**Deaths of Despair among Non-Hispanic Whites in the U.S.:**
**Differences along the Urban-Rural Continuum**

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**Acknowledgements**
The author acknowledges funding from the United States Department of Agriculture Economic Research Service and the Institute for New Economic Thinking. The author also acknowledges support from the Population Research Institute at The Pennsylvania State University (which receives core funding from the Eunice Kennedy Shriver National Institute of Child Health and Human Development (P2CHD041025), the Center for Policy Research and Lerner Center for Public Health Promotion at Syracuse University, and the USDA Agricultural Experiment Station Multistate Research Project: W4001, Social, Economic and Environmental Causes and Consequences of Demographic Change in Rural America.

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ABSTRACT

Over the past two decades, deaths from drugs, alcohol, and suicide (the so-called deaths of despair) have grown to be a major U.S. population health problem, particularly among non-Hispanic whites. Geographic differences in drug, alcohol, and suicide (DAS) mortality rates are large. Although many studies show higher DAS mortality rates in rural versus urban areas of the U.S., these studies are limited by a binary rural/urban focus, and explanations for this geographic variation are limited. To explore this topic, I use county-level data on non-Hispanic white DAS mortality rates (2011-15) merged with county- and state-level data on multiple compositional and contextual features. I find that, net of county demographic composition, average NH white DAS mortality rates are significantly higher in rural (both micropolitan and noncore) counties than in large fringe metro counties and that this rural mortality disadvantage is explained by socioeconomic composition factors; rural populations are characterized by higher levels of economic distress. Analyses restricted to rural counties further finds comparatively low rates of DAS mortality in farming and manufacturing dependent rural counties and high rates in mining and services dependent rural counties. Moreover, associations between mortality rates and county-level economic distress, family distress, and persistent population loss vary across different types of rural labor markets. Ultimately, the results of this study show that, although rural counties carry a disproportionate DAS mortality burden, the rural mortality penalty varies significantly by type of labor market and level of economic distress.

Key Words: health; mortality; rural-urban continuum; inequality; economic disadvantage; opioids

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1. Introduction

Nationwide, mortality rates from drugs, alcohol, and suicide increased from 29.8 to 46.3 deaths per 100,000 population (55.4%) between 1999 and 2015 (CDC 2016). The increase over this period was even more pronounced for non-Hispanic whites (86.8%). With the exception of American Indians, non-Hispanic (NH) whites have the highest drug, alcohol, and suicide mortality rates of all major racial/ethnic groups[1] (Monnat 2017b, Shiels et al. 2017).

Although mortality rate increases have been driven by a surge in opioid overdoses, deaths involving other drugs, alcohol, and suicides also increased over this period (Monnat 2017b). Drug, alcohol, and suicide (DAS) deaths are not a random collection; they often derive from depression, hopelessness, and chronic pain (Cheatle 2011, Russ et al. 2015), leading some to refer to them as "deaths of despair" (Case and Deaton 2017, Monnat 2016). Especially striking is that rates for all three increased during a period of declining mortality for other major causes of death, including heart disease and cancer (Case and Deaton 2015, Case and Deaton 2017).

Geographic differences in DAS mortality rates are large (Buchanich et al. 2016, Monnat 2017a, Rossen, Khan and Warner 2014, Shiels et al. 2017), but empirical explanations for these differences are limited. Although surveillance studies provide an important first step in describing the U.S. "deaths of despair" problem, they have several limitations for understanding geographic variation. First, these studies tend to compare rates across dichotomous rural/urban categories. Second, they treat rural as one homogenous category without considering broader variation in features of rural areas that may influence variation in rates, including economic

[1] In 2015, the combined drug, alcohol, and suicide mortality rate (using multiple cause of death files) was 60.3 per 100,000 population for non-Hispanic whites, 35.6 for NH blacks, 26.1 for Hispanics, 13.3 for Asians, and 111.1 for American Indians/Alaska Natives

conditions and labor market structure. Both of these limitations mask important within-rural variation in mortality rates. Finally, existing studies on urban-rural differences in DAS mortality focus on temporal trends rather than providing empirical explanations for geographic variation in mortality rates.

The present study addresses these limitations and advances the research on urban-rural disparities in "deaths of despair" by 1) describing and empirically explaining differences in U.S. county-level rates of NH white DAS mortality across the urban-rural continuum and 2) disaggregating and comparing rates across rural counties with different labor market structures and analyzing whether predictors of NH white DAS mortality rates are different across rural counties with different labor markets.

## 2. The geography of U.S. drug, alcohol, and suicide mortality

After decades of lower or nearly comparable all-cause mortality rates in rural than in urban areas, a rural mortality penalty emerged in the 1980s and has grown in each subsequent decade (Cosby et al. 2008). This trend reversal was due in part to higher rates of heart disease mortality in rural areas (Cossman et al. 2010), but increasing rural drug, alcohol, and suicide mortality rates (the so-called 'deaths of despair') have also contributed to the growing gap (Fontanella et al. 2015, Singh and Siahpush 2014). In fact, increases in DAS mortality for middle-age non-Hispanic whites have been so large as to reduce life expectancy overall for that group (Case and Deaton 2015, Case and Deaton 2017). However, the trends observed by Case and Deaton may have been largely driven by increases in DAS mortality rates among non-Hispanic whites living outside of large metropolitan areas (Monnat 2017a).

Existing research on urban-rural disparities in alcohol-induced deaths and suicides in the U.S. consistently finds higher rates in rural than in urban counties (Fontanella et al. 2015, Ivey-Stephenson et al. 2017, Kegler, Stone and Holland 2017, Nestadt et al. 2017). National research on drug overdoses generally finds comparable or slightly higher rates in urban than in rural counties when examining binary urban/rural differences (Buchanich et al. 2016, Mack, Jones and Ballesteros 2017, Rossen, Khan and Warner 2014). However, these simplified binary rural/urban comparisons can mask important differences in health outcomes across different degrees of rurality, regions, and opportunity structures (James 2014, Roberts et al. 2016). For example, Monnat and Rigg (2016) found that adolescents in both rural and small urban areas were more likely to misuse prescription opioids than their peers in large urban areas, a distinction that would have been missed had they used a binary metropolitan status measurement. In a study of suicide trends (1999-2015) using a six-category urban-rural continuum, Kegler et al. (2017) found an urban-rural suicide gradient, with incrementally higher suicide rates at each rising level of rurality. In a review of the literature on alcohol use patterns among urban and rural residents, Dixon and Chartier (2016) found that studies had different conclusions about urban-rural disparities in alcohol use disorders depending on whether they used a dichotomous vs. more detailed rural-urban classification.

Documenting rural-urban disparities in DAS mortality rates is an important first step, but empirical explanations for these disparities are lacking. Existing studies on rural-urban differences in DAS mortality are largely descriptive, emphasizing the contribution of differences in population composition (e.g., age, race) rather than the "fundamental" social determinants of health (Link and Phelan 1995) that are known to contribute to geographic differences in all-cause and other cause-specific types of mortality and morbidity (McLaughlin et al. 2007, Montez, Zajacova and Hayward 2016, Yang and Jensen 2015).

3. Social determinants of geographic differences in drug, alcohol, and suicide mortality

The social determinants of health (Solar 2010) and socio-ecological (Macintyre, Ellaway and Cummins 2002) models are used to frame my analyses of urban-rural continuum and within-rural differences in NH white DAS mortality rates. Social determinants of health are the structural conditions in which people live, work, and socialize that influence stress, health behaviors, and mortality, including economic resources, social relationships, labor markets, and the health care infrastructure.

As sociologist Emile Durkheim (1987/1966) argued over 120 years ago, social integration is a key factor in explaining suicide. During periods of serious social or economic upheaval, social cohesion declines, risk of disconnection (anomie) increases, and suicide rates increase (Durkheim 1987/1966). Along these lines, Case and Deaton (2015, 2017) and Monnat (2016, 2017a, 2017b) have suggested that suicide and other ‘deaths of despair’ (drug overdoses, alcohol-related deaths) may be connected to distressed economic conditions and subsequent hopelessness and dislocation. Though this hypothesis has not yet been rigorously tested, it is well justified. The past-decade surge in drug, alcohol, and suicide deaths corresponds with significant economic challenges, including long-term de-industrialization, growing income inequality, and increased geographic concentration of poverty (Iceland and Hernandez 2017, Saez 2016, Thiede, Kim and Valasik In Press). Moreover, economic disadvantage has emerged in once-prosperous middle- and working-class communities (Alexander 2017, Quinones 2015), where residents long accustomed to financial security and feelings of control over their destinies - fundamental social determinants of health (Syme 1989, Whitehead et al. 2016) - suddenly find themselves powerless (Chen 2015, Newman 1999).

Part of the challenge in understanding geographic differences in DAS mortality is in teasing out whether those differences are due to contextual features of communities themselves or the characteristics of the people living in different communities (i.e., places with higher mortality rates have high prevalence of high-risk individuals) (Marmot 2001). In ecological research, community composition is derived by aggregating characteristics of individuals, families, and households. Mental health and substance abuse problems are more prevalent among individuals with low income, low education, functional disabilities, and who are un- and under-employed (Dollard and Winefield 2002, Kerr et al. 2017, Kozman et al. 2012, Olfson et al. 2017, Spiller et al. 2009). Small urban and rural counties are disproportionately composed of economically disadvantaged residents (Slack 2010, Thiede, Lichter and Sanders 2015, Thiede, Lichter and Slack 2016). Economic insecurity, including poverty and joblessness can threaten individual identity, leading to unmet expectations, barriers to desired role attainment, and social and economic exclusion (Catalano and Dooley 1983, Whitehead et al. 2016). For example, Krueger (2017) found that prime-age men who are not in the labor force experience notably lower levels of emotional well-being, derive relatively little meaning from their daily activities, and are more likely than working men to feel pain and take pain medication daily, all of which increase substance abuse, overdose, and suicide risk (Ahmedani et al. 2017). Studies in the U.S. (Hempstead and Phillips 2015, Kerr et al. 2017, Phillips and Nugent 2014), Europe (Qin, Agerbo and Mortensen 2003), and Australia (Berk, Dodd and Henry 2006) show that place-level economic distress, like unemployment and poverty rates, are associated with higher suicide rates. Moreover, economic distress is often accompanied by family distress, like marital disintegration and multiple partner fertility (Burton et al. 2013), which are important distal risk factors for substance abuse (Ananat et al. 2017, Durkheim 1987/1966, Frasquilho et al. 2016, Olfson et al. 2017).

Structural (contextual) characteristics may also influence DAS mortality risk. Rural labor markets are less diversified than urban labor markets, making them more vulnerable to both economic shifts (Brown and Schafft 2011, Lichter 2016). Over the past 40 years, employment restructuring has led to the movement of many livable-wage production jobs out of rural areas and the concentration of high-wage high-skill service, finance, and technology-based employment in urban cores (Bailey, Jensen and Ransom 2014, Brown 2003, Lobao 2014, Peters 2013, Smith and Tickamyer 2011). This has resulted in wage polarization (Peters 2012) with fewer and lower-wage employment opportunities for rural residents (Burton et al. 2013, Slack 2014). Unstable labor markets are associated with higher prevalence of mental health problems, substance misuse, and suicide (Kaplan et al. 2015, Kerr et al. 2017, Pierce and Schott 2017). Counties dependent on industries like mining and manufacturing have suffered substantial employment downturns and wage stagnation in recent decades, making them high-risk environments for substance misuse (Keyes et al. 2014, McLean 2016). Moreover, OxyContin and other strong opioids were heavily marketed in mining dependent Appalachian communities long before they spread across the rest of the U.S. (Keyes et al. 2014, Quinones 2015). In fact, with such close ties to this region, OxyContin was once referred to "hillbilly heroin" (Inciardi et al. 2009).

The health care infrastructure is another potentially important contextual factor. Access to primary health care may facilitate preventive health interventions that protect against injury risk or long-term chronic pain and disability for which opioids are commonly prescribed. Access to mental health care may facilitate necessary substance abuse treatment. Counties lacking these services may have higher drug-related mortality rates. Rural areas face significant health care access barriers. Due to distance, emergency medical responses to overdoses and attempted suicides take longer, reducing odds of survival (Hancock et al. 2017). There is also less access to mental health and substance abuse treatment services in most rural areas (Borders and Booth 2007). Even when such services are available, stigma may be a greater barrier to treatment use among rural than urban residents (Pullen and Oser 2014).

Finally, social capital has been found to be associated with geographic variation in all-cause mortality (McLaughlin et al. 2007, Montez, Zajacova and Hayward 2016), but its relationship to DAS mortality has yet to be assessed. Opportunities for social interaction through churches, community associations, and sports and recreational facilities can facilitate personal and community linkages, trust, goodwill, belonging, and social cohesion, which may buffer against isolation, depression, boredom, and substance misuse (Putnam 2001, Yen and Syme 1999). On average, rural communities may be advantaged by their comparatively higher community attachment and social capital, but there is wide divergence in social capital across the U.S., with Midwestern farming dependent counties having much greater comparative social capital than other rural regions (Rupasingha, Goetz and Freshwater 2006).

Of course, compositional and contextual features are mutually reinforcing. Geographic differences in population health are driven by complex interactions between economic and political structures, human capital, and the relative vulnerability of residents (Brown 2003, Lobao and Saenz 2002, Lobao 2004, Lobao et al. 2016). Slow-moving stressors that have manifested over the past 40 years (e.g., industrial transformation, wage stagnation, rising income inequality) and short-term economic and policy shocks (e.g., the Great Recession, austerity, federal safety net policy changes) have had disproportionality negative effects on small cities and rural communities due to their greater concentrations of low-SES residents, less diversified labor markets, thinner and weaker institutions, and state and local fiscal decisions (Bailey, Jensen and Ransom 2014, Lobao 2007). Selective out-migration of the "best and brightest" (Carr and Kefalas 2009) has intensified the disproportionate geographic clustering of multigenerational economic distress in small urban and rural counties (Iceland and Hernandez 2017, Lichter 2016, Thiede, Kim and Valasik In Press). Research from both urban and rural sociology demonstrates that concentrated and multigenerational economic disadvantage can contribute to collective frustration and hopelessness, out-migration, lower tax bases, community disinvestments, infrastructural decay, crime, and substance misuse (Brown 2003, Carr and Kefalas 2009, McLean 2016, Sampson and Groves 1989, Smith and Tickamyer 2011). As a result, a growing body of evidence suggests there are strong associations between macro-level economic distress and poor mental health, substance abuse, and suicide (Frasquilho et al. 2016, Hempstead and Phillips 2015, Kaplan et al. 2015, Kerr et al. 2017).

Ultimately, distinguishing which (if any) of these social determinants of health contribute to geographic disparities in DAS mortality is an essential first step toward developing place-level targeted interventions. To summarize, my research question are as follows:

1) How do NH white DAS mortality rates differ along the U.S. urban-rural continuum?
2) To what extent do socioeconomic compositional vs. structural factors explain urban-rural continuum differences in DAS mortality, and are these factors associated with DAS mortality across all levels of metropolitan status?
3) Are these factors equally important predictors of DAS mortality rates across rural counties with different labor market structures?

4. Materials and methods

4.1 Mortality

My analyses draw on county-level mortality data for non-Hispanic whites (2011-2015) from the U.S. Centers for Disease Control and Prevention (CDC) Multiple Cause of Death (MCD) files, which identify causes of death from all death certificates filed in the U.S. Due to significant racial/ethnic differences in drug, alcohol, and suicide mortality rates, it is important to disaggregate rates by race/ethnicity rather than combine all groups into one county-level rate. However, CDC suppression criteria disables the ability to separately analyze black, Hispanic, and other racial/ethnic group rates due to small population sizes in most counties. Therefore, these analyses examined only NH white mortality rates. Suppression constraints also prohibit disaggregation by sex. The implications of these limitations are discussed at the end of the paper.

Each death certificate contains a single underlying cause of death (UCD) and up to twenty additional contributing (i.e., multiple) causes.[2] There are practical and conceptual reasons for using MCD versus UCD files for these analyses. First, CDC data suppression for counties with fewer than 10 deaths results in suppressed death counts and rates for over 15% of counties in the UCD data. Because of their smaller populations, these counties are disproportionately rural. Because the MCD files include all deaths that list a particular cause (underlying and contributing), more deaths are captured in the MCD files. Second, using MCD data reduces risk of undercounting deaths due to misclassification, which is especially common for suicides (Rockett, Kapusta and Coben 2014). Third, identifying a single factor as the underlying cause of death is an oversimplification of clinical and pathological processes leading to death (Fedeli et

[2] Each death is counted only once in these analyses. For example, if both a drug-related cause and an alcohol-related cause are included on the death certificate, the death is counted once.

al. 2015) and does not account for the possibility that the death may not have occurred without the presence of drugs or alcohol.

Like Case and Deaton (2015, 2017), I pooled drug, alcohol, and suicide deaths (aka, the "deaths of despair) into single county-level mortality counts and rates. CDC suppression criteria prohibit comparing separate county-level rates of drug mortality, alcohol mortality, and suicide mortality. Categorization of presumed causes of death used *International Statistical Classification of Diseases, 10th revision* (*ICD-10*) codes as follows: *Drug related* included accidental poisoning; intentional poisoning, and poisoning of undetermined intent by exposure to drugs (X40-X44, X60-64, Y10-Y14); drug-induced diseases (D52.1, D59.0, D59.2, D61.1, D64.2, E06.4, E16.0, E23.1, E24.2, E27.3, E66.1, G21.1, G24.0, G25.1, G25.4, G25.6, G44.4, G62.0, G72.0, I95.2, J70.2-J70.4, K85.3, L10.5, L27.0, L27.1, M10.2, M32.0, M80.4, M81.4, M83.5, M87.1, R50.2); drugs in the blood (R78.1-R78.5); and mental/behavioral disorders due to drugs (F11.0-F11.5, F11.7-F11.9, F12.0-F12.5, F12.7-F12.9, F13.0-F13.5, F13.7-F13.9, F14.0-F14.5, F14.7-F14.9, F15.0-F15.5, F15.7-F15.9, F16.0-F16.5, F16.7-F16.9, F18.0-F18.5, F18.7-F18.9, F19.0-F19.5, F19.7-F19.9). *Alcohol-related* included alcohol-induced diseases (E24.4, G31.2, G62.1, G72.1, I42.6, K29.2, K70.0-K70.4, K70.9, K85.2, K86.0, R78.0); mental/behavioral disorders due to alcohol (F10.0-F10.9); accidental poisoning, intentional poisoning, and poisoning of undetermined intent by alcohol (X45, X65, Y15). *Suicides* included intentional self-poisoning not included in the drug or alcohol categories and other self-harm (X66-X84, X87.0).

My analyses of county-level variation reflects the importance of counties as socioenvironmental units of analysis. Counties are small enough to reflect local economic and political conditions but also large enough to be meaningful for policy (Lobao 2007). County governments provide political and economic structure, the county represents the context within which most social and health services are delivered, and where most state funding for social programs is administered (Lobao 2004, Lobao 2007).

4.2 County Measures

County-level data came from the U.S. Census Bureau Decennial Census 2000, the Northeast Regional Center for Rural Development (Rupasingha, Goetz and Freshwater 2006), the Health Resources and Services Administration Area Health Resource Files (AHRF), and the United States Department of Agriculture Economic Research Service (ERS). To reduce reverse causality bias and allow for a lagged effect of predictors on mortality, I used measures that captured conditions before 2011 (generally year 2000), However, to capture relationships between overlapping economic conditions and DAS mortality, I performed additional analyses using the American Community Survey 5-year estimates (2011-2015) as predictors. Final variable selection was based on the research summarized above and assessments of multicollinearity and model fit. Descriptive statistics for all variables included in the analyses, including the years of variable measurement, are presented in Table 1. Descriptive statistics for the variables included in the supplemental sensitivity analyses are presented in the Appendix (Table A1)

Independent variables of interest were county urban-rural continuum, socioeconomic composition, and economic, social, and health care structural characteristics. *Urban-rural continuum* was based on the National Center for Health Statistics 2013 Urban-Rural Classification Scheme for Counties which are derived from the Office of Management and Budget's (OMB) delineation of metropolitan statistical areas (MSA) and micropolitan statistical areas. I used this classification system rather than the USDA ERS rural-urban continuum codes or urban influence codes in order to maintain categories consistent with CDC mortality reports. Categories are as follows: (1) Large central metro are counties in metropolitan statistical areas (MSAs) of 1 million or more population that contain all or part of a principal city of the area (e.g., Los Angeles County, CA; Cook County, IL) (2) Large fringe metro are remaining counties in MSAs of one million or more. (3) Medium/small metro are counties in MSAs of <1 million population. Although the NCHS separates these into small and medium sized counties, I collapsed them in the interest of model parsimony due to non-significant variation in mortality rates between the two groups. (4) Micropolitan are nonmetropolitan counties that OMB designates as belonging to a micropolitan statistical area. (5) Finally, noncore are the remaining nonmetropolitan counties that do not belong to a micropolitan statistical area. Throughout, I refer to metropolitan counties as urban and nonmetropolitan counties as rural.

Socioeconomic composition was measured with a factor-weighted index for NH white economic distress and an index for family distress. The NH white *economic distress index* captures economic disadvantage and human capital by combining NH white-specific measures of percent poverty (age 18-64), ratio of state-to-county median household income, percentage with less than a 4-year college degree (age 25+), percentage not working (unemployed and not in the labor force, age 21-64), and percentage with a disability (age 21-64). These variables are largely consistent with those included in the Economic Innovation Group's Distressed Communities Index for zip codes (Fikri and Lettieri 2017). Ideally, all measures would use consistent age groups that captured prime working age, but I was restricted to the age ranges available in the Census data. All economic distress measures were standardized at a mean of 0 and standard deviation of 1, multiplied by their factor weight score, and summed to create the index. The index has strong internal consistency (α=0.851). I also tested the inclusion of the gini coefficient for income inequality and percent of renters spending more than 30 percent of household income on rent, but neither loaded highly on the economic distress factor. The *family distress index* (α=0.725) combined the standardized values of the percentage of NH white families headed by a single parent and the percentage of all adults (age 16+) who are separated or divorced. NH white-specific estimates for divorce/separation were not available for 2000.

I included four county-level structural characteristics. *Employment sector dependence* was based on the USDA ERS economic dependency classification for 2004, which identifies counties as dependent on farming, mining, manufacturing, public sector (i.e., government), or service employment or as non-specialized. Categorizations are based on industry earnings and employment as a percentage of total labor, proprietors' earnings, and total employment in 1998-2000 (USDA 2017). In supplemental sensitivity analyses, I used the 2015 economic dependency classifications. *Health care infrastructure* was measured with two binary indicators for whether any part of the county was classified as a health care professional shortage area or mental health provider shortage area in 2010, based on a formula derived by the U.S. Health Resources & Services Administration.[3] *Persistent population loss* was a binary measure indicating that the county population declined between both the 1980 and 1990 censuses and the 1990 and 2000 censuses. I included it as a proxy for resource supply, (dis)investment, and structural distress. It

[3] Ideally, I would have included indicators that capture the supply of mental health and substance abuse professionals and facilities, but those data are not available nationally at the county level. The Area Health Resource File captures county-level measures for specific types of health care providers (e.g., psychiatrists, psychologists, social workers, occupational, physical, and recreational therapists), but prior to the 2013-14 AHRF release, counties with missing values on any measures were designated with values of 0, thereby making those measures unreliable because users are unable to identify which counties are missing vs. which counties truly have values of 0 on these measures. For more information, see User Documentation for the County Area Health Resource File 2015-2016 release, page 148. (https://datawarehouse.hrsa.gov/data/datadownload.aspx#MainContent_ctl00_gvDD_lbl_dd_topic_ttl_0).

is also a proxy for residential mobility selection effects; counties with persistent population loss are those from which the best-resourced young adults often leave due to lack of educational and employment opportunities, thereby leaving behind concentrations of the least-resourced and most vulnerable residents (Carr and Kefalas 2009). *Social capital* was measured with the 2005 social capital index available from the Northeast Regional Center for Rural Development (Rupasingha, Goetz and Freshwater 2006). The index was created using principal components analysis and captures four factors (1) per capita counts of religious, civic, business, political, professional, labor, bowling, recreational, golf, and sports establishments; (2) the 2004 voter turnout rate; (3) the 2000 Census response rate; and (4) per capita number of non-profit organizations. The factors are standardized at a mean of 0 and standard deviation of 1. I logged this variable for regression analyses to correct for its skewed distribution.

To account for the fact that DAS mortality rates are higher among young and middle-age adults, non-Hispanic whites, and veterans (McCarthy et al. 2012, Monnat 2017b), I controlled for NH white age composition (percentage under age 18 and percentage age 25-54), percent NH white overall, percent foreign born, and percentage of NH whites who are military veterans. I also considered percent age 65+ in lieu of percent under age 18, but it was strongly correlated with several predictor variables, preventing its inclusion in regression models. County health insurance coverage rates are not available for 2000, and therefore could not be included. The Small Area Health Insurance Estimates (SAHIE), derived from Current Population Survey data, are available for 2005, but they are not race-group specific. The overall coverage rate would not accurately represent NH white health insurance coverage because it would be downwardly biased in counties with larger shares of black and Hispanic residents (who have lower insurance rates). Given strong associations between socioeconomic status and health insurance coverage, the economic distress index likely covers the latent factors related to health insurance coverage. The distributions for percent NH white and foreign-born were skewed and not amended by logging, so I recoded them into quartiles for regression analysis. All other variables were normally distributed.

4.2 State-Level Control Variables

Although CDC mortality data suppression prevented me from controlling for a *county-level* baseline value of NH white DAS mortality rates preceding the years included in this study (DAS death counts were much lower in the early 2000s), I was able to control for *state-level* NH white DAS mortality rates. To ensure stable rates, I pooled deaths from 1999 to 2001. Although not an ideal baseline measure of county DAS mortality, it does control for whether counties are located in states that had high DAS mortality rates well before the period of interest in this study. DAS mortality rates may also be influenced by access to drugs, alcohol, and guns (the most common method of suicide) (Branas et al. 2004, Nordstrom et al. 2001, Prunuske et al. 2014). There are no national county-level measures of these variables, but state-level measures are available. State-level gun ownership estimates come from Kalesan et al. (2016) based on a 2013 nationally representative sample of U.S. adults in all states. State-level alcohol sales data (annual gallons of alcohol sold per 10,000 population) came from the National Institute on Alcohol Abuse and Alcoholism (NIAAA 2017). I averaged sales from 1999 to 2003 to generate stable estimates. I used 2011-15 for sensitivity analyses. State-level opioid prescription data (total opioid prescriptions dispensed by retail pharmacies per 100 residents) were available only for 2012 and came from Paulozzi, Mack and Hockenberry (2014). I standardized (at the state level) all four variables at a mean of 0 and standard deviation of 1 before merging them with the county-level data.

Region and division were strongly correlated with several of the predictors (e.g., employment sector dependence, state gun ownership), so they could not be included in the models. Tests for multicollinearity demonstrated no other concerns. A correlation matrix showing correlations between all variables included in regression analyses is presented in the Appendix (Table A2).

4.3 Analysis

Because no existing studies examine differences in DAS mortality rates along the urban-rural continuum, I begin by presenting temporal trends in NH white DAS mortality rates for large central metro, large fringe metro, medium/small metro, micropolitan, and noncore counties, disaggregated by underlying cause (drug-induced, alcohol-induced, suicide) and additional drug and alcohol contributing causes. These rates came from the U.S. Centers for Disease Control and Prevention Wide-ranging Online Data for Epidemiologic Research (WONDER) and represent the overall rate within each urban-rural continuum category rather than the *mean county* rate for a particular urban-rural category. Because I compare trends over time, I present age-adjusted rates for this part of the analysis.

After presenting these aggregate trends, I proceed with the main analyses, for which I used county-level NH white DAS mortality rates, pooled across 2011-15 in order to prevent data suppression. Mortality rates and U.S. Census Bureau variable estimates for counties with small non-Hispanic white populations are at risk of instability and large margins of error. Therefore, I restricted my analysis to counties with at least 1,000 non-Hispanic white adults in 2010. I excluded all counties in Alaska and Hawaii due to county boundary changes and missing values on county-level predictors. Therefore, analyses included 3,029 of the 3,143 U.S. counties. Due to CDC suppression constraints, analyses were based on crude rather than age-adjusted rates, but all regression models controlled for county age composition. Given that counties cannot easily change their age compositions, crude rates are arguably better measures of the overall mortality risk for a given population and help policymakers and public health experts understand where resources and interventions should be targeted.

The main analyses are presented in three components. First, I focus on identifying and explaining differences in county-level NH white DAS mortality rates along the urban-rural continuum. To do so, I examined descriptive statistics for mortality rates and predictor variables across the 5-category continuum, using difference of means (t-tests) to identify significant differences between large fringe metro counties (the reference category) and the other four urban-rural categories. Large fringe metro was selected as the reference category because it has the lowest mean DAS mortality rate. I then proceeded with regression analyses. Regression analyses were conducted using linear random effects models to account for the clustering of counties within states. Model residuals were normally distributed and diagnostic plots showed no potential heteroscedasticity problems, enabling me to keep mortality rates in their original linear form. To account for spatial autocorrelation (spillover effects), I used GeoDa to calculate a spatial lag of NH white DAS mortality rates for each county using first-order queen contiguity (neighbors have shared border). For each county, the spatial lag represents the average NH white DAS mortality rate among neighboring counties. I included those values as a parameter in the fully adjusted model. To identify independent relationships between county-level factors and DAS mortality rates, I first individually regressed each predictor on mortality rates controlling only for county age composition and state baseline NH white DAS mortality rate (1999-2001). Controlling for state NH white DAS mortality rates holds constant differences between counties with historically high versus low NH white DAS mortality rates, as proxied by the state in which they are located.

I then present results from five additive regression models. Model 1 includes only urban-rural continuum, county-level control variables (age composition, percent non-Hispanic white, percent foreign born, percent NH white veterans), and state baseline mortality rate. Model 2 adds the socioeconomic composition indices (economic distress and family distress). Model 3 excludes socioeconomic composition and adds county structural characteristics (labor market sector dependence, health care shortage indicators, persistent population loss, and social capital index). Model 4 includes both socioeconomic composition and structural factors. Finally, Model 5 controls for the average NH white DAS mortality rate among neighboring counties (spatial lag) and state covariates (gun ownership, opioid prescriptions, and alcohol sales). Significant random effects were found for economic distress; the association between county economic distress and mortality varies between states, with economic distress exhibiting more importance in states with higher average mortality rates. Therefore, I included random effects for economic distress in Models 2, 3, and 5. I also tested random effects for family distress and social capital. Family distress random effects were not significant. Social capital random effects were significant only in the model that excluded socioeconomic composition (Model 3), so they were not included in Models 4 or 5.

In the second component of the analyses, I ran the full model from above (Model 5) stratified by urban-rural category in order to identify whether significant predictors of NH white DAS mortality rates vary by metropolitan status. Because there are only 68 large central metro counties, for this part of the analysis, I combined large central and large fringe metro counties into one 'large metro' category.

The final component focused on identifying whether associations between mortality rates and socioeconomic composition, persistent population loss, and social capital are consistent or vary across different types of rural labor markets. Therefore, analyses were restricted to rural counties (i.e., micropolitan and noncore, N=1,874). I examined descriptive statistics for mortality rates and predictor variables across the USDA ERS economic dependency categories. I then present the results from fully adjusted random effects linear regression models of mortality rates stratified by economic dependency category. Due to the smaller numbers of counties and states within this rural subset of U.S. counties, these models did not support the inclusion of state-level covariates or the spatial lag. In addition, because the overwhelming majority of rural counties are health care provider shortage areas, I also excluded those two variables from these analyses. I still controlled for state baseline mortality rate (1999-2001).

### 4.4 Sensitivity Tests

I performed two sensitivity analyses. First I substituted temporally proximate predictor variables for the socioeconomic composition variables and demographic controls (2011-2015 ACS), ERS economic dependency classifications for 2015, persistent population loss for 1990 to 2010, and average per capita state alcohol sales for 2011-15. These variables represent county conditions that overlap with the deaths examined in this study rather than the conditions that prevailed in the decade prior to these deaths. Second, I modeled death counts (offset by the log of the NH white population) using random effects negative binomial models. Tables with coefficients from these models are presented in the Appendix, and I briefly describe minimal differences between models at the end of the Results section.

<Figure 1 about here>

5. Results

5.1 Trends in Non-Hispanic White Drug, Alcohol, and Suicide Mortality Rates by Urban-Rural Continuum

Figure 1 presents trends (1999-2015) in overall age-adjusted NH white mortality rates separately for the five urban-rural categories disaggregated by drug-induced, alcohol-induced, and suicide underlying causes, plus additional deaths where drugs or alcohol contributed but were not the underlying cause of death. The aggregate rate presented in the top bar for each year represents the overall DAS mortality rate for that urban-rural category. Several trends are worth highlighting. First, in 2015, the highest overall rate was among medium/small metro counties (58.8 per 100,000 population), and the lowest rate was among large fringe metro counties (50.1). Large central metro and noncore counties had nearly identical rates (55.5 and 55.9, respectively), while micropolitan counties had a slightly higher rate of 57.6. Second, between 1999 and 2015, the largest increase occurred in micropolitan counties (102.1%), and the smallest increase was in large central metro counties (60.9%). Large central metro counties had a higher DAS mortality rate than medium/small metro, micropolitan, and noncore counties until the late 2000s (driven by much higher drug and alcohol induced mortality rates in large central metro counties), but large increases in drug-induced mortality in medium/small metro, micropolitan, and noncore counties resulted in rates surpassing large fringe metro counties in the late 2000s. Third, despite widespread attention on drug overdose deaths, across every category except large central metro, combined rates from alcohol-induced deaths and suicides were higher than the rate for drug-induced deaths. Finally, although drug-induced mortality rates have increased the most since 1999, alcohol-induced and suicide mortality rates also increased across all five categories, with the largest alcohol-induced mortality increase occurring among medium/small metro and the largest suicide rate increase occurring in noncore counties.

Ultimately, from 1999 to 2015, age-adjusted NH white mortality rate differences between large fringe metro counties (the lowest mortality rates) and the other county types equated to approximately 56,569 excess NH white deaths in large central metro counties, 74,084 excess deaths in medium/small metro counties, 22,328 excess deaths in micropolitan counties, and 15,706 excess deaths in noncore counties[4].

<Table 1 about here>

<Figure 2 about here>

5.2 Correlates of Urban-Rural Continuum Differences in County-Level Non-Hispanic White Drug, Alcohol, and Suicide Mortality Rates

The mean county-level NH white DAS mortality rate (2011-15) was 54.0 (min=0.0, max=179.8) (Table 1), but as demonstrated in Figure 2, there is substantial variation between counties, with observable spatial clustering (Moran's I=0.52). Local Indicators of Spatial Autocorrelation (LISA) maps (not shown), revealed above average mortality rate clusters in New England, central Appalachia, Florida, parts of the Industrial Midwest, Oklahoma, much of the

[4] Excess deaths for 1999-2015 were calculated as the difference between age-adjusted mortality rates multiplied by the population for the group with the higher rate divided by 100,000. For example, excess deaths for noncore counties were calculated as the difference between the age-adjusted mortality rate for noncore counties and large fringe metro counties multiplied by the total noncore population divided by 100,000

desert southwest and Mountain West, and the Pacific region. Below average rate clusters were observed in parts of New York and Pennsylvania, Virginia, southern Texas, and the north-central Plains. Maps showing the geographic distribution of economic distress, family distress, and social capital are presented in the Appendix (Figures A1-A3).

Minimally adjusted regression models (controlling only for county age composition and the state baseline DAS mortality rate [1999-2001]) show associations between the predictor variables and county NH white DAS mortality rates (Table 1). All variables included in the economic and family distress indices (as well as the indices themselves), higher percent non-Hispanic white, and higher percent veteran were significantly associated with higher DAS mortality rates. Compared to counties with non-specialized labor markets, those dependent on farming or government employment had significantly lower mortality rates, while those dependent on mining had significantly higher mortality rates. Persistent population loss and health care shortage counties also had significantly higher mortality rates. Finally, county mortality rates were significantly higher among counties located in states with higher DAS mortality rates in 1999-2001, suggesting that long-term factors are potentially at play in driving current mortality rates.

<Table 2 about here>

Table 2 presents unadjusted mean mortality rates and values of predictor variables across the urban-rural continuum. Grey cell shading indicates when values are significantly different ($p<.05$) from the reference category (large fringe metro). The average unadjusted mortality rate is the highest for large central metro counties and lowest for large fringe metro counties. There is a clear urban-rural gradient in economic distress, with the overall economic distress index value and each component of the index increasing across the gradient from the most urban to most rural. Whereas micropolitan counties have significantly higher average family distress than large fringe metro counties, noncore counties have significantly lower average family distress. Persistent population loss is most prevalent among micropolitan, noncore, and large central metro counties, and health care shortage is more prevalent in each of the four groups outside of large fringe metro counties. Average social capital is highest for noncore counties and lowest for large central metro counties.

<Table 3 about here>

Coefficients from the multivariate random effects models are presented in Table 3. The null model (not shown), produced an intraclass correlation coefficient of 0.422, indicating significant between state variation in county-level mortality rates; about 42% of between-county variation in DAS mortality rates is to do differences between states. In the minimally adjusted model (Model 1), both micropolitan and noncore counties had significantly higher average DAS mortality rates than large fringe metro counties. On average, the difference between micropolitan and large metro fringe counties was 2.82 deaths per 100,000 population, and the difference between noncore and large metro fringe counties was 3.63 deaths per 100,000 population.

The introduction of the economic and family distress composition indices in Model 2 eliminated the significant difference for noncore and actually reversed the sign for micropolitan, indicating that, if economic and family distress were comparable between large metro fringe and micropolitan counties, DAS mortality rates would actually be lower in micropolitan counties.

Model 3 excluded the socioeconomic composition variables and included structural variables for county labor market, health care infrastructure, and social capital. The introduction of these variables did not explain the micropolitan and noncore mortality penalty, as evidenced by their continued positive and statistically significant coefficients. Model 4 integrated both the socioeconomic composition and structural variables, revealing sign reversals for medium/small metro, micropolitan, and noncore counties. This suggests that if medium/small metro, micropolitan, and noncore counties had comparable socioeconomic composition and labor market structures as large fringe metro counties, they would have significantly lower average DAS mortality rates than large fringe metro counties.

The coefficients changed little with the introduction of the spatial lag and state gun ownership, alcohol sales, and prescription opioid measures in Model 5. Several other variables were statistically significant in Model 5. Net of all covariates, both economic and family distress were associated with significantly higher NH white DAS mortality rates. Specifically, a standard deviation (SD) increase in economic distress is associated with an average increase of 5.4 deaths per 100,000 population, while a SD increase in family distress is associated with an average increase of 4.59 deaths per 100,000. Labor market structure is also relevant. Compared to counties with non-specialized labor markets, mining dependent counties have an average of 6.2 more deaths per 100,000 population, service dependent counties have an average of 2.3 more deaths, and public sector dependent counties have an average of 5.1 *fewer* deaths. Persistent population loss is associated with an average increase of 2.2 deaths per 100,000. Social capital was associated with a significantly lower DAS mortality rate in the model that excluded socioeconomic composition, but in the full model, higher social capital was associated with a slightly higher mortality rate. As shown in the correlation matrix (Appendix Table A2), both economic and family distress are inversely related to social capital. This explains the reversal in sign for social capital; counties with higher economic and family distress have lower social capital, thereby explaining the relationship between social capital and DAS mortality. Although mental health provider shortage was associated with significantly higher average DAS mortality in Model 3, health care infrastructure was not significantly associated with mortality in the fully adjusted model. Again, this difference was explained by greater economic distress in health care shortage counties. Finally, significant random effects for economic distress indicate that the association between economic distress and mortality rates varies across counties.

<Table 4 about here>

5.3 Correlates of County-Level Non-Hispanic White Drug, Alcohol, and Suicide Mortality Rates Stratified by Metropolitan Status

Coefficients from fully adjusted models stratified by metropolitan status are presented in Table 4. Both economic and family distress were significantly associated with higher mortality rates across all metro status categories. Labor markets were differentially associated with mortality across categories. In all but noncore counties, public sector dependence was associated with lower mortality rates. In large metro and micropolitan counties, service sector dependence was associated with higher mortality rates. In micropolitan and noncore counties, mining dependence was associated with higher mortality rates. Persistent population loss was associated with higher mortality rates only among noncore counties. Net of all confounders, neither health care infrastructure nor social capital were associated with mortality rates at any level of metropolitan status.

### 5.4 Within –Rural Differences in County-Level Non-Hispanic White Drug, Alcohol, and Suicide Mortality Rates

The final part of the analyses were restricted to rural counties to assess potential differential associations between rural labor market structure and DAS mortality. Descriptive statistics for rural counties stratified by USDA ERS economic dependency type are presented in Appendix Table A2. Among rural counties, the average DAS mortality rate was the highest for mining dependent (72.9 per 100,000 population), followed by services (63.1), public sector (57.5), non-specialized (56.5), manufacturing (51.7), and farming (47.5). Average NH white economic distress is highest among mining dependent counties and lowest in service and farming dependent counties, but service dependent counties have the highest average family distress. Average family distress is lowest and social capital is highest in farming dependent counties. Social capital is lowest in mining and public sector counties. Nearly 56% of rural farming dependent counties and nearly 40% of rural mining dependent counties are characterized by persistent population loss, compared to less than 10% of government and service dependent rural counties.

<Table 5 about here>

Coefficients from regressions on rural counties stratified by economic dependency classification are presented in Table 5. These models demonstrate that different factors are at play in predicting NH white DAS mortality rates across different types of rural labor markets. Net of controls, county NH white economic distress was associated with significantly higher mortality rates in all but farming dependent rural counties, with the largest difference in mining and service sector counties. Family distress was significantly associated with higher mortality rates among farming dependent counties as well as manufacturing, government, and non-specialized rural counties, but not mining or services dependent. Persistent population loss was significantly and positively associated with mortality only among farming and services dependent counties. For example, rural service dependent counties with persistent population loss experienced an annual average of 21.7 more deaths per 100,000 population than rural service dependent counties without persistent population loss. Finally, net of controls, social capital was not associated with mortality among any of the rural labor market categories.

### 5.4 Results from Sensitivity Analysis

Coefficients from multivariate random effects negative binomial models of death counts are presented in the Appendix (Table A3). In these models, the coefficients represent the percentage change in the DAS mortality rate. For example, in Model 5, a standard deviation in increase in NH white economic distress was associated with a 9% average increase in the DAS mortality rate. There were minimal differences between these and the linear models. In the fully adjusted model, the coefficient comparing noncore to large fringe metro is statistically significant (and negative). It was also negative in the linear regression model, but was not significant. The only other differences are in relation to health care infrastructure. Whereas neither type of shortage area was significant in the linear model, in the negative binomial model, health professional shortage was associated with lower DAS mortality rates, while mental health shortage was associated with higher DAS mortality rates.

The second group of sensitivity analyses involved using predictors and demographic control variables that temporally overlapped with (rather than preceded) the mortality rates (2011-15). Descriptive statistics and model results from these analyses are presented in the Appendix (Tables A4-A8), and maps displaying the geographic distribution of economic distress and family distress for 2011-15 are presented in Appendix Figures A4 and A5. Comparing the fully adjusted models (Model 5) from both analyses shows two main differences.

First, in the analyses using socioeconomic predictors from 2000, DAS mortality rates were not significantly different between large central metro counties and large fringe metro counties. However, in the analyses using socioeconomic predictors from 2011-15, large central metro counties had significantly higher mortality rates than large fringe metro counties. Additional analyses (not shown) revealed that this is because the economic distress gap widened between large central metro and large fringe metro between 2000 and 2011-15; large central metro counties had lower average economic distress in 2011-15 vs. 2000 whereas large fringe metro counties had slightly higher average economic distress in 2011-15 vs. 2000.

Second, there were differences in associations between labor market structure (economic dependency) and mortality rates depending on whether the 2004 or 2015 ERS dependency typologies were used. In the full models using the 2015 typology, farming dependent counties had significantly lower mortality rates than counties with non-specialized labor markets, but this difference was restricted to rural counties. Moreover, NH white economic distress was significantly associated with higher mortality rates in rural farming dependent counties when using the 2015 ERS typology and the 2011-15 socioeconomic indicators, but not when using the 2004 ERS typology and 2000 socioeconomic indicators. Exploring reasons for these differences is beyond the scope of this study, but future research should examine the roles of county labor market and socioeconomic change on mortality rates.

## 6. Discussion and conclusion

### 6.1 Discussion

Consistent with recent U.S. research on accidental drug overdoses and suicide trends (Buchanich et al. 2016, Kegler, Stone and Holland 2017, Rossen, Khan and Warner 2014), this study found significant geographic variation and spatial clustering in NH white drug, alcohol, and suicide mortality rates (2011-15). This is the first national study to examine the social determinants of these geographic disparities by comparing mortality rates across the urban-rural continuum and comparing predictors of rates across different types of rural counties. In so doing, this study identifies the characteristics of counties bearing the heaviest DAS mortality burdens.

Analyses suggest several main conclusions. First, holding county demographic composition constant, average mortality rates were significantly higher in rural (both micropolitan and noncore counties) than in urban fringe counties. The NCHS characterizes urban fringe counties as being akin to suburbs, where residents often fare better on a wide array of health measures relative to inner cities (central metro) and rural hinterlands (U.S. Centers for Disease Control and Prevention 2017). The overall rural DAS mortality penalty found in this study is consistent with research on a wide range of health measures and behaviors. Rural areas also have higher prevalence of self-rated fair/poor health, several chronic diseases, disability and functional limitations, chronic pain, injuries, psychological distress, physical inactivity, obesity, and smoking (Coben et al. 2009, Glasgow, Morton and Johnson 2004, Monnat and Beeler Pickett 2011, Schiller et al. 2012). But NH white DAS mortality rates do not follow a neat urban-rural gradient; although rural counties also had a higher average mortality rate than medium/small metro counties, large central metro counties had an average mortality rate comparable to rural counties (results from models using different reference groups not shown but available from the author upon request). These differences are obscured when combining all metropolitan counties into one category. Therefore, it is equally important to disaggregate across levels of urban as it is to disaggregate across levels of rural.

Second, analyses showed that the rural DAS NH white mortality penalty is explained by the comparatively disadvantaged socioeconomic composition of NH whites in rural counties. Both NH white economic distress and family distress were salient predictors of NH white DAS mortality rates at every level of metropolitan status considered in this study. This finding is consistent with the "fundamental cause" theory that socioeconomic factors are essential determinants of preventable disease disparities (Adler and Newman 2002, Link and Phelan 1995) and with previous research showing associations between the socioeconomic composition of counties and all-cause mortality (James and Cossman 2017, James 2014, McLaughlin et al. 2007, Yang and Jensen 2015). These trends held both when using predictors that temporally overlapped with the years of mortality considered in this study (2011-15) and when using predictors representing county-level conditions that preceded these deaths (e.g., 2000). This suggests that current DAS mortality patterns likely reflect economic and social conditions that prevailed decades ago (Tickamyer and Duncan 1990), with the consequences playing out now.

Third, findings suggest that large DAS mortality disparities across different types of rural labor markets play a critical role in understanding broader geographic patterns in DAS mortality. Specifically, the rural DAS mortality penalty is disproportionately concentrated in mining and service sector dependent counties, while farming and government sector counties have comparatively lower mortality rates. Economic distress plays an important role in both mining and service sector counties, but persistent population loss is an especially salient predictor of higher mortality rates in rural service sector counties. These and other differences across rural labor markets highlight the heterogeneity of rural counties, with different combinations of compositional and contextual features increasing the risk or buffering against high DAS mortality rates.

As demonstrated in numerous in-depth accounts, local labor market dependence on a declining industry and the economic instability, population loss, and disinvestments following job losses in that industry tend to overlap and be mutually reinforcing, often manifesting in collective psychosocial distress, family and community breakdown, and social disorders like substance misuse (Alexander 2017, McLean 2016, Quinones 2015, Reding 2010, Sherman 2009). Mining dependence and persistent population loss are disproportionality concentrated among rural counties, places with the least health care and substance abuse treatment resources. That the coefficients from mining dependence and persistent population loss remained significant and robust in fully adjusted models suggests that other important factors are at play in these places. Culture may be one important unmeasured factor. For example, self-medicating for pain and diversion of prescription medications to friends and family members has long been part of the culture in Appalachia (Keyes et al. 2014), and social norms and attitudes are important substance abuse risk factors (Galea, Ahern and Vlahov 2003). William Julius Wilson (1993, 1997) has long emphasized the important intersections between social structure and culture in explaining urban poverty and its associated consequences. Similar overlapping processes have also played out in some rural areas (Duncan 1996, Hartley 2004, Sherman 2009) and must be contended with if there is any hope at reducing the disproportionate DAS mortality burden in these places.

Fourth, in models that did not include socioeconomic composition, social capital was significantly associated with lower DAS mortality rates. Opportunities for civic engagement facilitate social interaction, trust, goodwill, and social cohesion, and increase residents' sense of community belonging, potentially buffering against depression and substance misuse (Putnam 2001). However, the association between social capital and lower mortality rates disappeared with the inclusion of socioeconomic composition. Counties with greater socioeconomic distress have lower social capital, suggesting a double whammy for counties characterized by this combination of economic and social disadvantage.

Findings should be considered in light of limitations. First, analyses were ecologic and cannot account for decedents' individual characteristics, including duration of county residence. Second, suppression prevented disaggregating rates by sex and age group and examining geographic variation in rates for other racial/ethnic groups. Associations between the factors considered here and mortality rates may vary across groups. Suppression also prevented examining changes in mortality rates over time and disaggregating drug-induced, alcohol-induced, and suicide deaths. However, it may be impossible to neatly disentangle drug, alcohol, and suicide deaths due to their high comorbidity (Cheatle 2011, Conner et al. 2014, Kaplan et al. 2014, Kaplan et al. 2016). Third, death certificates may misclassify causes of death, and results may be biased by heterogeneity in cause-of-death reporting, but using MCD files reduces the likelihood of undercounting due to misclassification (Rockett, Kapusta and Coben 2014). Fourth, county-level data on opioid prescriptions, gun ownership, and other potentially important factors are not available. Fifth, there is heterogeneity *within* counties that cannot be accounted for in these analyses. Many metropolitan counties have outlying rural areas with different resident characteristics and labor market opportunities than those in the urban core of the county. Moreover, urban-rural boundaries are highly fluid and shift over time, with significant interaction occurring in the urban-rural interface (Lichter and Brown 2011, Lichter and Brown 2014). Urban-rural boundary blurring means that people and communities regular experience both urban and rural worlds, making distinct comparisons between them somewhat artificial (Lichter and Ziliak 2017). Sixth, associations between county environments and mortality rates likely play out over an extended period, but these analyses incorporated only recent information (i.e., since 2000) about county environments and did not consider changes in environments over a longer period of time. Future research should examine the role of changing labor markets and concomitant county socioeconomic changes on DAS mortality rates. Finally, it is unlikely than drugs, alcohol, and suicide exclusively capture despair-related deaths. Heart disease and cancer remain the leading causes of death in the U.S., and both have decidedly behavioral proximate causes they may be related to distress, anxiety, and despair (e.g., poor diet, smoking). Future research should examine whether the factors that explain geographic variation in DAS mortality are the same as those that explain geographic variation in other types of preventable behavior-related mortality.

Ultimately, the cliché that "addiction does not discriminate" ignores the fact that DAS mortality rates vary significantly by geography and are clustered among places characterized by higher prevalence of economic and family distress and disadvantaged labor markets. Although rural counties have a disproportionate NH white DAS mortality burden, the rural mortality penalty varies significantly by type of labor market and level of economic distress. Without a clear understanding of this geographic variation and without identifying the types of places at risk of high mortality rates, resources and policy solutions may be misdirected. The economic and social burdens of DAS mortality are substantial, and the places that are least equipped to do so are disproportionately carrying this burden. Funding to address risk factors (e.g., economic development, treatment, recovery) is often allocated on a population basis, resulting in underfunding the places in greatest need. High rates of substance misuse, drug overdose, and their associated problems may repel the very community investments that could potentially improve economic conditions and quality of life, thereby contributing to a cycle of economic, social, and health decline. Understanding that certain combinations of population and contextual characteristics place some counties at greater risk of high DAS mortality rates than others, and that similar risks are often shared by neighboring counties, could facilitate regional responses and better resource targeting (McLaughlin et al. 2007). Finally, despite widespread media and political attention on drug overdoses (especially opioids), it is important to recognize that combined rates from alcohol-induced deaths and suicides remain higher than the rate for drug-induced deaths. In the current frenzy to get a tourniquet on the opioid epidemic, we must not lose sight of these other large contributors to mortality.

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Table 1. Variables Included in Regression Analysis with Summary Statistics and Bivariate Regression Results Predicting NH White DAS Mortality Rate, 2011-15

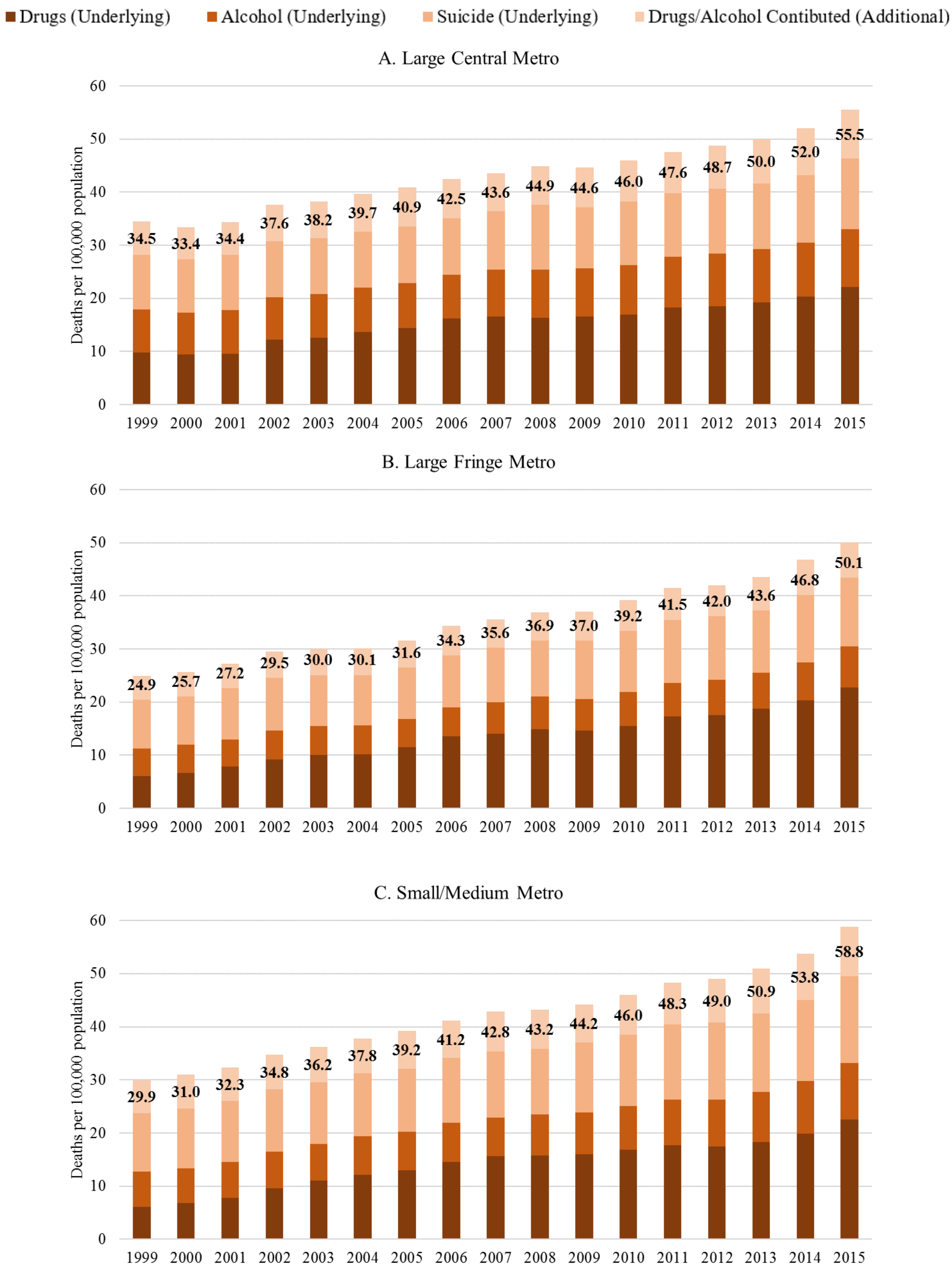
| | Summary Statistics | | | | Bivariate Regression Estimates[1] | |
|---|---|---|---|---|---|---|
| Variable | Mean | SD | Min | Max | β | SE |
| NH white DAS mortality rate, 2011-15 | 54.0 | (20.1) | 0.0 | 179.8 | ----- | |
| Economic Distress Index Measures | 0.0 | (1.0) | -3.2 | 5.6 | 7.79 | (0.37)*** |
| NH whites (18-64) in poverty, 2000 (%) | 10.1 | (4.6) | 1.8 | 43.3 | 2.88 | (0.39)*** |
| Ratio of state-to-county NH white median household income, 1999 (%) | 118.7 | (23.1) | 49.9 | 227.6 | 6.11 | (0.38)*** |
| NH whites (age 25+) w<4-year college degree, 2000 (%) | 81.9 | (8.8) | 19.4 | 95.1 | 6.27 | (0.37)*** |
| NH whites (age 21-64) not working, 2000 (%) | 25.7 | (6.6) | 11.2 | 64.6 | 7.84 | (0.39)*** |
| NH whites (age 21-64) with any disability, 2000 (%) | 19.3 | (5.1) | 7.2 | 43.6 | 8.07 | (0.35)*** |
| Family Distress Index Measures | 0.0 | (1.0) | -4.0 | 3.9 | 7.41 | (0.34)*** |
| NH white single-parent families, 2000 (%) | 10.3 | (2.4) | 1.0 | 20.5 | 5.39 | (0.33)*** |
| Separated/divorced (age 16+), 2000 (%) | 11.3 | (2.2) | 3.7 | 21.2 | 8.58 | (0.37)*** |
| Employment Sector Dependence, 2004 | | | | | | |
| Farming | 12.8 | | | | -6.65 | (1.07)*** |
| Mining | 3.9 | | | | 10.95 | (1.60)*** |
| Manufacturing | 29.7 | | | | -1.38 | (0.79) |
| Public (government) | 11.8 | | | | -5.61 | (1.04)*** |
| Services | 11.0 | | | | -1.02 | (1.12) |
| Non-specialized (reference) | 30.8 | | | | ----- | |
| Health care professional shortage area, 2010 | 82.4 | | | | 2.30 | (0.83)** |
| Mental health care provider shortage area, 2010 | 86.7 | | | | 3.27 | (0.93)*** |
| Persistent population loss (1980 to 2000) | 18.5 | | | | 2.41 | (0.86)** |
| Social capital index, 2005 | -0.3 | (1.3) | -3.9 | 14.3 | NA | |
| Social capital index, 2005 (logged) | 2.3 | 0.1 | 1.8 | 3.2 | -2.70 | (0.42)*** |
| NH whites under age 18, 2000 (%) | 23.4 | (3.0) | 6.9 | 38.2 | -3.08 | (0.35)*** |
| NH whites age 25-54, 2000 (%) | 41.4 | (3.7) | 22.8 | 62.5 | -0.40 | (0.35) |

| | | | | | |
|---|---|---|---|---|---|
| Total NH white population, 2000 (%) | 82.1 | (17.9) | 1.6 | 99.8 | NA |
| Q1 (bottom 25th percentile) (reference) | | | | | ----- |
| Q2 (25th to 50th percentile) | | | | | 2.91 (0.92)** |
| Q3 (50th to 75th percentile) | | | | | 3.21 (1.07)** |
| Q4 (top 25th percentile) | | | | | 2.20 (1.18) |
| Total foreign born population, 2000 (%) | 3.4 | (4.8) | 0.0 | 50.9 | NA |
| Q1 (bottom 25th percentile) (reference) | | | | | ----- |
| Q2 (25th to 50th percentile) | | | | | -0.20 (0.87) |
| Q3 (50th to 75th percentile) | | | | | -0.13 (0.93) |
| Q4 (top 25th percentile) | | | | | -3.58 (1.05)*** |
| NH whites (age 18+) who are veterans, 2000 (%) | 15.0 | (2.8) | 5.1 | 35.1 | 4.75 (0.34)*** |
| Spatial lag (average DAS mortality rate among neighbor counties) | 45.6 | (12.4) | 6.2 | 108.6 | 9.75 (0.40)*** |
| State-Level Measures | | | | | |
| NH white DAS mortality rate, 1999-2001 (deaths per 100,000 pop) | 33.3 | (8.5) | 21 | 64.2 | 12.78 (0.85)*** |
| Gun ownership, 2013 (%) | 33.0 | (13.4) | 5.2 | 61.7 | -0.39 (1.06) |
| Alcohol sales per 10,000 pop, 1999-2003 | 87.3 | (22.4) | 52 | 142.9 | -2.21 (1.10)* |
| Opioid prescriptions dispensed per 100 pop, 2012 | 2.3 | (0.5) | 1.3 | 4.1 | 0.36 (0.91) |

County N=3,029; State N=49

SD=standard deviation; SE=standard error; ***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2000) and state NH white DAS mortality rate (1999-2001). All continuous variables are standardized at a mean of 0 and standard deviation of 1 for regression analysis. Regression coefficients represent the change in the NH white DAS mortality rate (deaths per 100,000 population) for a 1 SD increase in the value of the predictor variable



Drugs (Underlying)
Alcohol (Underlying)
Suicide (Underlying)
Drugs/Alcohol Contibuted (Additional)
A. Large Central Metro
Deaths per 100,000 population
0
10
20
30
40
50
60
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
34.5
33.4
34.4
37.6
38.2
39.7
40.9
42.5
43.6
44.9
44.6
46.0
47.6
48.7
50.0
52.0
55.5
B. Large Fringe Metro
Deaths per 100,000 population
0
10
20
30
40
50
60
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
24.9
25.7
27.2
29.5
30.0
30.1
31.6
34.3
35.6
36.9
37.0
39.2
41.5
42.0
43.6
46.8
50.1
C. Small/Medium Metro
Deaths per 100,000 population
0
10
20
30
40
50
60
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
29.9
31.0
32.3
34.8
36.2
37.8
39.2
41.2
42.8
43.2
44.2
46.0
48.3
49.0
50.9
53.8
58.8

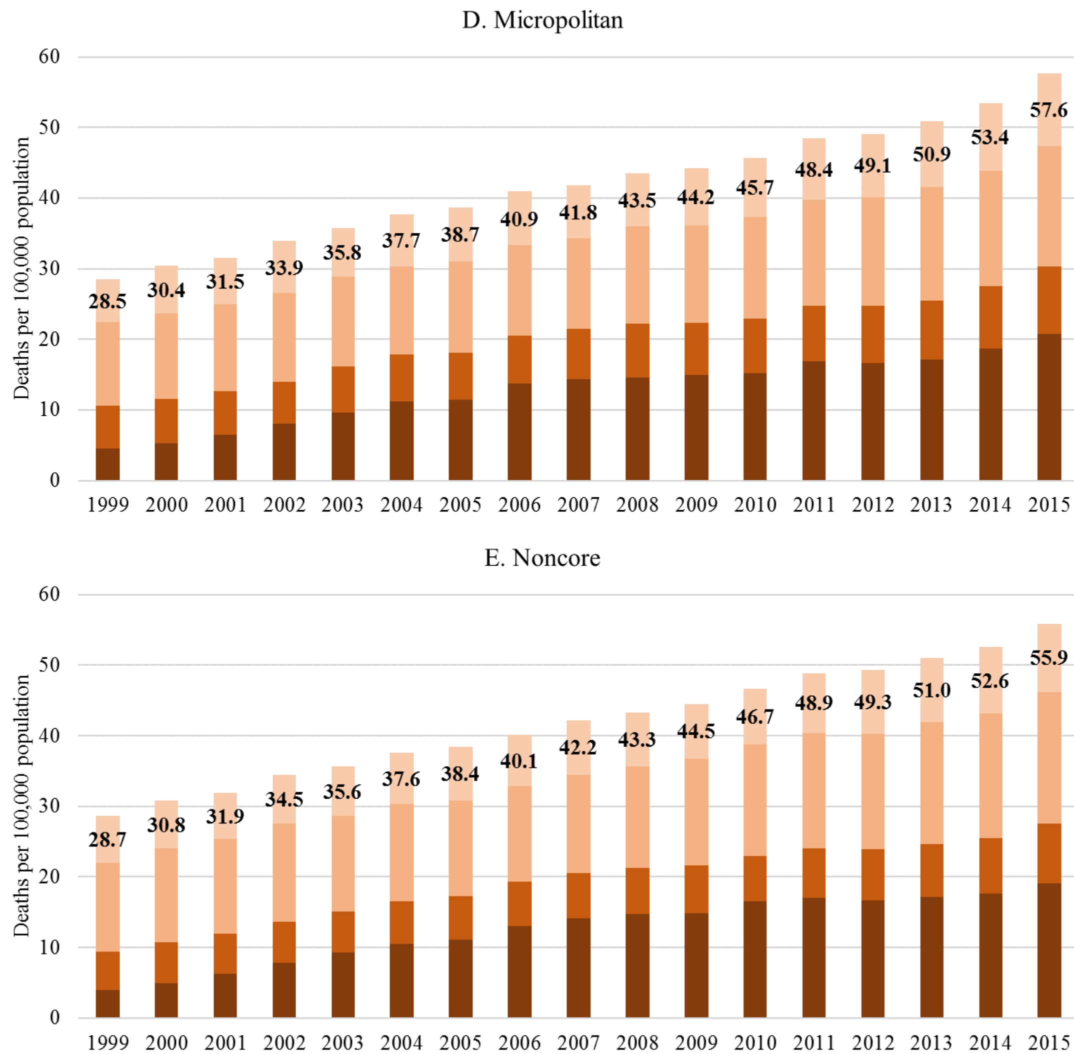



**Figure 1. Trends in Non-Hispanic White Drug, Alcohol, and Suicide[1] Mortality Rates by Urban-Rural Continuum[2], 1999-2015**

*Notes*: Rates are age-adjusted;
[1]Drug and alcohol-induced suicides are included in the drug-induced category. In 2015, 12.4% of all NH white suicides were drug induced, and only 0.1% were alcohol-induced. This represents very little change since 1999, when 11.5% of all NH white suicides were drug induced, and 0.1% were alcohol-induced.
[2]Urban-rural continuum categories are based on the National Center for Health Statistics Urban-Rural Classification Scheme for Counties (https://www.cdc.gov/nchs/data_access/urban_rural.htm). (1) Large central metro: counties in metropolitan statistical areas (MSAs) of 1 million or more population that have been identified by NCHS classification rules as central because they contain all or part of a principal city of the area; (2) Large fringe metro: remaining counties (similar to suburbs) in MSAs of one million or more. (3) Small/medium metro: Counties in MSAs of <1 million population; (4) Micropolitan: Nonmetropolitan counties that are designated by the Office of Management and Budget as belonging to a micropolitan statistical area; (5) Noncore: remaining nonmetropolitan counties that do not belong to a micropolitan statistical area.

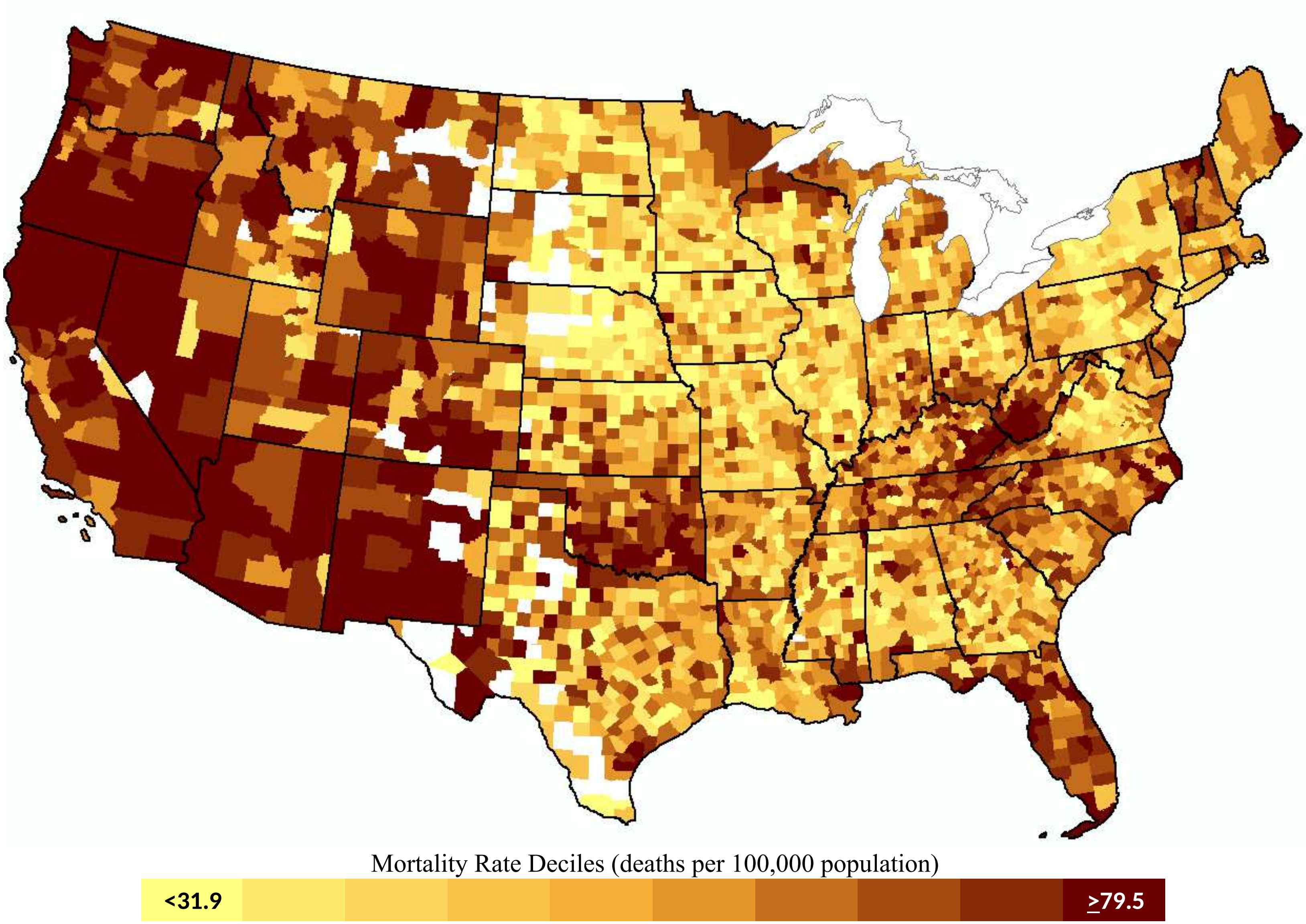



**Figure 2. Non-Hispanic White Crude Drug, Alcohol, and Suicide Mortality Rate, 2011-15**
*Note*: Excludes counties with fewer than 1,000 non-Hispanic white adults (age 18+)

Table 2. Descriptive Statistics by Urban-Rural Continuum

| Variable | Mean and standard deviation (SD) or Percent | | | | |
|---|---|---|---|---|---|
| | Large Central Metro (N=68) | Large Fringe Metro (N=367) | Medium/Small Metro (N=720) | Micropolitan (N=628) | Noncore (N=1,246) |
| NH White DAS mortality rate, 2011-15 | 57.2 | 49.5 | 53.9 | 55.4 | 54.5 |
| | (17.5) | (13.7) | (17.8) | (20.5) | (22.6) |
| Economic Distress Index, 2000[1] | -1.16 | -0.82 | -0.24 | 0.07 | 0.41 |
| | (0.80) | (0.86) | (0.82) | (0.85) | (0.97) |
| NH whites (18-64) in poverty, 2000 (%) | 7.4 | 6.2 | 9.4 | 10.6 | 11.6 |
| | (2.6) | (2.8) | (4.2) | (4.4) | (4.5) |
| Ratio of state-to-county NH white med HH inc., 1999 (%) | 96.2 | 95.2 | 110.7 | 119.9 | 130.8 |
| | (17.4) | (18.5) | (19.1) | (19.1) | (20.3) |
| NH whites (age 25+) w<4-year college degree, 2000 (%) | 63.1 | 77.0 | 79.6 | 82.2 | 85.5 |
| | (13.1) | (11.3) | (8.8) | (7.6) | (5.2) |
| NH whites (age 21-64) not working, 2000 (%) | 22.0 | 22.8 | 25.1 | 25.9 | 27.0 |
| | (4.1) | (4.3) | (5.6) | (6.0) | (7.7) |
| NH whites (age 21-64) with any disability, 2000 (%) | 15.6 | 16.8 | 18.6 | 19.5 | 20.6 |
| | (3.4) | (4.3) | (4.5) | (4.7) | (5.5) |
| Family Distress Index, 2000[1] | 0.48 | -0.04 | 0.24 | 0.25 | -0.28 |
| | (0.93) | (0.89) | (0.88) | (0.92) | (1.06) |
| NH white single-parent families, 2000 (%) | 10.5 | 10.2 | 10.8 | 11.0 | 9.6 |
| | (2.4) | (2.1) | (2.1) | (2.2) | (2.4) |
| Separated/divorced (age 16+), 2000 (%) | 13.0 | 11.2 | 11.7 | 11.6 | 10.8 |
| | (2.0) | (1.8) | (2.0) | (2.1) | (2.4) |
| Employment Sector Dependence, 2004 | | | | | |
| Farming | 0.0 | 0.3 | 5.8 | 5.7 | 24.8 |
| Mining | 0.0 | 0.8 | 1.7 | 4.6 | 6.0 |
| Manufacturing | 5.9 | 30.5 | 31.7 | 38.1 | 25.4 |
| Public (government) | 14.7 | 9.5 | 16.9 | 13.5 | 8.5 |
| Services | 66.2 | 23.2 | 14.7 | 7.8 | 3.8 |
| Non-specialized (reference) | 13.2 | 35.7 | 29.2 | 30.3 | 31.5 |
| Persistent population loss (1980 to 2000) | 16.2 | 3.0 | 7.8 | 14.3 | 31.5 |
| Health care professional shortage area, 2010 | 95.6 | 68.1 | 82.1 | 77.9 | 88.4 |
| Mental health care provider shortage area, 2010 | 95.6 | 70.0 | 78.2 | 88.7 | 95.0 |

| | | | | | |
|---|---|---|---|---|---|
| Social capital index, 2005[1] | -0.40 | -0.29 | -0.33 | -0.14 | 0.31 |
| | (0.85) | (0.62) | (1.18) | (0.81) | (1.16) |
| Social capital index, 2005 (logged)[1] | -0.42 | -0.27 | -0.22 | -0.12 | 0.29 |
| | (0.93) | (0.66) | (0.87) | (0.86) | (1.14) |
| NH whites under age 18, 2000 (%) | 19.4 | 24.9 | 23.4 | 23.3 | 23.3 |
| | (4.4) | (3.0) | (3.2) | (2.8) | (2.7) |
| NH whites age 25-54, 2000 (%) | 47.0 | 44.9 | 42.3 | 41.1 | 39.6 |
| | (4.5) | (3.3) | (3.1) | (3.2) | (3.0) |
| Total NH white population, 2000 (%) | 56.3 | 81.9 | 80.8 | 81.9 | 84.4 |
| | (16.9) | (15.2) | (16.6) | (18.8) | (17.8) |
| Total foreign born population, 2000 (%) | 15.5 | 4.8 | 3.9 | 3.4 | 2.1 |
| | (11.3) | (5.3) | (4.5) | (4.5) | (2.8) |
| NH whites (age 18+) who are veterans, 2000 (%) | 13.4 | 14.8 | 15.2 | 14.9 | 15.0 |
| | (2.9) | (2.5) | (2.9) | (2.9) | (2.8) |
| Spatial lag | 43.7 | 44.1 | 46.3 | 46.2 | 45.5 |
| (average DAS mortality rate among neighbor counties) | (12.8) | (9.2) | (12.2) | (13.4) | (12.7) |
| State-Level Measures | | | | | |
| NH white DAS mortality rate, 1999-2001 | 32.9 | 32.3 | 33.1 | 33.1 | 33.2 |
| (deaths per 100,000 pop) | (8.6) | (6.3) | (8.6) | (8.6) | (8.7) |
| Gun ownership, 2013 (%) | 28.8 | 30.0 | 32.8 | 33.9 | 34.3 |
| | (9.7) | (12.3) | (12.6) | (11.7) | (11.5) |
| Alcohol sales per 10,000 pop, 1999-2003 | 2.2 | 2.2 | 2.3 | 2.2 | 2.2 |
| | (0.5) | (0.5) | (0.5) | (0.5) | (0.5) |
| Opioid prescriptions dispensed per 100 pop, 2012 | 89.0 | 91.9 | 88.6 | 89.1 | 89.5 |
| | (23.1) | (24.0) | (22.5) | (22.7) | (22.8) |

County N=3,029; State N=49

Grey cell indicates significant difference from reference category (large fringe metro), p<.05; two-tailed test

[1]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. Therefore, positive values indicate above mean and negative values indicate below mean.

Table 3. Results from Multivariate Random Effects Regression on County NH White DAS Mortality Rate, 2011-15

| | Difference in DAS Mortality Rate (deaths per 100,000 population) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Model 1 | | Model 2 | | Model 3 | | Model 4 | | Model 5[3] | |
| Predictor[1] | β | SE | β | SE | β | SE | β | SE | β | SE |
| Urban-Rural Continuum (ref=Large fringe metro) | | | | | | | | | | |
| Large central metro | 3.54 | (2.26) | 2.56 | (2.02) | 2.50 | (2.21) | 1.01 | (2.01) | 2.20 | (1.96) |
| Medium/small metro | 1.07 | (1.07) | -2.63 | (0.97)** | 1.46 | (1.04) | -2.08 | (0.96)* | -1.95 | (0.94)* |
| Micropolitan | 2.82 | (1.14)* | -2.77 | (1.05)** | 2.41 | (1.12)* | -2.66 | (1.04)* | -2.11 | (1.02)* |
| Noncore | 3.63 | (1.14)** | -1.58 | (1.05) | 3.34 | (1.12)** | -2.14 | (1.07)* | -1.85 | (1.05) |
| Economic distress, 2000[2] | | | 6.56 | (0.78)*** | | | 6.97 | (0.81)*** | 5.44 | (0.72)*** |
| Family distress, 2000[2] | | | 4.67 | (0.38)*** | | | 4.54 | (0.38)*** | 4.59 | (0.37)*** |
| Economic dependence, 2004 (ref=non-specialized) | | | | | | | | | | |
| Farming | | | | | -3.72 | (1.09)*** | -1.34 | (1.00) | -0.95 | (0.97) |
| Mining | | | | | 9.86 | (1.55)*** | 7.66 | (1.44)*** | 6.23 | (1.41)*** |
| Manufacturing | | | | | -0.57 | (0.75) | -0.27 | (0.69) | -0.08 | (0.68) |
| Public sector | | | | | -6.46 | (0.99)*** | -5.06 | (0.91)*** | -5.08 | (0.89)*** |
| Services | | | | | 0.62 | (1.10) | 2.91 | (1.01)** | 2.23 | (0.99)* |
| Health professional shortage area, 2010 | | | | | 0.55 | (0.83) | -0.77 | (0.76) | -0.86 | (0.74) |
| Mental health provider shortage area, 2010 | | | | | 1.99 | (0.93)* | 1.10 | (0.85) | 0.95 | (0.83) |
| Persistent population loss, 1980-2000 | | | | | 4.41 | (0.88)*** | 2.77 | (0.80)*** | 2.19 | (0.78)** |
| Social capital, 2005(logged)[2] | | | | | -4.20 | (0.75)*** | 0.84 | (0.47) | 1.08 | (0.46)* |
| Fixed Effect Intercept | 53.79 | (1.70)*** | 55.83 | (1.71)*** | 49.95 | (1.94)*** | 56.05 | (1.99)*** | 56.21 | (1.81)*** |
| State-Level Variance | 36.76 | (9.25)*** | 52.20 | (14.31)*** | 30.38 | (8.41)*** | 55.60 | (15.33)*** | 28.68 | (9.25)*** |
| County-Level Variance | 244.63 | (6.35) | 191.38 | (5.02)*** | 222.28 | (5.84)*** | 184.58 | (4.85)*** | 177.79 | (4.67)*** |
| Economic Distress Random Effect Variance | | | 14.54 | (4.48)*** | | | 14.24 | (4.38)*** | 8.72 | (3.11)** |
| Economic Distress Covariance | | | 21.36 | (7.32)*** | | | 23.84 | (7.55)** | 13.39 | (4.96)** |

| | | |
|---|---|---|
| Social Capital Random Effect Variance | 13.27 | (5.21)** |
| Social Capital Covariance | -3.00 | (4.85) |

County N=3,029; State N=49

SE=standard error; ***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2000), percent non-Hispanic white (2000), percent foreign born (2000), percent veteran (2000), and state DAS mortality rate (1999-2001)

[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable.

[3]Model 5 also controls for county DAS mortality spatial lag (average mortality among neighboring counties), state percent gun ownership (2013), per capita average alcohol sales (1999-2003), per capita opioid prescriptions dispensed (2012)

Table 4. Results from Multivariate Random Effects Regression on County NH White DAS Mortality Rate (2011-15), Stratified by Urban-Rural Continuum

| | Large Metro[3] | | Medium/Small Metro | | Micropolitan | | Noncore | |
|---|---|---|---|---|---|---|---|---|
| Predictor[1] | β | SE | β | SE | β | SE | β | SE |
| Economic distress, 2000[2] | 6.93 | (1.36)*** | 3.00 | (0.99)** | 4.02 | (1.54)** | 4.86 | (1.00)*** |
| Family distress, 2000[2] | 6.08 | (0.67)*** | 5.77 | (0.762)*** | 5.13 | (0.81)*** | 2.60 | (0.70)*** |
| Economic dependence, 2004 (ref=non-specialized) | | | | | | | | |
| Farming | -0.35 | (10.05) | -1.23 | (1.91) | -0.87 | (2.51) | -0.85 | (1.39) |
| Mining | -0.56 | (5.47) | 0.94 | (3.38) | 6.72 | (2.71)* | 6.87 | (2.24)** |
| Manufacturing | -1.42 | (1.24) | 0.07 | (1.04) | 1.14 | (1.33) | -0.43 | (1.32) |
| Public sector | -5.88 | (1.74)** | -4.54 | (1.25)*** | -6.97 | (1.74)*** | -3.27 | (1.90) |
| Services | 3.15 | (1.30)* | 1.69 | (1.34) | 5.28 | (2.23)* | 2.53 | (2.69) |
| Health prof. shortage area | -1.38 | (1.21) | 1.02 | (1.20) | -0.27 | (1.40) | -2.59 | (1.52) |
| Mental health provider shortage area | 1.63 | (1.22) | 1.90 | (1.08) | -1.46 | (1.76) | -0.31 | (2.21) |
| Persistent population loss | 1.43 | (2.38) | -1.00 | (1.63) | 2.95 | (1.54) | 3.22 | (1.31)* |
| Social capital (logged)[2] | 1.84 | (1.03) | 0.74 | (0.68) | -0.28 | (1.04) | 0.62 | (0.79) |
| Fixed Effect Intercept | 50.49 | (2.90)*** | 49.18 | (2.37)*** | 58.64 | (3.18)*** | 55.44 | (3.03)*** |
| State-Level Variance | 21.64 | (11.88)* | 22.96 | (9.89)* | 30.76 | (13.26)* | 7.04 | (4.20)* |
| County-Level Variance | 78.53 | (5.87)*** | 100.40 | (5.79)*** | 141.12 | (8.88)*** | 265.55 | (11.03)*** |
| Economic Distress Random Effect Variance | 6.49 | (4.38) | 6.42 | (4.36) | 27.23 | (13.59)* | 6.71 | (5.01) |
| Economic Distress Covariance | 11.16 | (6.73) | 7.72 | (5.70) | 21.91 | (11.88) | 10.05 | (4.22)* |
| County N | 435 | | 720 | | 628 | | 1246 | |
| State N | 39 | | 47 | | 45 | | 44 | |

SE=standard error; ***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2000), percent non-Hispanic white (2000), percent foreign born (2000), percent veteran (2000), county DAS mortality spatial lag (average mortality among neighboring counties), state DAS mortality rate (1999-2001), state percent gun ownership (2013), per capita average alcohol sales (1999-2003), per capita opioid prescriptions dispensed (2012)

[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable.

[3]Large metro combines large central and large fringe metro counties

Table 5. Results from Multivariate Random Effects Regression on County NH White DAS Mortality Rate (2011-15) in Rural (Micropolitan and Noncore) Counties by ERS Economic Dependency Category

| Predictor[1] | Farming β (SE) | Mining β (SE) | Manufacturing β (SE) | Public Sector β (SE) | Services Dependent β (SE) | Non-Specialized β (SE) |
|---|---|---|---|---|---|---|
| Economic distress, 2000[2] | 0.97<br>(2.18) | 12.17**<br>(3.33) | 3.78**<br>(1.27) | 8.30***<br>(2.14) | 9.84**<br>(3.59) | 7.36***<br>(1.05) |
| Family distress, 2000[2] | 4.25**<br>(1.43) | -1.74<br>(3.08) | 3.23***<br>(0.94) | 4.67**<br>(1.78) | 3.68<br>(2.47) | 4.01***<br>(0.92) |
| Persistent pop loss, 1980-2000 | 5.49*<br>(2.77) | 8.75<br>(5.74) | 0.39<br>(1.78) | -1.02<br>(5.57) | 21.68**<br>(7.88) | 2.31<br>(1.57) |
| Social capital, 2005 (logged) [2] | -1.24<br>(1.44) | -0.91<br>(4.57) | 1.89<br>(1.40) | 3.45<br>(1.95) | -2.72<br>(2.60) | 1.76<br>(1.11) |
| Fixed Effect Intercept | 51.41***<br>(3.50) | 55.61***<br>(9.45) | 54.17***<br>(2.53) | 51.37***<br>(4.43) | 60.38***<br>(10.28) | 54.08***<br>(2.48) |
| State-Level Variance | 17.69<br>(31.23) | 0.00<br>(0.00) | 57.01*<br>(24.52) | 28.62<br>(30.19) | 0.00<br>(0.00) | 56.05**<br>(19.01) |
| County-Level Variance | 305.60***<br>(27.08) | 529.93<br>(79.44) | 178.49***<br>(11.38) | 308.27<br>(37.54) | 234.45<br>(36.84) | 180.95***<br>(11.19) |
| County N | 345 | 104 | 555 | 191 | 96 | 583 |
| State N | 30 | 25 | 37 | 40 | 33 | 42 |

***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2000), percent non-Hispanic white (2000), percent foreign born (2000), percent veteran (2000), and state DAS mortality rate (1999-2001)

[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable.

**Appendix – List of Tables and Figures**

Table A1. Correlation Matrix for all Variables included in Main Regression Analyses (continued below)

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (1) Large Central Metro | ----- | | | | | | | | | | | |
| (2) Large Fringe Metro | -.056 | | | | | | | | | | | |
| (3) Medium/Small Metro | -.085 | -.207 | | | | | | | | | | |
| (4) Micropolitan | -.078 | -.190 | -.286 | | | | | | | | | |
| (5) Noncore | -.127 | -.310 | -.467 | -.428 | | | | | | | | |
| (6) Economic distress, 2000 | -.176 | -.307 | -.132 | .033 | .343 | | | | | | | |
| (7) Family distress, 2000 | .073 | -.014 | .135 | .130 | -.236 | .307 | | | | | | |
| (8) Farming dependent, 2004 | -.058 | -.139 | -.117 | -.108 | .300 | -.017 | -.395 | | | | | |
| (9) Mining dependent, 2004 | -.031 | -.059 | -.065 | .018 | .090 | .179 | .046 | -.078 | | | | |
| (10) Manufacturing dependent, 2004 | -.079 | .007 | .024 | .094 | -.079 | .010 | .126 | -.249 | -.131 | | | |
| (11) Public sector dependent, 2004 | .014 | -.026 | .089 | .027 | -.086 | .001 | .083 | -.140 | -.074 | -.238 | | |
| (12) Services dependent, 2004 | .268 | .145 | .067 | -.052 | -.192 | -.244 | .071 | -.134 | -.071 | -.228 | -.128 | |
| (13) Non-specialized economy, 2004 | -.058 | .039 | -.020 | -.006 | .013 | .092 | .036 | -.256 | -.135 | -.433 | -.244 | -.234 |
| (14) Health professional shortage area, 2010 | .052 | -.140 | -.005 | -.061 | .132 | .189 | .042 | .086 | .071 | -.135 | .032 | -.007 |
| (15) Mental health provider shortage area, 2010 | .040 | -.182 | -.140 | .030 | .205 | .186 | .023 | .104 | .054 | -.082 | .008 | -.077 |
| (16) Persistent population loss, 1980-2000 | -.009 | -.148 | -.154 | -.055 | .279 | .070 | -.252 | .329 | .083 | -.103 | -.116 | -.099 |
| (17) Social capital index, 2005 | -.061 | -.107 | -.126 | -.070 | .255 | -.344 | -.416 | .318 | -.064 | -.091 | -.126 | -.018 |
| (18) Percent NH white under age 18, 2000 | -.200 | .176 | -.012 | -.016 | -.033 | -.167 | -.104 | .092 | .050 | .103 | -.186 | -.181 |
| (19) Percent of NH whites age 25-54, 2000 | .232 | .352 | .145 | -.038 | -.397 | -.349 | .339 | -.304 | .025 | .107 | .036 | .210 |
| (20) Percent NH white, 2000 | -.219 | -.005 | -.040 | -.005 | .107 | .025 | -.091 | .028 | -.017 | .085 | -.180 | -.027 |
| (21) Percent foreign born, 2000 | .383 | .111 | .053 | -.004 | -.231 | -.282 | -.004 | .004 | -.016 | -.150 | .035 | .270 |
| (22) Percent military veterans, 2000 | -.082 | -.027 | .045 | -.020 | .020 | .059 | .175 | -.055 | -.028 | -.149 | .157 | .029 |
| (23) NH white DAS mortality rate spatial lag | -.024 | -.046 | .030 | .024 | -.009 | .319 | .344 | -.122 | .187 | -.105 | .075 | .064 |
| (24) State NH white DAS mortality rate, 1999-2001 | .021 | -.050 | .038 | .036 | -.035 | .156 | .287 | -.056 | .126 | -.157 | .125 | .085 |
| (24) State percent of residents who own a gun, 2013 | -.111 | -.157 | -.005 | .005 | .138 | .213 | -.040 | .082 | .108 | -.010 | .019 | -.146 |
| (25) State opioid prescribing rate, 2012 | -.072 | -.044 | .020 | .032 | .007 | .356 | .193 | -.117 | .027 | .229 | -.038 | -.123 |
| (26) State avg. alcohol sales (gallons per cap), 1999-2003 | .022 | -.016 | -.014 | .017 | .001 | -.206 | -.023 | .072 | .018 | -.146 | .023 | .113 |

Table A1 (cont). Correlation Matrix for all Variables included in Main Regression Analyses

| | (13) | (14) | (15) | (16) | (17) | (18) | (19) | (20) | (21) | (22) | (23) | (24) | (25) | (26) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (14) Health prof. shortage, 2010 | .024 | | | | | | | | | | | | | |
| (15) MH provider shortage, 2010 | .030 | .361 | | | | | | | | | | | | |
| (16) Persistent pop loss, 1980-2000 | -.023 | .079 | .119 | | | | | | | | | | | |
| (17) Social capital index, 2005 | -.013 | -.058 | .033 | .410 | | | | | | | | | | |
| (18) % NH white under age 18, 2000 | .063 | -.080 | -.037 | -.048 | .065 | | | | | | | | | |
| (19) % of NH whites age 25-54, 2000 | -.063 | -.107 | -.199 | -.299 | -.270 | .110 | | | | | | | | |
| (20) Percent NH white, 2000 | .048 | -.135 | -.052 | .106 | .453 | .390 | -.129 | | | | | | | |
| (21) Percent foreign born, 2000 | -.054 | .023 | .000 | -.164 | -.231 | -.186 | .193 | -.447 | | | | | | |
| (22) Percent military veterans, 2000 | .070 | .104 | .035 | -.075 | -.051 | -.199 | -.136 | -.140 | .048 | | | | | |
| (23) NH white DAS mort. rate spatial lag | .017 | .112 | .056 | -.138 | -.304 | -.093 | .112 | -.066 | .097 | .251 | | | | |
| (24) State NHW DAS mort rate, 1999-01 | -.002 | .148 | .065 | -.203 | -.290 | -.196 | .127 | -.311 | .233 | .340 | .679 | | | |
| (24) State gun ownership %, 2013 | -.009 | .059 | .101 | .056 | -.084 | .015 | -.065 | -.087 | -.208 | -.031 | .164 | .272 | | |
| (25) State opioid prescribing rate, 2012 | -.044 | -.050 | -.003 | -.055 | -.302 | .003 | .081 | .008 | -.310 | -.211 | .159 | .091 | .442 | |
| (26) State per cap alcohol sales 99-03 | -.007 | .128 | .070 | -.039 | .178 | -.071 | .031 | -.068 | .139 | .261 | .051 | .314 | -.042 | -.500 |

(+/- r, p<.05)

| ≤.20 | .21 to .40 | .41 to .60 | .61 to .80 | >.80 |
|---|---|---|---|---|

Unshaded correlations are not statistically significant

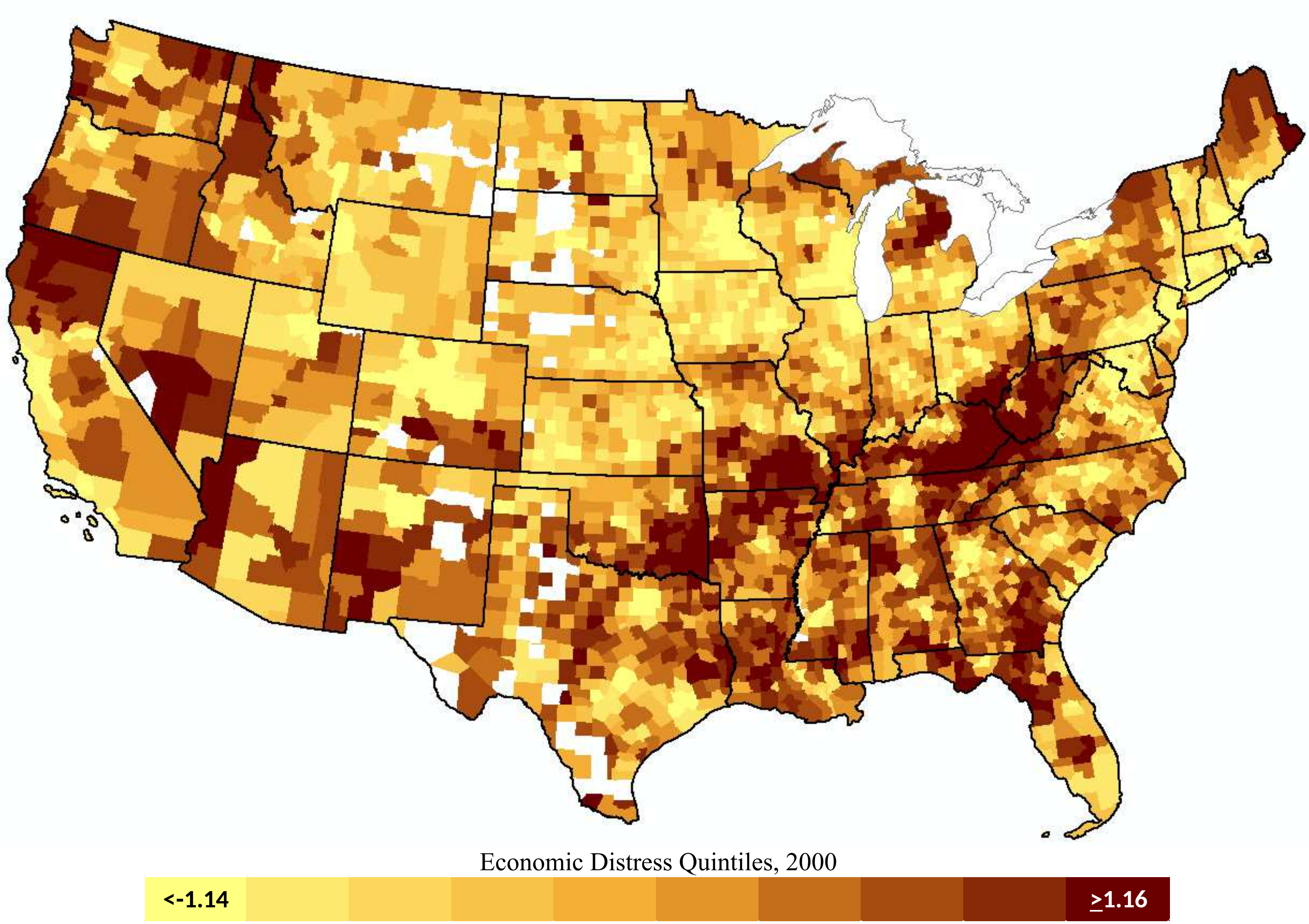



**Figure A1. Non-Hispanic White Economic Distress Index, 2000**

*Note*: Excludes counties with fewer than 1,000 non-Hispanic white adults (age 18+)

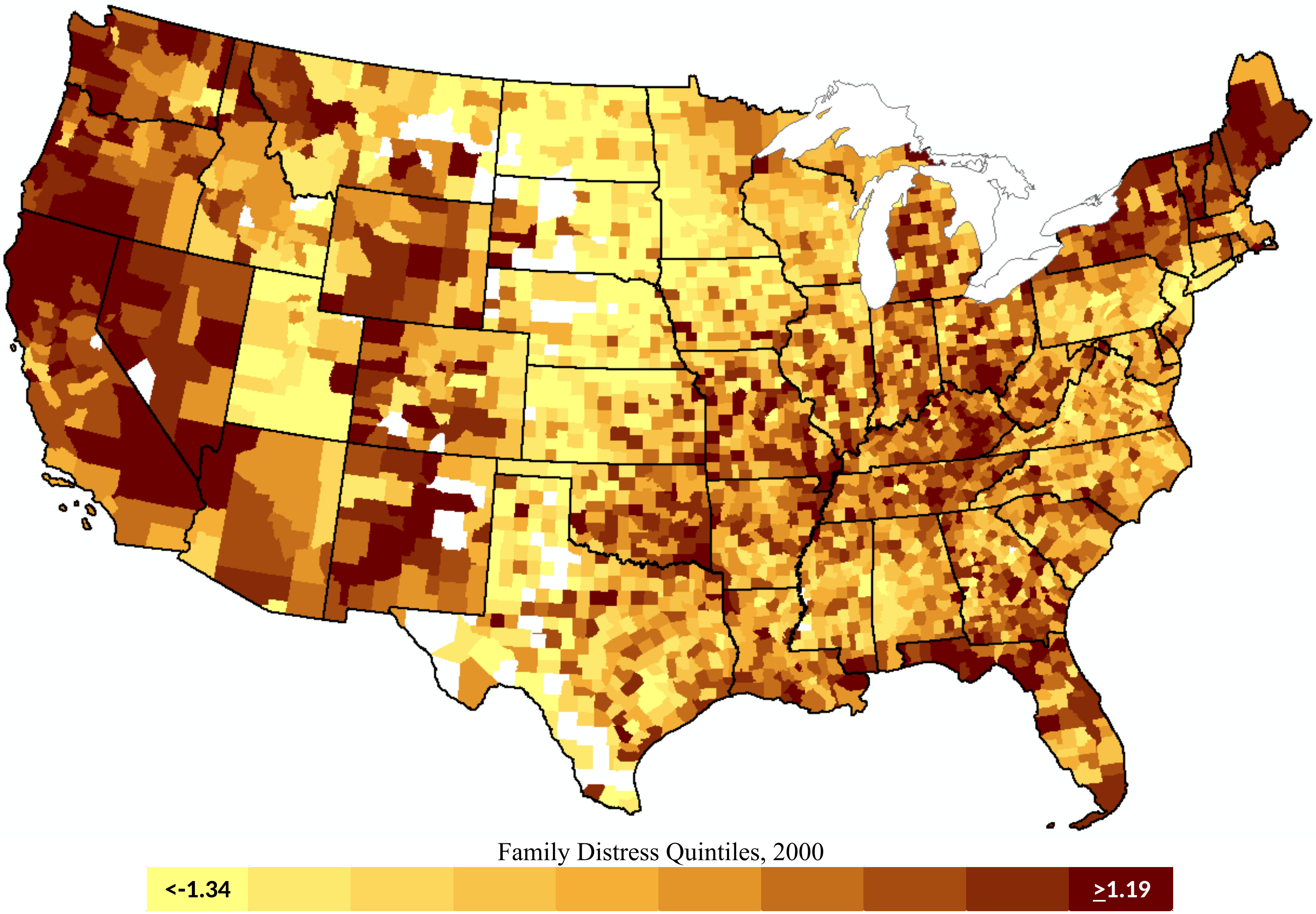
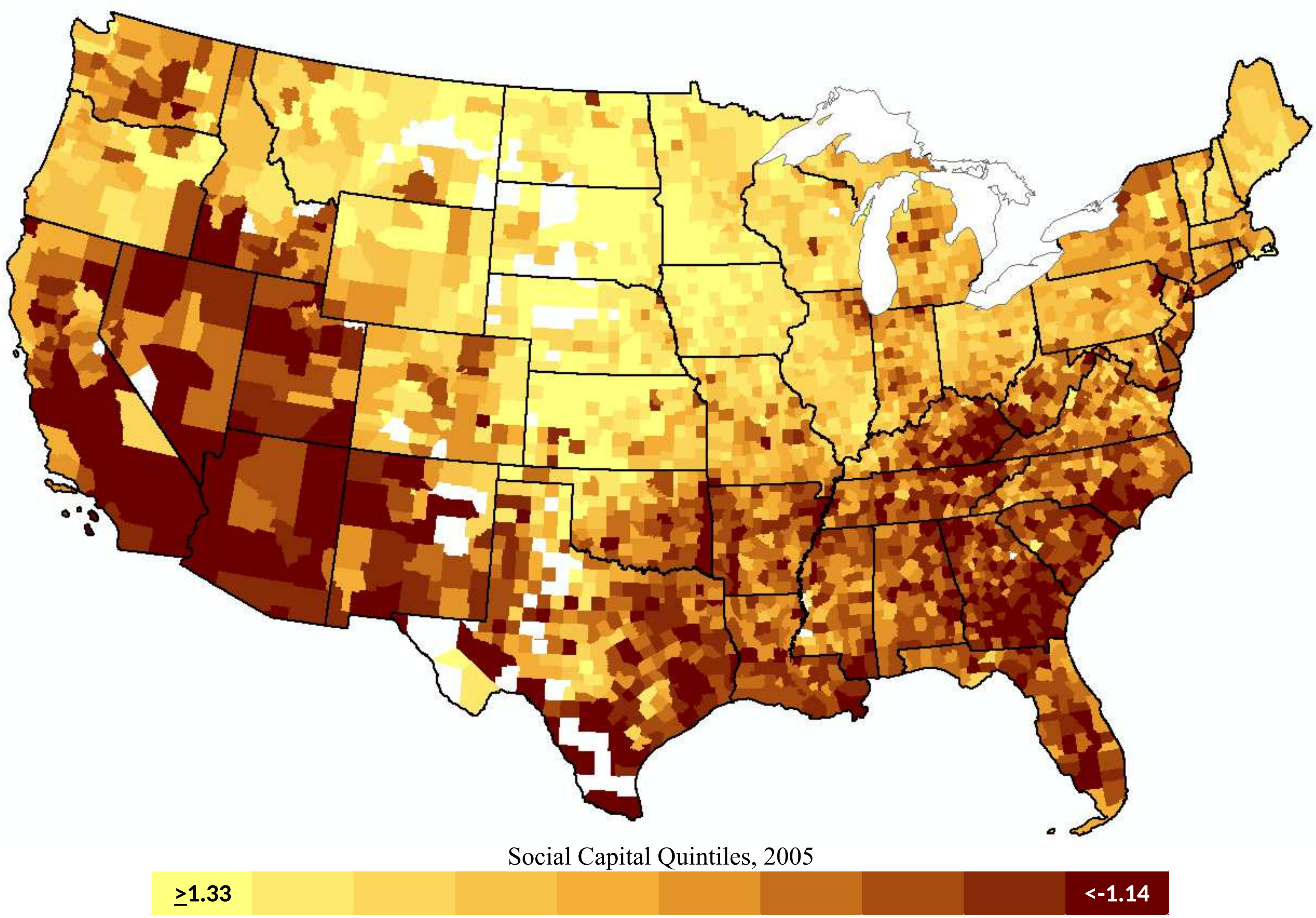



**Figure A2 Family Distress Index, 2000**

*Note*: Excludes counties with fewer than 1,000 non-Hispanic white adults (age 18+)




*Note*: Excludes counties with fewer than 1,000 non-Hispanic white adults (age 18+)

**Figure A3 Social Capital Index, 2005**

Table A2. Descriptive Statistics for Rural (Micropolitan and Noncore) Counties by ERS Economic Dependency Category

| | Farming (N=345) | | Mining (N=104) | | Manufacturing (N=555) | | Public (Gov't) (N=191) | | Services (N=96) | | Non-Specialized (N=583) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| NH white DAS mortality rate, 2011-15 | 47.5 | (21.3) | 72.9 | (29.5) | 51.7 | (16.6) | 57.5 | (25.1) | 63.1 | (23.5) | 56.5 | (21.2) |
| Economic Distress Index Measures | -0.05 | (0.64) | 0.94 | (1.53) | 0.25 | (0.77) | 0.42 | (0.92) | -0.25 | (1.00) | 0.47 | (1.00) |
| NH whites (18-64) in poverty, 2000 (%) | 11.0 | (3.2) | 13.6 | (7.1) | 9.9 | (3.5) | 13.0 | (5.5) | 10.1 | (4.6) | 11.9 | (4.6) |
| Ratio of state-to-county NH white median household income, 1999 (%) | 127.7 | (17.9) | 132.6 | (30.0) | 122.9 | (18.4) | 127.9 | (21.3) | 116.3 | (20.5) | 131.5 | (20.3) |
| NH whites (age 25+) w<4-year college degree, 2000 (%) | 84.4 | (3.9) | 86.0 | (5.0) | 86.5 | (4.2) | 80.4 | (9.2) | 75.0 | (11.1) | 85.0 | (4.9) |
| NH whites (age 21-64) not working, 2000 (%) | 22.3 | (5.3) | 32.5 | (11.0) | 26.5 | (5.7) | 29.0 | (6.2) | 25.4 | (6.7) | 27.7 | (7.5) |
| NH whites (age 21-64) with any disability, 2000 (%) | 17.5 | (4.4) | 23.3 | (7.4) | 20.9 | (4.4) | 20.4 | (5.4) | 18.1 | (5.1) | 21.0 | (5.3) |
| Family Distress Index Measures | -1.08 | (1.05) | 0.17 | (1.03) | 0.18 | (0.79) | 0.11 | (1.03) | 0.38 | (0.99) | 0.03 | (0.93) |
| NH white single-parent families, 2000 (%) | 8.0 | (2.2) | 10.7 | (2.6) | 10.6 | (2.0) | 10.3 | (2.7) | 10.8 | (2.3) | 10.4 | (2.3) |
| Separated/divorced (age 16+), 2000 (%) | 9.1 | (2.6) | 11.5 | (2.0) | 11.7 | (1.8) | 11.7 | (2.4) | 12.1 | (2.3) | 11.3 | (2.1) |
| Persistent population loss (1980 to 2000) | 55.9 | | 38.5 | | 16.0 | | 6.3 | | 8.3 | | 24.0 | |
| Health care professional shortage area, 2010 | 91.3 | | 95.2 | | 75.9 | | 90.1 | | 78.1 | | 87.3 | |
| Mental health care provider shortage area, 2010 | 98.2 | | 98.1 | | 88.8 | | 92.7 | | 84.4 | | 94.2 | |
| Social capital index, 2005 | 0.95 | (1.41) | -0.26 | (0.77) | -0.10 | (0.79) | -0.33 | (0.92) | 0.27 | (0.87) | 0.15 | (0.94) |
| Social capital index, 2005 (logged) | 0.88 | (1.35) | -0.26 | (0.81) | -0.08 | (0.82) | -0.35 | (0.97) | 0.30 | (0.86) | 0.16 | (0.97) |
| NH whites under age 18, 2000 (%) | 24.0 | (2.8) | 24.0 | (3.1) | 23.6 | (2.3) | 22.0 | (3.4) | 21.6 | (2.9) | 23.3 | (2.5) |
| NH whites age 25-54, 2000 (%) | 38.2 | (2.7) | 41.5 | (3.1) | 41.0 | (2.2) | 40.6 | (3.6) | 42.6 | (6.3) | 39.6 | (2.5) |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total NH white population, 2000 (%) | 83.9 | (18.2) | 81.1 | (19.7) | 84.5 | (16.9) | 75.0 | (21.7) | 89.2 | (11.6) | 84.8 | (17.9) |
| Total foreign born population, 2000 (%) | 3.4 | (4.6) | 3.2 | (4.1) | 2.0 | (2.5) | 2.8 | (3.6) | 3.5 | (3.3) | 2.2 | (3.3) |
| NH whites (age 18+) who are veterans, 2000 (%) | 14.6 | (2.1) | 14.8 | (3.5) | 14.3 | (2.0) | 16.2 | (4.1) | 15.6 | (3.4) | 15.3 | (2.8) |
| State-Level Measures (N=49) | | | | | | | | | | | | |
| NH white DAS mortality rate, 1999-2001 | 34.7 | (9.5) | 34.7 | (9.8) | 30.9 | (5.8) | 33.7 | (8.9) | 33.7 | (9.1) | 33.5 | (8.8) |
| Gun ownership, 2013 (%) | 37.3 | (10.4) | 37.0 | (10.3) | 32.0 | (11.4) | 35.4 | (11.2) | 34.7 | (12.1) | 35.1 | (11.2) |
| Alcohol sales per 10,000 pop, 1999-2001 | 2.2 | (0.4) | 2.2 | (0.4) | 2.2 | (0.4) | 2.2 | (0.4) | 2.3 | (0.5) | 2.2 | (0.4) |
| Opioid prescriptions dispensed per 100 pop, 2012 | 90.1 | (23.9) | 90.9 | (20.4) | 91.2 | (24.3) | 91.2 | (23.2) | 86.5 | (21.6) | 90.3 | (23.0) |

SD=standard deviation

Table A3. Results from Multivariate Random Effects Negative Binomial Model of NH White DAS Death Count, 2011-15

| Predictor[1] | Model 1<br>IDR (95% CI) | Model 2<br>IDR (95% CI) | Model 3<br>IDR (95% CI) | Model 4<br>IDR (95% CI) | Model 5[3]<br>IDR (95% CI) |
|---|---|---|---|---|---|
| Urban-Rural Continuum (ref=Large fringe metro) | | | | | |
| Large central metro | 1.08* | 1.03 | 1.04 | 1.00 | 1.02 |
| | (1.01 to 1.15) | (0.97 to 1.08) | (0.98 to 1.11) | (0.95 to 1.05) | (0.97 to 1.07) |
| Medium/small metro | 1.02 | 0.94*** | 1.03 | 0.95*** | 0.96** |
| | (0.99 to 1.06) | (0.92 to 0.97) | (1.00 to 1.06) | (0.93 to 0.98) | (0.93 to 0.98) |
| Micropolitan | 1.05** | 0.93*** | 1.04* | 0.94*** | 0.95*** |
| | (1.01 to 1.09) | (0.90 to 0.96) | (1.01 to 1.08) | (0.91 to 0.96) | (0.92 to 0.97) |
| Noncore | 1.07*** | 0.96** | 1.06** | 0.95** | 0.96** |
| | (1.03 to 1.11) | (0.92 to 0.99) | (1.02 to 1.10) | (0.92 to 0.98) | (0.93 to 0.99) |
| Economic distress, 2000[2] | | 1.12*** | | 1.13*** | 1.09*** |
| | | (1.09 to 1.14) | | (1.10 to 1.15) | (1.07 to 1.12) |
| Family distress, 2000[2] | | 1.11*** | | 1.11*** | 1.11*** |
| | | (1.09 to 1.12) | | (1.09 to 1.12) | (1.09 to 1.12) |
| Economic dependence, 2004 (ref=non-specialized) | | | | | |
| Farming | | | 0.94* | 1.00 | 1.01 |
| | | | (0.90 to 0.99) | (0.96 to 1.04) | (0.97 to 1.05) |
| Mining | | | 1.17*** | 1.11*** | 1.08*** |
| | | | (1.11 to 1.24) | (1.06 to 1.17) | (1.03 to 1.14) |
| Manufacturing | | | 0.99 | 0.99 | 1.00 |
| | | | (0.96 to 1.01) | (0.97 to 1.01) | (0.98 to 1.02) |
| Public sector | | | 0.88*** | 0.90*** | 0.90*** |
| | | | (0.85 to 0.91) | (0.87 to 0.92) | (0.87 to 0.92) |
| Services | | | 1.00 | 1.04** | 1.03* |
| | | | (0.97 to 1.04) | (1.01 to 1.07) | (1.00 to 1.06) |
| Health professional shortage area, 2010 | | | 1.01 | 0.98 | 0.98* |

| | | | | | |
|---|---|---|---|---|---|
| | | | (0.98 to 1.04) | (0.96 to 1.00) | (0.95 to 1.00) |
| Mental health provider shortage area, 2010 | | | 1.05** | 1.03* | 1.03* |
| | | | (1.02 to 1.08) | (1.00 to 1.06) | (1.00 to 1.05) |
| Persistent population loss, 1980-2000 | | | 1.09*** | 1.04** | 1.03* |
| | | | (1.06 to 1.13) | (1.01 to 1.07) | (1.00 to 1.06) |
| Social capital, 2005 (logged)[2] | | | 0.94*** | 1.01 | 1.02* |
| | | | (0.92 to 0.96) | (0.99 to 1.02) | (1.00 to 1.03) |
| Fixed Intercept | -7.53 (0.030)*** | -7.51 (0.027)*** | -7.62 (0.033)*** | -7.50 (0.032)*** | -7.51 (0.029)*** |
| Random Intercept | 0.012 (0.003)*** | 0.014 (0.003)*** | 0.009 (0.003)*** | 0.014 (0.003)*** | 0.008 (0.002)*** |
| Random Slope (Economic Distress) | NA | 0.002 (0.0006)*** | NA | 0.002 (0.0006)*** | 0.001 (0.0004)*** |
| Economic Distress Covariance | NA | 0.003 (0.001)*** | NA | 0.003 (0.001)** | 0.001 (0.0008) |
| Random Slope (Social Capital) | NA | NA | 0.002 (0.0008)*** | NA | NA |
| Social Capital Covariance | NA | NA | -0.001 (0.001) | NA | NA |
| Neg 2 Res Log Pseudo-Likelihood | 964.26 | 113.79 | 696.78 | 28.78 | 121.87 |

County N=3,029; State N=49
IDR=Incidence Density Ratio; CI=confidence interval
***p<.001; **p<.01; *p<.05; two-tailed tests
[1]All models control for county age composition (2000), percent non-Hispanic white (2000), percent foreign born (2000), percent veteran (2000), and state NH white DAS mortality rate (1999-2001)
[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable.
[3]Model 5 also controls for county DAS mortality spatial lag (average mortality among neighboring counties), state percent gun ownership (2013), per capita average alcohol sales (1999-2003), and per capita opioid prescriptions dispensed (2012)

Table A4. Variables Included in Regression Analysis with Summary Statistics and Bivariate Regression Results Predicting NH White DAS Mortality Rate, 2011-15 (using predictors that temporally overlap with mortality rates)

| | Summary Statistics | | | | Bivariate Regression Estimates[1] |
|---|---|---|---|---|---|
| Variable | Mean | SD | Min | Max | β (SE) |
| Economic Distress Index Measures, 2011-15[2, 3] | 0.0 | (1.0) | -3.3 | 4.8 | 6.26 (0.35)*** |
| NH whites (18-64) in poverty, 2011-15 (%)[2] | 13.3 | (5.4) | 1.6 | 47.0 | 3.25 (0.35)*** |
| Ratio of state-to-county NHW med HH inc., 2011-15 (%)[2] | 118.0 | (24.3) | 49.2 | 262.1 | 4.98 (0.34)*** |
| NHW (age 25+) w<4-year college degree, 2011-15 (%)[2] | 77.5 | (10.2) | 9.5 | 95.3 | 4.93 (0.34)*** |
| NH whites (age 16-64) not working, 2011-15 (%)[2, 3] | 32.6 | (8.3) | 13.0 | 69.9 | 5.43 (0.40)*** |
| NH whites (age 18-64) with any disability, 2011-15 (%)[2, 3] | 8.0 | (2.8) | 1.9 | 23.1 | 6.95 (0.34)*** |
| Family Distress Index Measures, 2011-15[2] | 0.0 | (1.0) | -4.2 | 4.7 | 6.07 (0.32)*** |
| NH white single-parent families, 2011-15 (%)[2] | 12.7 | (3.4) | 0.0 | 28.9 | 3.75 (0.31)*** |
| NH white separated/divorced (age 16+), 2011-15 (%)[2,4] | 13.7 | (2.8) | 3.4 | 26.9 | 6.82 (0.33)*** |
| Employment Sector Dependence, 2015 | | | | | |
| Farming | 15.2 | | | | -7.64 (1.04)*** |
| Mining | 7.6 | | | | 6.73 (1.28)*** |
| Manufacturing | 16.9 | | | | -2.40 (0.87)** |
| Public (government) | 14.3 | | | | -4.05 (0.96)*** |
| Services | 13.0 | | | | 1.33 (1.09) |
| Non-specialized (reference) | 40.4 | | | | |
| Health care professional shortage area, 2010 | 82.4 | | | | 2.24 (0.82)** |
| Mental health care provider shortage area, 2010 | 86.7 | | | | 3.29 (0.92)*** |
| Persistent population loss (1990 to 2010) | 16.0 | | | | 2.39 (0.90)** |
| Social capital index, 2005 | 0.0 | (1.0) | -2.9 | 10.7 | NA |
| Social capital index, 2005 (logged)[2] | 0.0 | (1.0) | -3.8 | 7.0 | -3.04 (0.43)*** |
| NH whites under age 18, 2011-15 (%)[2] | 20.2 | (3.1) | 5.9 | 35.1 | -3.57 (0.36)*** |
| NH whites age 25-54, 2011-15 (%)[2] | 36.9 | (3.6) | 10.9 | 58.9 | -0.76 (0.33)* |
| Total NH white population, 2011-15 (%) | 78.1 | (18.9) | 1.0 | 99.6 | NA |
| Q1 (bottom 25th percentile) (reference) | | | | | |
| Q2 (25th to 50th percentile) | | | | | 2.45 (0.89)** |

| | | | | | |
|---|---|---|---|---|---|
| Q3 (50th to 75th percentile) | | | | | 3.54 (1.04)** |
| Q4 (top 25th percentile) | | | | | 2.97 (1.16)* |
| Total foreign born population, 2011-15 (%) | 4.6 | (5.5) | 0.0 | 51.7 | NA |
| Q1 (bottom 25th percentile) (reference) | | | | | |
| Q2 (25th to 50th percentile) | | | | | 0.84 (0.86) |
| Q3 (50th to 75th percentile) | | | | | -0.14 (0.91) |
| Q4 (top 25th percentile) | | | | | -3.41 (1.04)** |
| NH whites (age 18+) who are veterans, 2011-15 (%)[2] | 10.8 | (2.8) | 2.7 | 38.1 | 2.49 (0.33)*** |
| Spatial lag (average NH white DAS mortality rate among neighbor counties) [2] | 45.6 | (12.4) | 6.2 | 108.6 | 9.51 (0.40)*** |
| State-Level Measures | | | | | |
| NH white DAS mortality rate, 1999-2001 (deaths per 100,000 pop) [2] | 33.3 | (8.5) | 20.5 | 64.2 | 12.21 (0.94)*** |
| Gun ownership, 2013 (%)[2] | 33.0 | (13.4) | 5.2 | 61.7 | 0.18 (1.06) |
| Alcohol sales per 10,000 pop, 2011-15[2] | 2.5 | (0.6) | 1.4 | 4.7 | -1.93 (1.02) |
| Opioid prescriptions dispensed per 100 residents, 2012[2] | 2.3 | (0.5) | 1.3 | 4.1 | 0.99 (0.88) |

County N=3,029; State N=49

SD=standard deviation; SE=standard error; ***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2011-15) and state NH white DAS mortality rate (1999-2001).

[2]All continuous variables are standardized at a mean of 0 and standard deviation of 1 for regression analysis. Regression coefficients represent the change in the NH white DAS mortality rate (deaths per 100,000 population) for a 1 SD increase in the value of the predictor variable.

[3]Values for 2011-15 are not comparable to those from 2000 because of differences in age groups included in the universe. This includes the economic distress index.

[4]The main analyses (using variables from 2000 ACS) include percent of total population (age 16+) divorced or separated because race/ethnic specific values were not available. Therefore, the family distress index for 2011-15 is not directly comparable to the index for 2000.

Table A5. Descriptive Statistics (for predictor variables that temporally overlap with mortality rates) by Urban-Rural Continuum

| Variable | Mean and Standard Deviation (SD) or Percent | | | | |
|---|---|---|---|---|---|
| | Large Central Metro (N=68) | Large Fringe Metro (N=367) | Medium/Small Metro (N=720) | Micropolitan (N=628) | Noncore (N=1,246) |
| Economic Distress Index, 2011-15[1, 2] | -1.24 | -0.74 | -0.16 | 0.15 | 0.33 |
| | (0.67) | (0.89) | (0.80) | (0.87) | (1.02) |
| NH whites (18-64) in poverty, 2011-15 (%) | 10.2 | 9.3 | 13.0 | 14.6 | 14.2 |
| | (2.9) | (4.0) | (4.8) | (5.5) | (5.5) |
| Ratio of state-to-county NH white median HH income, 2011-15 (%) | 92.8 | 96.4 | 111.1 | 120.7 | 128.4 |
| | (15.7) | (19.9) | (20.4) | (21.4) | (22.9) |
| NH whites (age 25+) w<4-year college degree, 2011-15 (%) | 53.8 | 71.1 | 74.9 | 78.5 | 81.7 |
| | (13.7) | (12.8) | (9.9) | (8.4) | (6.3) |
| NH whites (age 16-64) not working, 2011-15 (%)[2] | 26.7 | 29.8 | 32.2 | 33.1 | 33.7 |
| | (4.3) | (5.7) | (6.8) | (7.6) | (9.9) |
| NH whites (age 18-64) with any disability, 2011-15 (%)[2] | 5.7 | 6.7 | 7.8 | 8.3 | 8.5 |
| | (1.5) | (2.1) | (2.3) | (2.5) | (3.2) |
| Family Distress Index, 2011-15[1, 3] | -0.08 | -0.21 | 0.13 | 0.30 | -0.16 |
| | (0.85) | (0.89) | (0.88) | (0.93) | (1.09) |
| NH white single-parent families, 2011-15 (%) | 13.2 | 12.3 | 13.3 | 13.9 | 11.9 |
| | (2.9) | (2.9) | (3.0) | (3.1) | (3.6) |
| NH white separated/divorced (age 16+), 2011-15 (%)[3] | 12.9 | 13.1 | 13.9 | 14.2 | 13.7 |
| | (2.4) | (2.4) | (2.5) | (2.7) | (3.1) |
| Employment Sector Dependence, 2015 | | | | | |
| Farming | 0.0 | 3.5 | 6.9 | 5.4 | 29.1 |
| Mining | 2.9 | 1.9 | 4.4 | 8.4 | 10.9 |
| Manufacturing | 1.5 | 12.0 | 15.1 | 23.4 | 16.9 |
| Public (government) | 16.2 | 9.3 | 17.8 | 16.9 | 12.3 |
| Recreation | 4.4 | 10.6 | 10.1 | 13.2 | 15.7 |
| Non-specialized (reference) | 76.4 | 65.1 | 49.9 | 38.7 | 26.5 |

| | | | | | |
|---|---|---|---|---|---|
| Persistent population loss (1990 to 2010) | 11.8 | 1.6 | 6.7 | 11.1 | 28.4 |
| Health care professional shortage area, 2010 | 95.6 | 68.1 | 82.1 | 77.9 | 88.4 |
| Mental health care provider shortage area, 2010 | 95.6 | 70.0 | 78.2 | 88.7 | 95.0 |
| Social capital index, 2005[1] | -0.40 | -0.29 | -0.22 | -0.14 | 0.31 |
| | (0.85) | (0.62) | (0.88) | (0.81) | (1.16) |
| Social capital index, 2005 (logged)[1] | -0.42 | -0.27 | -0.22 | -0.12 | 0.29 |
| | (0.93) | (0.66) | (0.88) | (0.86) | (1.14) |
| NH whites under age 18, 2011-15 (%) | 17.0 | 21.3 | 20.1 | 20.2 | 20.1 |
| | (3.3) | (2.8) | (3.2) | (3.0) | (3.0) |
| NH whites age 25-54, 2011-15 (%) | 44.1 | 39.6 | 37.8 | 36.7 | 35.2 |
| | (5.1) | (2.6) | (2.9) | (3.1) | (3.2) |
| Total NH white population, 2011-15 (%) | 49.8 | 75.9 | 76.5 | 78.0 | 81.2 |
| | (15.6) | (17.5) | (17.4) | (19.6) | (18.4) |
| Total foreign born population, 2011-15 (%) | 17.9 | 6.8 | 5.0 | 4.4 | 3.0 |
| | (11.0) | (6.7) | (4.9) | (4.9) | (3.9) |
| NH whites (age 18+) who are veterans, 2011-15 (%) | 8.6 | 10.5 | 11.1 | 10.8 | 10.9 |
| | (3.1) | (2.6) | (2.9) | (2.9) | (2.6) |
| <u>State-Level Measures</u> | | | | | |
| Alcohol sales per 10,000 pop, 2011-15 | 2.4 | 2.3 | 2.4 | 2.4 | 2.4 |
| | (0.5) | (0.6) | (0.6) | (0.5) | (0.5) |

[1]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. Therefore, positive values indicate above mean and negative values indicate below mean.

[2]Values for 2011-15 are not comparable to those from 2000 because of differences in age groups included in the universe. This includes the economic distress index.

[3]The main analyses (using variables from 2000 ACS) include percent of total population (age 16+) divorced or separated because race/ethnic specific values were not available. Therefore, the family distress index for 2011-15 is not directly comparable to the index for 2000.

Table A6. Results from Multivariate Random Effects Regression on County NH White DAS Mortality Rate, 2011-15
(Using predictors that temporally overlap with mortality rates)

| | Model 1 | | Model 2 | | Model 3 | | Model 4 | | Model 5[3] | |
|---|---|---|---|---|---|---|---|---|---|---|
| Predictor[1] | β | SE | β | SE | β | SE | β | SE | β | SE |
| Urban-Rural Continuum (ref=Large fringe metro) | | | | | | | | | | |
| Large central metro | 3.22 | (2.31) | 6.57 | (2.11)** | 2.96 | (2.26) | 5.92 | (2.08)** | 6.83 | (2.02)*** |
| Medium/small metro | 0.40 | (1.07) | -3.23 | (1.00)** | 0.73 | (1.04) | -2.75 | (0.98)** | -2.33 | (0.95)* |
| Micropolitan | 1.85 | (1.13) | -4.15 | (1.08)*** | 1.47 | (1.11) | -4.19 | (1.07)*** | -3.23 | (1.04)** |
| Noncore | 2.44 | (1.12)* | -2.99 | (1.07)** | 2.53 | (1.11)* | -3.44 | (1.09)*** | -2.78 | (1.06)** |
| Economic distress, 2011-15[2,4] | | | 5.15 | (0.87)*** | | | 6.08 | (0.89)*** | 4.74 | (0.74)*** |
| Family distress, 2011-15[2,4] | | | 4.22 | (0.38)*** | | | 3.62 | (0.38) *** | 3.67 | (0.36)*** |
| Economic dependence, 2015 (ref=non-specialized) | | | | | | | | | | |
| Farming | | | | | -6.88 | (1.10)*** | -4.98 | (1.01) *** | -4.63 | (0.98) *** |
| Mining | | | | | 5.90 | (1.29)*** | 6.32 | (1.19) *** | 4.72 | (1.16) *** |
| Manufacturing | | | | | -1.99 | (0.86)* | -1.46 | (0.79) | -1.21 | (0.77) |
| Public sector | | | | | -5.19 | (0.95)*** | -4.66 | (0.89) *** | -4.46 | (0.86) *** |
| Services | | | | | 0.09 | (1.10) | 3.66 | (1.04) *** | 2.34 | (1.01) * |
| Health professional shortage area, 2010 | | | | | 1.01 | (0.85) | 0.24 | (0.78) | -0.07 | (0.76) |
| Mental health provider shortage area, 2010 | | | | | 2.00 | (0.94)* | 1.07 | (0.87) | 0.96 | (0.85) |
| Persistent population loss, 1990-2010 | | | | | 5.01 | (0.94)*** | 3.27 | (0.86) *** | 2.59 | (0.84)* |
| Social capital, 2005 (logged)[2] | | | | | -3.97 | (0.72)*** | 0.57 | (0.48) | 1.09 | (0.47)* |
| Fixed Effect Intercept | 54.64 | (1.71)*** | 57.68 | (1.66)*** | 50.96 | (1.89)*** | 57.62 | (1.93) *** | 57.75 | (1.74) *** |
| State-Level Variance | 34.32 | (8.81)*** | 37.48 | (10.92)*** | 26.64 | (7.51)*** | 42.58 | (12.58) *** | 18.77 | (6.65)** |
| County-Level Variance | 253.12 | (6.57)*** | 206.00 | (5.41)*** | 232.20 | (6.10)*** | 198.02 | (5.22) *** | 188.64 | (4.97) *** |
| Economic Distress Random Effect Variance | | | 21.08 | (6.17)*** | | | 20.07 | (5.92) *** | 10.62 | (3.66)** |

| | | | | | |
|---|---|---|---|---|---|
| Economic Distress Covariance | | 17.20 (7.29)* | | 23.33 (7.85) ** | 11.73 (4.47)** |
| Social Capital Random Effect Variance | | | 11.11 (4.78)* | | |
| Social Capital Covariance | | | -3.05 (4.48) | | |

County N=3,029; State N=49

SE=standard error; ***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2011-15), percent non-Hispanic white (2011-15), percent foreign born (2011-15), and state DAS mortality rate (1999-2001)

[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable.

[3]Model 5 also controls for county DAS mortality spatial lag (average mortality among neighboring counties), state percent gun ownership (2013), per capita average alcohol sales (2011-15), per capita opioid prescriptions dispensed (2012)

[4]The economic and family distress coefficients are not directly comparable to the main analyses because they include slightly different variables (due to availability) than the indices for 2000.

Table A7. Results from Multivariate Random Effects Regression on County NH White DAS Mortality Rate (2011-15), Stratified by Urban-Rural Continuum (using predictor variables that temporally overlap with mortality rates)

| | Large Metro[3] | | Medium/Small Metro | | Micropolitan | | Noncore | |
|---|---|---|---|---|---|---|---|---|
| Predictor[1] | β | SE | β | SE | β | SE | β | SE |
| Economic distress, 2011-15[2] | 7.13 | (1.16)*** | 2.03 | (0.84)* | 2.17 | (1.14) | 3.47 | (0.86)*** |
| Family distress, 2011-15[2] | 4.18 | (0.87)*** | 5.02 | (0.67)*** | 6.28 | (0.81)*** | 1.66 | (0.61)** |
| Economic dependence, 2015 (ref=non-specialized) | | | | | | | | |
| Farming | -0.82 | (3.28) | -2.66 | (1.96) | -7.44 | (2.73)** | -5.29 | (1.57)*** |
| Mining | -0.15 | (3.64) | 7.62 | (2.34)** | 6.26 | (2.21)** | 2.88 | (1.95) |
| Manufacturing | -0.43 | (1.58) | 0.36 | (1.24) | -0.82 | (1.47) | -2.98 | (1.55) |
| Public sector | -5.52 | (1.78)** | -3.62 | (1.22)** | -5.42 | (1.67)** | -2.52 | (1.88) |
| Recreation | 0.78 | (1.89) | 0.94 | (1.64) | 2.66 | (2.06) | 2.32 | (1.98) |
| Health prof. shortage area, 2010 | -1.26 | (1.29) | 1.46 | (1.27) | 0.20 | (1.46) | -1.50 | (1/60) |
| Mental health provider shortage area, 2010 | 2.41 | (1.28) | 1.99 | (1.15) | -2.22 | (1.83) | -1.51 | (2.31) |
| Persistent population loss, 1990-2010 | 4.74 | (2.84) | 0.05 | (1.80) | 2.38 | (1.82) | 3.67 | (1.35)** |
| Social capital, 2005 (logged)[2] | 2.75 | (1.01)* | 1.29 | (0.70) | 0.93 | (1.10) | -0.06 | (0.85) |
| Fixed Effect Intercept | 47.68 | (2.96)*** | 48.41 | (2.36)*** | 61.26 | (3.20)*** | 56.48 | (3.14)*** |
| State-Level Variance | 6.65 | (5.11) | 11.97 | (6.39)* | 20.30 | (9.29)* | 9.48 | (4.90)* |
| County-Level Variance | 91.89 | (6.75)*** | 112.84 | (6.37)*** | 160.20 | (9.62)*** | 280.48 | (11.51)*** |
| County N | 435 | | 720 | | 628 | | 1246 | |
| State N | 39 | | 47 | | 45 | | 44 | |

***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2000), percent non-Hispanic white (2000), percent foreign born (2000), percent veteran (2000), and state DAS mortality rate (1999-2001)

[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable. The economic and family distress coefficients are not directly comparable to the main analyses because they include slightly different variables (due to availability) than the indices for 2000.

[3]Large metro category combines large central and large fringe metro

Table A8. Results from Multivariate Random Effects Regression on County NH White DAS Mortality Rate (2011-15) in Nonmetropolitan Counties by 2015 ERS Economic Dependency Category
(Using predictor variables that temporally overlap with mortality rates)

| | Farming | Mining | Manufacturing | Public Sector | Recreation | Non-Specialized |
|---|---|---|---|---|---|---|
| Predictor[1] | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) | β (SE) |
| Economic distress, 2011-15[2] | 4.64* | 7.51** | 0.17 | 6.82*** | 5.53** | 4.87*** |
| | (2.04) | (2.42) | (1.47) | (1.97) | (2.04) | (1.22) |
| Family distress, 2011-15[2] | 2.41* | -2.78 | 5.02*** | 3.92* | 2.85 | 3.44*** |
| | (1.18) | (2.13) | (1.03) | (1.65) | (1.66) | (0.86) |
| Persistent population loss, 1990-2010 | 0.72 | 14.53*** | 1.69 | 5.56 | -1.12 | 3.56 |
| | (2.46) | (4.17) | (2.20) | (4.98) | (5.83) | (1.95) |
| Social capital, 2005 (logged) [2] | 0.40 | -5.16 | -0.53 | 3.27 | -1.04 | 1.05 |
| | (1.56) | (2.71) | (1.49) | (1.90) | (1.93) | (1.31) |
| Fixed Effect Intercept | 47.79*** | 56.56*** | 48.43*** | 51.18*** | 56.50*** | 56.96*** |
| | (3.73) | -(6.66) | (2.66) | (4.62) | (5.70) | (2.63) |
| State-Level Variance | 19.48 | 0.00 | 18.54* | 34.86 | 98.34** | 43.56** |
| | (16.69) | (0.00) | (10.38) | (26.87) | (37.73) | (16.93) |
| County-Level Variance | 302.48 | 436.81*** | 150.92*** | 316.58*** | 191.72*** | 231.57*** |
| | (23.92) | -(49.46) | (12.25) | (34.80) | (21.21) | (14.46) |
| County N | 353 | 171 | 346 | 218 | 213 | 573 |
| State N | 30 | 25 | 31 | 40 | 38 | 44 |

***p<.001; **p<.01; *p<.05; two-tailed tests

[1]All models control for county age composition (2000), percent non-Hispanic white (2000), percent foreign born (2000), percent veteran (2000), and state DAS mortality rate (1999-2001)

[2]The economic distress, family distress, and social capital indices are standardized to have a mean of 0 and standard deviation of 1. The coefficients for those variables represent the change in the mortality rate for a 1 standard deviation increase in the predictor variable. The economic and family distress coefficients are not directly comparable to the main analyses because they include slightly different variables (due to availability) than the indices for 2000.

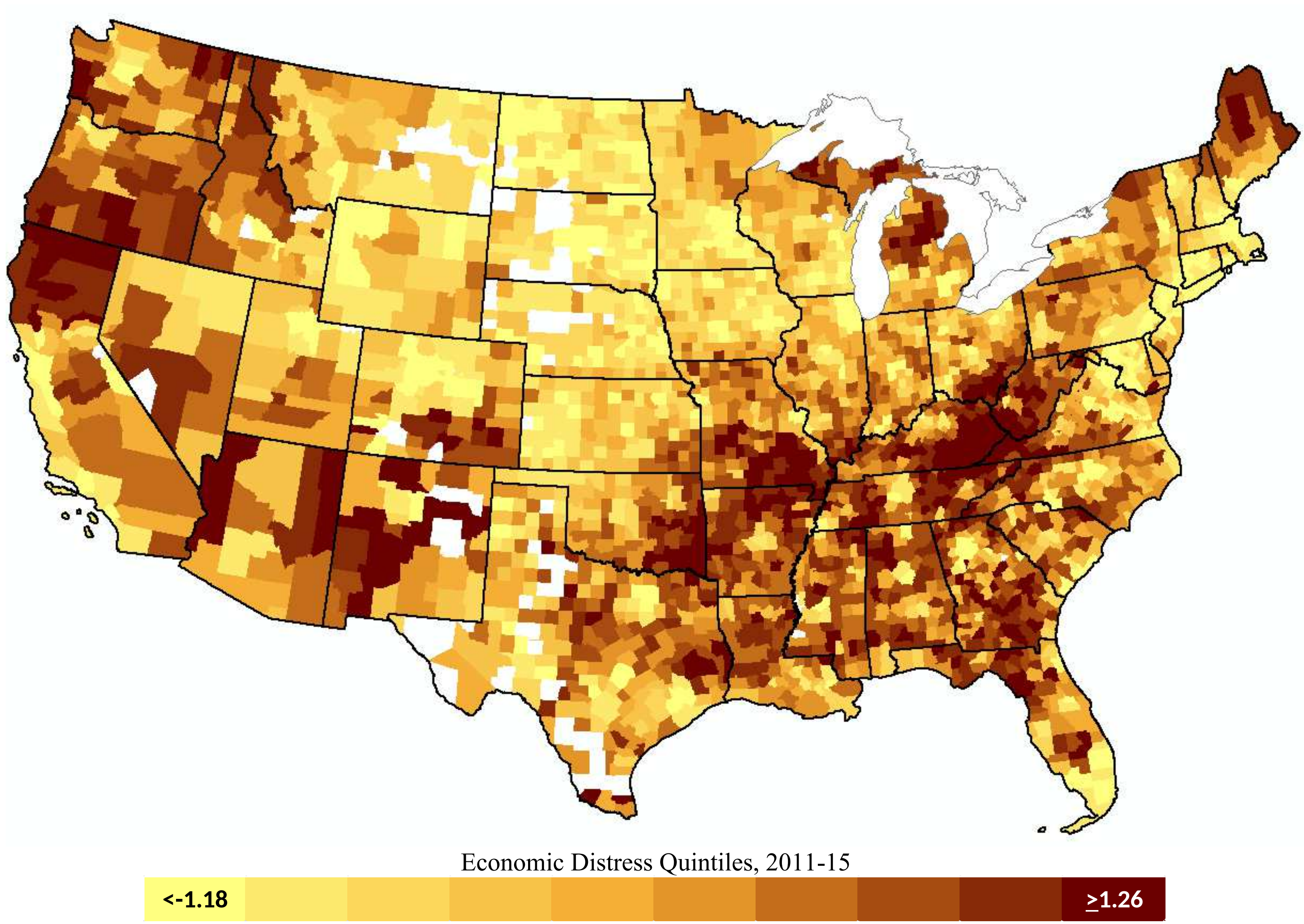



**Fig. A4. Non-Hispanic White Economic Distress, 2011-15**

*Note*: Excludes counties with fewer than 1,000 non-Hispanic white adults (age 18+)

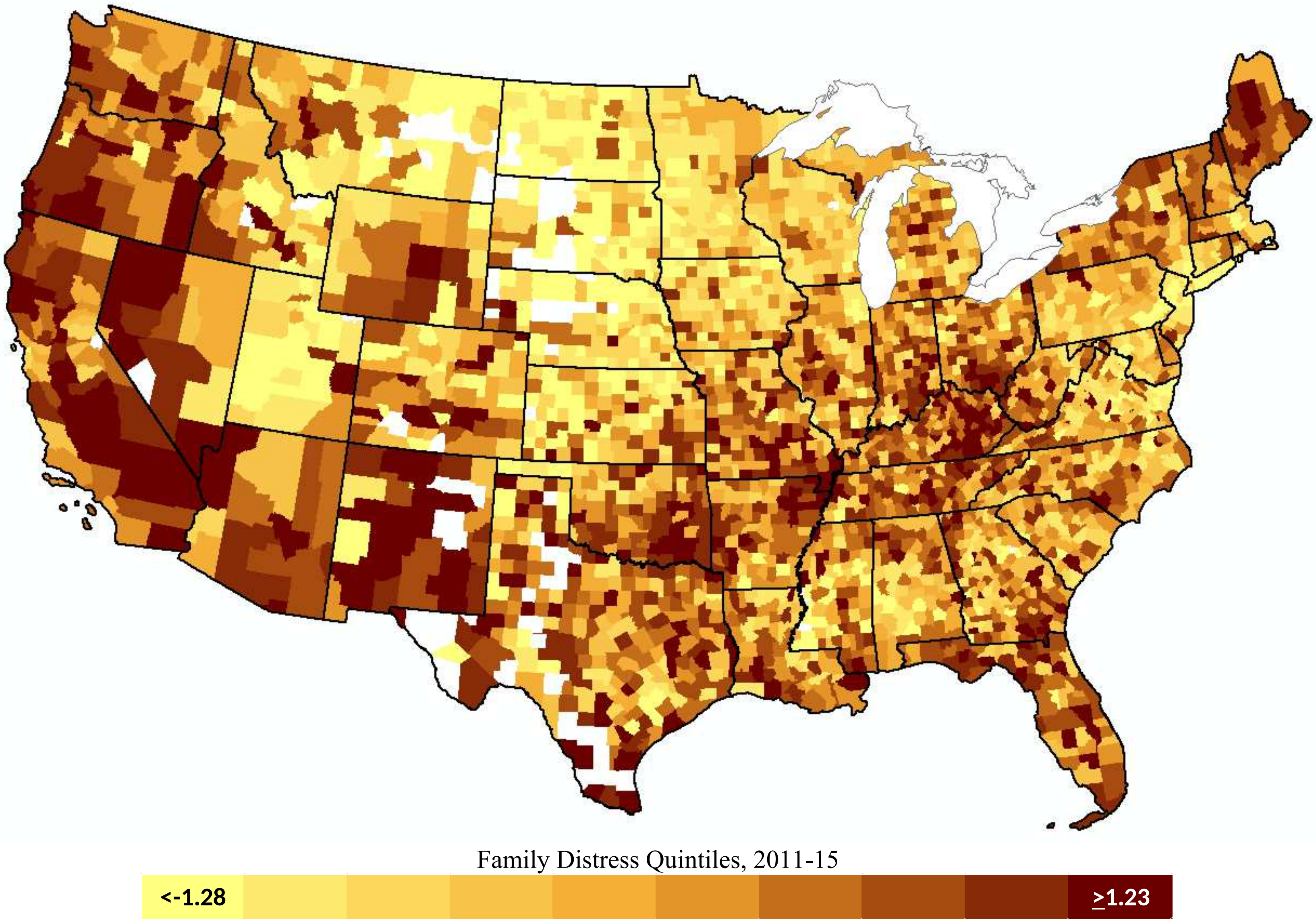



**Fig. A5. Non-Hispanic White Family Distress, 2011-15**

*Note*: Excludes counties with fewer than 1,000 non-Hispanic white adults (age 18+)