Mississippi counties have over a third of their adult population with a BMI greater or equal to 30. The range of percent of obese adults per county is between 30 to 47 percent. On average, Mississippi counties reported 4.09 mental unhealthy days a month with a standard deviation of .31 days. This is significantly higher than the national average of mentally unhealthy days which is 3.8 days a month (.6 standard deviation) with a range of 2.1 to 5.6 (Robert Wood Johnson Foundation, 2011). Fifty of Mississippi's 82 counties are classified as persistently in poverty, which is just over 60 percent of the total

Table 1. Descriptive statistics for counties in Mississippi[a]

	Mean (SD)	Range
Health indicators		
Obesity rate	36.91 (3.65)	30-47
Poor mental health days	4.09 (.31)	3.4-5
Food access and availability		
Percent of counties with at less one farmers market	67.1	0-1
Per capita grocery stores	.24 (.11)	0-.67
Per capita full-service restaurants	.42 (.22)	0-1.09
Per capita convenience stores	.49 (.23)	0-1.15
Per capita fast food restaurants	.55 (.25)	0-1.00
Percentage of household without a personal vehicle and more than one mile from the nearest store	5.17 (2.59)	1.42-12.94
Per capita SNAP benefits	27.54 (10.28)	11.19-59.42
Demographic and Health controls		
Age-adjusted mortality rate per 100,000	995.49 (12.94)	756.09-1282.94
Primary care doctors per 1,000	40.40 (25.77)	0-148.00
Percent with access to exercise opportunities	43.20 (23.44)	1.00-83.00
Percent of counties that are Persistent Poverty	61.00	0-1
Percent 65 and older	13.86 (2.08)	9.20-18.20
Percent Female	51.17 (2.22)	40.90-54.20
Percent Unemployed	9.29 (2.84)	4.70-18.40
Percent African American	40.73 (20.88)	2.60-85.70
Percent native American	.60 (1.97)	.10-16.20
Percent Hispanic	2.17 (1.77)	.40-10.70
Percent Asian American	.46 (.55)	0-2.80
Percent White Non-Hispanic	55.42 (20.00)	13.70-93.50
Population per sq. mile (logged in analysis)	62.23 (64.03)	3.4-338.7
N	82	

[a]County means with standard deviation in parentheses

counties. On average, counties are 40.73 percent African American with a large standard deviation of 20.88 and a large range of 2.60 to 85.70. Mississippi is a rural state with a county average of 62.23 persons per square mile. Food access and availability is on average poor in the state with one county reporting no grocery stores at all. These issues are further stratified by poverty, as displayed by Table 2.

Table 2 shows the county mean of dependent and key independent variables by persistent poverty status. Persistent poverty counties are significantly smaller in size (42.52 vs. 93.04 persons per sq. mile), have a higher percent of African Americans (52.01 vs. 23.12), have higher age-adjusted mortality rates (1013.35 vs. 967.58), and fewer physicians (36.60 vs. 46.32). In terms of the dependent variables, persistent poverty counties have a significantly higher obesity rates (38.60 vs. 34.28) and the adult population experiences significantly more mentally unhealthy days per month (4.25 vs. 3.85). When examining food access and availability, persistent

Table 2. Mean of key variables by persistent poverty status of county for Mississippi

	Persistent poverty	Non-persistent poverty	T-test[a]
Health indicators			
Obesity rate	38.60	34.28	***
Mentally Unhealthy days	4.25	3.85	***
Food access and availability			
Percent of counties with at least one Farmers market	65.63	68.00	NS[b]
Per capita grocery stores	.25	.23	NS
Per capita full-service restaurants	.37	.48	*
Per capita convenience stores	.45	.55	*
Per capita fast food restaurants	.51	.62	*
Percentage of household without a personal vehicle and more than one mile from the nearest store	6.33	3.37	***
Per capita SNAP benefits	32.17	20.30	***
Demographic and Health characteristics			
Age-adjusted mortality rate per 100,000	1013.35	967.58	*
Primary care doctors per 1,000	36.60	46.34	*
Percent with access to exercise opportunities	40.26	47.06	NS
Percent 65 and older	13.81	13.89	NS
Percent Female	51.29	50.97	NS
Percent African American	52.01	23.12	***
Population per sq mile	42.52	93.04	**
N	50	32	

[a] *P<.05; **P<.01; ***P<.001
[b] Chi-square test

poverty counties have significantly less full-service restaurants, fewer convenience stores and fewer fast food restaurants. In addition, these counties also have a significantly higher percentage of households without a personal vehicle that are located more than one mile from the nearest store (6.33 vs. 3.37), and a significantly higher per capita of the population receiving SNAP benefits (32.17 vs. 20.30). In our analysis, there was no significant difference between persistent and non-persistent poverty counties for the percent of counties with at least one farmer's market, grocery stores per capita, percent of counties with access to exercise opportunities, percent of county residents age 65 and older, and percent of female residents in the county. We continue our investigation into the predictors of physical and mental health by using univariate regression.

Table 3 shows univariate regression results for both dependent variables and include the unstandardized and standardized beta coefficients. The standardized beta coefficients are used to compare effect size of variables measured in different units. For obesity, univariate regression shows percent African American to have the largest significant positive effect (.760) on a county's physical health, followed by per capita SNAP benefits (.730), poor mental health days (.702), percent unemployed (.668), persistent poverty (.581), and the percent of households without a personal vehicle that are located more than one mile from the nearest store (.574). Some of the food availability predictors have modest but significant negative effects on obesity. More per capita full-service restaurants, fast food and convenience stores all decrease obesity rates. Having any access to any food retailer (full-service restaurants, fast food or convenience stores) decreases obesity rates.

The findings are similar for mental health but with per capita SNAP benefits having the largest significant positive effect (.842) on county poor mental health, with racial composition (percent African American) having the second largest influence (.758) on mental health of a county, followed by percent unemployed (.732), and persistent poverty (.628). Similarly, some of the food availability predictors have modest but significant negative effects on poor mental health. Per capita full-service

Table 3. Univariate linear regression for obesity rates and poor mental health for Mississippi counties (N=82)[a]

	Obesity rates		**Poor mental health days**	
	Unstandardized Coef.	*Beta*	*Unstandardized Coef.*	*Beta*
Obesity rates	-		.060*** (-.007)	.702
Poor mental health days	8.210*** (-.931)	.702	-	
Persistent Poverty	4.319*** (-.676)	.581	.399*** (-.055)	.628
Farmer's market	-.072 (-.862)	-	-.004 (-.074)	-
Per capita grocery stores	4.09 (-3.518)	.129	.523* (-.298)	.193
Per capita full-service restaurants	-7.287*** (-1.626)	-.448	-.504*** (-.145)	-.219
Per capita fast food restaurants	-4.439*** (-1.545)	-.306	-.271** (-.135)	-.362
Per capita convenience stores	-6.642*** (-1.600)	-.421	-.458*** -(.142)	-.340
Per capita SNAP benefits	.259*** (-.027)	.730	.026*** (-.002)	.842
Percentage of household without a personal vehicle and more than one mile from the nearest store	.809*** (-.129)	.574	.075*** (-.010)	.627
Age-adjusted mortality rate per 100,000	.011** (.003)	.356	.001** (.001)	.363
Percent with access to exercise opportunities	-.045*** (-.017)	-.290	-.003* (-.001)	-.212
Primary care doctors per 1,000	-.032** (-.015)	-.224	-.002* (-.001)	-.205
Percent 65 and older	-.136 (-.196)	-.078	.006 (-.017)	.037
Fifty-one percent or more of females	1.810** (-.816)	.241	.137* (-.070)	.213
Percent Unemployed	.856*** (-.107)	.668	.080*** (-.008)	.732
Percent African American	.133*** (-.013)	.760	.011*** (-.001)	.758
Percent White Non-Hispanic	-.135*** (-.014)	-.741	-.012*** (-.001)	-.758
Percent Native American	-.076 (-.207)	-.041	.013 (-.018)	.080
Percent Hispanic	-.607*** (-.22)	-.295	-.043** (-.019)	-.243
Percent Asian American	-2.183*** (-.702)	-.328	-.180*** -(.060)	-.316
Population per sq mile (logged)	-2.157*** (.440)	-.481	-.168*** (-.039)	-.439

[a] *P<.05; **P<.01; ***P<.001

restaurants, fast food and convenience stores all decrease the number of poor mental health days. Based upon the univariate regression results, we can see that mental health and physical health are closely connected. We further explore this relationship by conducting multivariate regression models separately for county obesity rates and poor mental health days.

Table 4 presents the multivariate regression models for obesity rates (Models 1a and 2a) and poor mental health (Models 1b and 2b). Model 1 includes the key independent variables associated with food environment and Model 2 is the final model that adds in important health and demographic controls for

Table 4. Multiple linear regression for obesity rates and poor mental health for Mississippi counties (N=82) [ab]

	Obesity		Poor mental health days	
	Model 1a	Model 2a	Model 1b	Model 1b
Persistent Poverty	1.597*	1.466#	0.102*	0.112*
	(-0.714)	(-0.765)	(-0.050)	(-0.051)
Farmers market	(0.290	0.600	0.012	-0.004
	(-0.587)	(-0.655)	(-0.041)	(-0.043)
Per capita grocery stores	-1.569	-2.071	0.078	-0.025
	(-2.463)	(-2.843)	(-0.177)	(-0.188)
Per capita convenience stores	-1.501	-3.453	-0.148	-0.086
	(-4.153)	(-4.310)	(-0.290)	(-0.285)
Per capita full-service restaurants	-0.788	-0.567	0.071	0.167
	(-1.427)	(-1.856)	(-0.112)	(-0.123)
Per capita fast food restaurants	-1.053	1.121	0.156	0.005
	(-4.277)	(-4.551)	(-0.297)	(-0.301)
Per capita SNAP benefits	0.188***	0.128*	0.021***	0.020***
	(-0.036)	(-0.059)	(-0.003)	(-0.004)
Percent household without a personal vehicle	0.055	-0.026	0.020	0.017
	(-0.170)	(-0.189)	(-0.012)	(-0.013)
Age-adjusted mortality rate per 100,000		0.001	0.001	0.001
		(-0.003)	(0.001)	(0.001)
Percent with access to exercise opportunities		-0.017	0.001	0.001
		(-0.016)	(-0.001)	(-0.001)
Primary care doctors per 1,000		0.003	0.001	0.001
		(-0.015)	(-0.001)	(-0.001)
Percent 65 and older		-0.216	0.031*	
		(-0.179)	(-0.012)	
Fifty-one percent or more of females		1.198#	-0.032	
		(-0.716)	(-0.047)	
Percent Unemployed		0.137	0.020	
		(-0.204)	(-0.014)	
Population per sq. mile (logged)		-0.603	0.051	
		(-0.746)	(-0.049)	
Intercept	32.274***	37.172***	3.531***	2.767***
	(-1.563)	(-6.039)	(-0.185)	(-0.400)
R^2	0.614	0.649	0.760	0.790

[a] Non-standardized coefficients with standard errors in parentheses

[b] #P<.10; *P<.05; **P<.01; ***P<.001

counties. Model 1a shows that persistent poverty and per capita SNAP benefits have a significant positive impact on county level obesity rates. These relationships remain significant and positive, although slightly diminished, in Model 2a when important health and demographics controls are added. Models 1a and 2a clearly show that there is a connection between persistent poverty and increased obesity rates in Mississippi. The table also shows that when more of the population participates in a government nutrition assistance program, there is an increase in the obesity rate, while controlling for food environment, health and demographic variables. Models 1b and 2b show similar results for poor mental health days with persistent poverty and per capital SNAP benefits as significant positive predictors for a county's increased average poor mental health.

Discussion

Poverty rates have been increasing in the United States over the past 20 years (Shaefer & Edin, 2013). Estimates from the 2006–2010 American Community Survey (ACS) indicate that 40.7 million people have incomes below the poverty line and a substantial segment of this population has lived in high poverty counties for years (Food Research and Action Center [FRAC], 2017). Rural counties with a high percentage of persistent poverty are concentrated in the South, including the Mississippi Delta where at least 20 percent of their residents have been living in poverty during the past three decades (Lance, 2012). Past research has established poverty has been consistently associated with a number of factors adversely impacting health including housing insecurity, low educational attainment, and food insecurity. The health impact of persistent poverty on food access, food insecurity and obesity has been established in urban settings, but few studies have explored these associations in rural areas.

Our analysis provides new insights into the relationship among food access, and physical and mental health outcomes across persistent and non-persistent poverty counties in Mississippi. Mississippi has the highest prevalence of poverty (24.1%), food insecurity (18.7%), and obesity (35%) in the U.S. (Centers

for Disease Control and Prevention, 2013; Coleman-Jensen et al., 2016) and our findings confirmed the strong influence of persistent poverty on obesity, reduced food availability, and mental health outcomes, particularly among vulnerable groups such as African Americans and older adults. We add to the literature in four important ways.

First, we find that persistent poverty counties in Mississippi have higher obesity rates than non-persistent poverty counties (38.6% vs. 34.2%). This is important as a higher percentage of African Americans and women in Mississippi reside in persistent poverty counties--two population groups that are overrepresented among adults with obesity. These findings are consistent with national data which show that African American adults are nearly 1.5 times as likely to be obese compared with White adults; more than 75 percent of African Americans are overweight or obese, including 57.2 percent of women (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016). Recent national data, however, indicates that the gap between low- and high-income groups is narrowing over time as obesity rates are increasing among higher income groups (Flegal, Kruszon-Moran, Carroll, Fryar, & Ogden, 2016). These findings are consistent with results from previous studies, which showed the association between higher obesity, Type 2 diabetes rates, and lower per capita grocery stores in non-metro areas (Dinour et al., 2007; Franklin et al., 2012). Other studies have also found that psychological stress produced by the lack of access to healthy food and food insecurity can place children and adults at an increased risk for mental illness (Muldoon et al., 2013; Tarasuk et al., 2013). In addition, nutritional deficiencies may also be causally associated with depressive disorders (Compton & Shim, 2015).

Second, we find an interesting relationship between food access and health that may be unique to Mississippi's rural environment. The evidence of the relationship between persistent poverty and obesity is robust and consistent (Bennett et al., 2011; Jilcott Pitts et al., 2013); however, the evidence of the relationship between food access and the risk of obesity is mixed when examining differences across places (Bhattacharya, Currie, & Haider, 2004; Dinour et al., 2007; Larson & Story, 2011). Mississippi has the highest rate of food insecurity in the nation, which

is compounded by issues of low food access. At the county level, food access is directly associated with the availability of full service grocery stores, convenience stores, and restaurants. Our data show that regardless of current county-level poverty status, counties that have been persistently poor were more likely to have fewer full-service restaurants, convenience stores, and fast food restaurants. Interestingly, the mean number of grocery stores per capita was slightly higher in persistent poverty counties than non-persistent poverty counties. This seemingly counterintuitive difference was not statistically significant.

Further, we found in univariate results that having access to full-service restaurants, fast food or convenience stores decreases obesity rates and poor mental well-being with farmers' markets having no impact on either health measure. This is interesting and is telling of Mississippi's unique food environment due to the extreme rurality of the state. Many rural poor communities tend to have a lack of food choices that would allow residents to adopt healthy dietary practices. This may be the result of barriers associated with food access and transportation. In addition, if community members adopt their family traditions and customs pertaining to food, such as foods that are high in calories and sugar, they are probably more likely to adhere to unhealthy dietary practices. The relationship between obesity and food access is thought to be a function of a dependence on inexpensive, energy dense foods and the instability associated with having enough food at the beginning of the month followed by food insecurity at the end of the month (Hossfeld & Rico Mendez, 2018). For many of the residents who live in persistent poverty counties, being food insecure may lead to higher rates of obesity and poor mental well-being. The food insecurity-obesity paradox is caused by the coexistence of economic and social disadvantage and proximity to healthy foods that occurs within persistent poverty counties (Larson & Story, 2011; Rutten, Yaroch, Patrick, & Story, 2012). Since these factors affect the lives of persistent poverty county residents, they may lack the economic resources to patronize farmers' markets, making the presence of them moot.

Third, we found per capita SNAP benefits to be positively associated with obesity and poor mental well-being. Our measure

of per capital SNAP benefits may actually be capturing food insecurity rather than food access. Food insecure households rely on a variety of resources in order to get enough to eat, with 61% of food insecure households reporting participation in federal programs, including SNAP (Coleman-Jensen et al., 2016). Our finding is consistent with past research that finds poor physical health and mental health to be positively linked to food insecurity (Dinour et al., 2007; Franklin et al., 2012; Muldoon et al., 2013; Tarasuk et al., 2013). Obesity and food insecurity are both considered forms of malnutrition resulting from poor dietary quality, and both are highly correlated with poverty (Ball & Crawford, 2006; Larson & Story, 2011; Rutten et al., 2012).

Fourth, we find that a higher mean number of mentally unhealthy days is associated with persistent poverty counties compared to non-persistent poverty counties. This finding is consistent with a growing body of literature that demonstrates the negative consequences of food availability for behavioral and mental health outcomes (McLaughlin et al., 2012). Studies have shown that low-income families often experience high levels of stress, anxiety, and depression given the financial and emotional demands associated the inability to access healthy foods (Leung, Epel, Willett, Rimm, & Laraia, 2015; Liu, 2014). Poor mental health and obesity often co-occur, and women are more vulnerable to an obesity-depression cycle (Laraia et al., 2015). Depression can both be a cause of and result from stress, which can impact eating and physical activity behavioral patterns (Leung et al., 2015). A fuller examination of the relationship between persistent poverty, food insecurity, depression and other mental health related outcomes is beyond the scope of this study; however, our findings show patterns among rural, low-income populations.

Limitations of the Study

A few limitations of the study should be noted. First, the main limitation is the use of publicly available cross-sectional data. The challenge of the cross-sectional design was amplified by the fact that the data were collected at different years. Our level of analysis also limits us. It is common for data available to the

public to be aggregated to the county, thus limiting our ability to examine individual-level effects. Second, the analyses were restricted to Mississippi—one southern state with high rates of persistent poverty counties, food insecurity, and chronic diseases. Using data from other states in different geographic regions and more income heterogeneity may yield different findings.

Conclusion

Malnutrition, in all its forms, is increasing globally. The growing problem in the United States in terms of health has to do with food and the food environment in which people live. The food that is cheap and plentiful and easy to access is often food that has little to no nutritional value and is high in calories and fat. In Mississippi, malnutrition is linked to obesity and poor mental well-being, particularly for those who live in rural, persistent poverty counties. The findings from this research point to the need for the transformation of the food system. The current food system includes diets that now hinder health and nutrition. These unhealthy diets may be the source of cultural and generational influences on the eating patterns of many communities. Research suggests that community food systems initiatives may hold the greatest opportunity for creating long-term, significant change in food insecurity in high poverty areas (Hossfeld & Rico Mendez, 2018). Supporting community food systems initiatives holds the greatest likelihood of creating substantive, meaningful, long-term change in food insecurity.

Since this would require a systems-change in food production, distribution, and consumption, all elements of the food system should be examined. Increased federal dollars to support these initiatives is imperative in building food secure, inclusive, healthy communities, through increasing funding streams for community food projects through USDA National Institute of Food and Agriculture (NIFA) and Agriculture and Food Research Initiative (AFRI) funding programs. Other policy opportunities include developing and support of bi-partisan state and local legislation that seeks to ensure healthy food options for food desert residents so that accessing healthy food at corner and convenience stores is a viable option. For example,

replicating creative successful programs such as food "RX," that links health care and "prescription" programs for healthy foods to local farmers' markets where residents have access to affordable fruits and vegetables. In addition, communities and state governments should coordinate their efforts to prioritize mental health as part of comprehensive sustainable development programs that consider food and health priorities, particularly in low resourced communities.

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Appendix

Table A. Pearson's r correlation matrix

	1	2	3	4	5	6	7	8	9	10	11	12
1. Persistent poverty	1											
2. Obesity rate	0.58	1										
3. Poor mental health days	0.63	0.70	1									
4. Age-adjusted mortality rate per 100,000	0.19	0.36	0.36	1								
5. Farmers market	0.02	-0.01	-0.01	0.06	1							
6. Per capita grocery stores	0.10	0.13	0.19	0.31	0.1	1						
7. Per capita full-service restaurants	-0.22	-0.31	-0.22	-0.04	0.21	-0.14	1					
8. Per capita fast food restaurants	-0.25	-0.45	-0.36	-0.09	0.17	-0.16	0.58	1				
9. Per capita convenience stores	-0.22	-0.42	-0.34	-0.03	0.10	-0.08	0.58	0.95	1			
10. Per capita SNAP benefits	0.57	0.73	0.84	0.52	0	0.23	-0.20	-0.38	-0.33	1		
11. Percent household without a personal vehicle	0.56	0.57	0.63	0.30	-0.17	0.13	-0.54	-0.54	-0.56	0.58	1	
12. Percent with access to exercise opportunities	-0.14	-0.29	-0.21	-0.24	0.27	-0.26	0.54	0.42	0.38	-0.20	-0.48	1
13. Primary care doctors per 1,000	-0.19	-0.22	-0.21	-0.11	0.20	-0.18	0.66	0.53	0.54	-0.18	-0.49	0.44
14. Percent 65 and older	0.02	-0.08	0.04	-0.09	-0.12	0.33	-0.30	-0.09	-0.08	-0.14	0.10	-0.35
15. Percent female	0.07	0.05	0.25	-0.05	-0.01	0.14	0.37	0.27	0.32	0.19	-0.16	0.26
16. Percent unemployed	0.50	0.67	0.73	0.38	-0.02	0.13	-0.47	-0.40	-0.40	0.79	0.68	-0.34
17. Percent African American	0.68	0.76	0.76	0.33	0.05	0.08	-0.25	-0.41	-0.39	0.83	0.66	-0.15
18. Percent White Non-Hispanic	-0.68	-0.74	-0.76	-0.32	-0.07	-0.06	0.21	0.40	0.38	-0.81	-0.65	0.12
19. Percent Native American	0.08	-0.04	0.08	0.01	-0.05	-0.03	-0.02	-0.09	-0.06	-0.07	0.02	-0.11
20. Percent Hispanic	-0.20	-0.29	-0.24	-0.07	0.17	-0.10	0.31	0.13	0.13	-0.27	-0.23	0.37
21. Percent Asian American	-0.17	-0.33	-0.32	-0.22	0.17	-0.42	0.41	0.49	0.44	-0.28	-0.36	0.55
22. Population per sq mile	-0.39	-0.40	-0.41	-0.30	0.24	-0.32	0.51	0.44	0.39	-0.35	-0.53	0.57

Table A. continued

	13	14	15	16	17	18	19	20	21
13. Primary care doctors per 1,000	1								
14. Percent 65 and older	-0.22	1							
15. Percent female	0.35	0.17	1						
16. Percent unemployed	-0.32	-0.03	-0.08	1					
17. Percent African American	-0.10	-0.24	0.08	0.78	1				
18. Percent White Non-Hispanic	0.09	0.29	-0.07	-0.74	-0.99	1			
19. Percent Native American	-0.02	0.01	-0.01	-0.12	-0.11	0.02	1		
20. Percent Hispanic	0.03	-0.23	-0.14	-0.40	-0.28	0.19	-0.01	1	
21. Percent Asian American	0.45	-0.56	-0.01	-0.29	-0.14	0.09	-0.06	0.26	1
22. Population per sq mile	0.45	-0.44	0.11	-0.44	-0.25	0.20	-0.04	0.34	0.69