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Short Report

Socioeconomic variables explain rural disparities in US mortality rates: Implications for rural health research and policy

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ABSTRACT

Objectives: Rural disparities in age-adjusted mortality are growing in the United States. While socioeconomic variables have been found to explain significant variation in life expectancy across US counties, previous research has not examined the role of socioeconomic variables in explaining rural mortality disparities. The purpose of this study was to quantify the rural mortality disparity after controlling for socioeconomic variables.
Methods: Recursive partitioning, or tree regression, was used to fit models predicting premature mortality across counties in the United States, adjusted for age, median income, and percent in poverty in 4 time periods (from 2004 to 2012) with and without inclusion of an urban-rural variable.
Results: We found median income and percent in poverty explained about 50% of the variation in age-adjusted premature mortality rates across US counties in each of the four time periods. After controlling for these socioeconomic variables, rural mortality disparities largely disappeared, explaining less than 2% of the variance in premature mortality.
Conclusions: Addressing poverty and other socioeconomic issues should be a priority to improve health in rural communities. Interventions designed to target social determinants of health in rural areas are needed to address the growing rural mortality disparity that is largely explained by measures of poverty and income. Researchers examining rural health disparities should routinely include socioeconomic variables in their analyses.

Introduction

Despite decreasing mortality rates overall, rural health disparities are growing as mortality rates in rural areas have improved at a slower pace compared to improvements in urban areas of the United States (James, 2014). The gap between rural and urban counties in all-cause age-adjusted mortality rates grew significantly from 1969 to 2009 (Singh & Siahpush, 2014) when the rural-urban gap in life expectancy increased from 0.4 to 2.0 years (Singh & Siahpush, 2014). In 2017, the CDC published a Morbidity and Mortality Weekly Report Rural Health Series to examine these disparities and begin identifying public health actions to address them. They reported rural disparities in age-adjusted excess mortality (i.e., potentially preventable deaths) across the five leading causes of death – heart disease, cancer, unintentional injury, chronic lower respiratory disease, and stroke (Moy et al., 2017). Rural areas were also found to have a higher prevalence of smoking and lower prevalence of maintaining a normal body weight and meeting aerobic activity recommendations, behaviors that are related to health outcomes (Matthews et al., 2017). Rural areas were also found to have lower self-reported seat-belt use (Beck, Downs, Stevens, & Sauber-Schatz, 2017).

The CDC Rural Health Series has explored a variety of other factors that may contribute to rural mortality disparities. They found differences in healthcare services. For example, among women aged 18–64 who were enrolled in employer-sponsor health insurance, rural areas had lower rates of genetic testing for breast cancer gene mutations, which is important for prevention and treatment decisions, though the gap between rural and urban rates decreased from 2009 to 2014 (Kolor at al., 2017). In addition, 62% of rural counties did not have a diabetes self-management education (DSME) program – an evidence-based practice that improves diabetes management – compared with only 39% of urban counties. The CDC researchers found that rural counties with a higher number of persons with diabetes and those with a higher percent of the population with insurance were more likely to have a DSME program. Rural counties with a higher unemployment rate and those with a higher percent of the population with a high school education or less were less likely to have a DSME program (Rutledge, Masalovich, Blacher, & Saunders, 2017).

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The CDC has explored environmental exposures and found that residents in rural areas face greater occupational exposure to vapor-gas, dust, and fumes, in both agricultural and non-agricultural jobs (Doney et al., 2017). They also found that, while rural counties tend to have less air pollution (specifically less fine particulate matter – $PM_{2.5}$ – and ozone), they have worse water quality. Rural community water systems were found to have higher concentrations of Haloacetic Acids – HAA5 – and Total Trihalomethanes – TTHM (Strosnider, Kennedy, Monti, & Yip, 2017). Rural residents who do not have access to community water systems are also at risk. According to the CDC, at least 15% of the US population is not served by approved public water systems, but instead use individual systems not covered by the Safe Water Drinking Act. These individual systems common in rural areas can pose increased risk of both chemical and biological contaminants (Centers for Disease Control and Prevention). For example, well water consumption in rural California was found to be associated with Parkinson's Disease, likely due to contamination from pesticides (Gatto, Cockburn, Bronstein, Manthripragada, & Ritz, 2009). In addition, based on reports of outbreaks in Canada and the US, approximately 50% of all waterborne diseases occur in small non-community drinking water systems, and lack of adequate water treatment is a leading cause of outbreaks involving these small systems (Pons et al., 2015).

Thus, there are several factors that may contribute to higher excess mortality in rural areas, including differences in health-related behaviors, access to healthcare services, and environmental exposures. In an effort to identify the underlying drivers of health outcomes so that efforts can be made to reduce disparities, researchers are increasingly examining social determinants of health. Dwyer-Lindgren et al. recently reported that socioeconomic and race/ethnicity variables explain 60% of the variation in life expectancy across US counties (Dwyer-Lindgren et al., 2017). However, they did not examine the extent to which these variables explain rural-urban differences in mortality, and we could find no other published research that quantifies the impact of social determinants on rural mortality disparities. Therefore, the purpose of this study was to explore rural disparities in age-adjusted premature mortality, after controlling for socioeconomic variables.

Methods

County level data (n = 3138) were from the Area Health Resources Files from the U.S. Department of Health and Human Services and the County Health Rankings from the Robert Wood Johnson Foundation and the University of Wisconsin Population Health Institute. The primary outcome of interest was premature mortality, specifically years of potential life lost rate per 100,000. Deaths occurring prior to age 75 were considered premature. The primary predictor of interest was the National Center for Health Statistics Urban-Rural Classification Scheme for Counties, with median age, median income, and percent in poverty used as covariates. County median income and percent in poverty were from the Census Small Area Income and Poverty Estimates and Census American Community Survey respectively. Median age from the 2010 U.S. Census was used to age-adjust all models.

Recursive partitioning, or tree regression, was performed using JMP Pro 12 to fit models predicting premature mortality. This approach was used because of nonlinear relationships between the independent variables and the outcome, collinearity observed between many of the independent variables and potentially important interaction terms. To prevent overfitting of the model, excluded row validation was used by withholding a random 30% of the data to use as a validation set. The model was considered complete and no additional branches were added when the model fit using the training data and the model fit using the validation data began to diverge. The model fit was evaluated using R^2.

Models were fit to predict premature mortality in 4 different year ranges; 2004-06, 2006-08, 2008-10, and 2010-12. For each range, models were fit with and without including the Urban-Rural Classification variable. The difference in R^2 between the models with and without the Urban-Rural Classification variable was used to explain the amount of variance in the response explained by the classification variable. Each model was fit 5 times and then averaged because recursive partitioning is highly sensitive to the training dataset.

Table 1
Model R^2 by year and variables included.

Year	2004–06	2006–08	2008–10	2010–12
Without Urban-Rural Code	0.5050	0.5395	0.5382	0.4961
With Urban-Rural Code	0.5230	0.5498	0.5415	0.4997
Increase in R^2	0.0180	0.0102	0.0034	0.0036

Results

In every tree regression model built, the first split was on either of the two socioeconomic status variables, with the majority being first split on median income. This indicates the importance of socioeconomic status in explaining differences in premature mortality. The results are summarized in Table 1. In each year range examined, the model without the Urban-Rural Classification variable explained around 50% of the variance in premature mortality, and the addition of this variable increased the amount of variance explained. However, this increase was always less than 2%. The amount of variance explained by the rural-urban variable is small relative to the total amount of variance explained by the socioeconomic variables in the model. Also observed is that the increase in variance explained by the county rural-urban classification decreases as time progresses.

Discussion

The unique contribution of a rural-urban variable in accounting for variation in premature mortality, after controlling for age and socioeconomic status, was very small – less than 2% – across all four time periods. This indicates that the large majority of the rural disparity in the United States, at least in mortality rates, is explained by differences in socioeconomic variables. Our finding that socioeconomic variables explain approximately 50% of the variance in premature mortality in the US is consistent with previous research (Dwyer-Lindgren et al., 2017). Our research adds to this previous work by demonstrating that rural disparities largely disappear after controlling for socioeconomic variables. Addressing the social determinants of health as the root cause of rural health disparities is likely to be more effective than interventions targeting the healthcare system, given that "health care is a necessary but insufficient prerequisite for health equity" (page 986) (Woolf, 2017).

Previous research supports the effectiveness of interventions targeting social determinants of health, including those that address education, community development, poverty and employment (Thornton et al., 2016). However, interventions that include rural residents are needed as this is a "less well-studied" population (Purnell et al., 2016). For example, research has found that, although rural students are less likely to attain a bachelor's degree relative to non-rural students, community social resources increase the likelihood of attaining this degree (Byun, Meece, & Irvin, 2012). Interventions increasing these resources in rural areas might reduce the socioeconomic barriers that contribute to poor health outcomes. Education may be a good target because the association between socioeconomic variables and life expectancy has been found to be mostly mediated through behavioral and metabolic risk factors (Dwyer-Lindgren et al., 2017), and schools have been identified as an important target for health-related behavior interventions in rural areas (Meyer et al., 2016). Additional research on policy and environmental strategies to prevent obesity in rural communities is needed for both physical activity (Meyer et al., 2016) and nutrition (Calancie et al., 2015;). Our research also

supports previous calls for research on the economic impact of increasing access to local foods in rural communities to reduce risk of obesity (Calancie et al., 2015;).

Although the rural disparity in premature mortality, independent of age and socioeconomic status, is small, it is nevertheless worthy of further exploration. Mortality due to specific causes and other health outcomes should be studied to determine the relative impact of socioeconomic variables at a more granular level to better target interventions. For example, additional research is needed to understand the barriers to implementation and use of programs such as the diabetes self-management education program in rural areas (Rutledge et al., 2017). In addition, much work is needed to better understand and address the environmental exposures that put rural residents at risk. Previous research has shown that farmers, a rural sub-group with lower overall mortality rate relative to the general population, have higher rates of certain cancers (Waggoner et al., 2010). The CDC has found that rural residents in both agricultural and non-agricultural jobs face significant respiratory disease risk from occupational exposure (Doney et al., 2017).

Finally, given the importance of health-related behaviors in mediating the relationship between socioeconomic variables and life expectancy across settings (Dwyer-Lindgren et al., 2017), additional research is needed to explore potential differences between rural and urban populations that drive health-related behaviors among those who are socially and economically disadvantaged. Some researchers have suggested that culture is a key variable that impacts health behaviors differently for rural versus urban communities (Hartley, 2004; Farmer et al., 2012; Gessert et al., 2015). For example, while rural populations tend to value independence and self-sufficiency, they also tend to be more stoic and fatalistic about health and disease relative to urban populations (Gessert et al., 2015). These values may impact the effectiveness of educational and environmental interventions in the adoption of healthy lifestyles and use of healthcare services in rural areas. A key challenge to progress in this research is the measurement of culture (Farmer et al., 2012; Gessert et al., 2015). While preliminary results indicate that dimensions of community culture predict health status, more research is needed to determine if and how these relationships differentially impact health and mortality in rural versus urban settings (Pellegrin & Nigg, 2017).

Conclusions

Given the importance of socioeconomic variables in explaining rural health disparities, research examining differences in health outcomes by rural-urban level should routinely include and, where appropriate, control for these variables. From a public health program and policy perspective, tackling poverty and the other social determinants that impact health should be a primary focus for reducing premature mortality in rural areas. Such interventions are likely to be more effective in addressing rural health disparities than those focused on health system factors, such as healthcare access and quality.

Ethics statement

We did not collect data from human subjects. We used publicly available county-level data in this study.

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