Are rural places less safe for motorists? Definitions of urban and rural to understand road safety disparities

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ABSTRACT
The objectives of the study are to understand road safety within the context of regional development processes and to assess how urban–rural categories represent differences in motor vehicle occupant fatality risk. We analysed 2015 motor vehicle occupant deaths in Wisconsin from 2010 to 2014, using three definitions of urban–rural continua and negative binomial regression to adjust for population density, travel exposure and the proportion of teen residents. Rural–Urban Commuting Area codes, Beale codes and the Census definition of urban and rural places do not explain differences in urban and rural transportation fatality rates when controlling for population density. Although it is widely believed that rural places are uniquely dangerous for motorised travel, this understanding may be an artefact of inaccurate constructs. Instead, population density is a more helpful way to represent transportation hazards across different types of settlement patterns, including commuter suburbs and exurbs.

INTRODUCTION
In the USA, in 2013, the fatality rate per 100 million vehicle-miles of travel (VMT) was 2.6 times higher in rural areas than in urban areas.[1] Explanations for this disparity focus on two aspects of transportation injury risk: (1) behavioural factors such as speeding, alcohol consumption and seat belt use and (2) environmental factors such as infrastructure design and lack of access to trauma centres.[1–3]

Yet, previous research about rurality reminds us that rural places and populations are heterogeneous, that there is no agreed-on definition of rurality and that a simple urban–rural dichotomy, if invalid, prevents research and practice from addressing the underlying urban development factors that influence population health.[4–6] For example, 'rural' places include traditional small towns that may be as safe as 'urban' places with similar built environments. Similarly, 'urban' places include zones of sparse development and natural landscapes that resemble rural places. To better capture this diversity of rurality, and to include the full spectrum of urban places (eg, commuter suburbs and exurbs), we used different definitions of urban–rural continua to explore whether using more specific categories would identify which types of rural places are uniquely hazardous for travel compared with their urban counterparts.

A key aspect of this analysis is that we adjusted for population density, in addition to using urban–rural categories. Although population density is central to economic theory of urbanisation, many operational definitions of urban and rural places do not explicitly include it as a criterion. The US Census does include population density as a criterion, and sets 1000 persons per square mile as a starting point for inclusion in an urban area, but this definition does not reflect heterogeneity in population density within the category. Our framework allows us to account for hazards that associate with population density across the landscape such as high travel speeds, unsafe infrastructure design and higher travel distances (exposure), which we posit are relevant risk factors across the entire urban–rural continuum.[7–10] Thus, this analysis brings together questions of sprawl and rurality into a general framework, which is necessary because the transportation injury risks associated with urbanisation patterns do not stop at the metropolitan edge.

METHODS
Our sample included all populated census tracts (N=1392) for the US state of Wisconsin. We classified each census tract according to two different definitions of urban–rural continua, each one capturing a specific aspect of rurality. The first continuum is based on Rural–Urban Commuting Area (RUCA) codes that reflect commuting patterns and economic relationships across places.[11] For instance, a place may be located outside of a large metropolitan area, but if a significant proportion of its population commutes to work inside the metropolitan area, this place is considered more urban than rural. The second continuum is based on a classification system designed by Chi and Marcouiller[12] to study urbanisation processes in Wisconsin. This classification system, which we refer to as the modified Beale code, describes urban and rural places as they would be perceived by urban migrants; it distinguishes between metropolitan and non-metropolitan areas, and further classifies each area by the size of its population centres. In addition to these two continua, we analysed differences in fatality rates using the Census definition of rural and urban areas. McAndrews *et al*., 2016 provides further discussion of these operation definitions of urban-rural continua.[13]

We used a negative binomial model with a log-link function to estimate motor vehicle occupant fatality rates for each level of the urban–rural continuum, which was included as a categorical variable. We specified the model based on theoretical relationships, prior empirical research, bivariate relationships between motor vehicle occupant fatality rates and potential independent variables, and the Akaike information criterion (AIC) as a measure of model fit.

In addition to the log transformation of population density, we controlled for other independent variables that are hypothesised to influence motor vehicle occupant fatality rates. Traditionally, VMT is used to represent exposure, but population density already captures information about travel distances and is highly correlated with VMT (correlation coefficient (r)= −0.7 for our data). Therefore, we controlled for travel using the average daily number of trips per household in each census tract, which is less correlated with the distance of travel. We also controlled for the proportion of the population aged 16–19, representing teen drivers with higher injury risk. We initially considered median household income and the proportion of the population over age 65 as potential explanatory variables that could explain differences in urban and rural transportation fatality rates, but we did not include them in the final model because their associations with fatality rates were not statistically significant.

We used police-reported crash and fatality data for 2010–2014, collected at the state level and reported nationally with the Fatality Analysis Reporting System.[14] We geocoded motor vehicle occupant fatalities based on the location of the crash. We manually assigned two fatalities to their nearest census tract, because their locations fell outside the census tract boundaries. We used 2010 census tract boundaries and population density estimates from the US Census. Population (exposure) estimates are from the US Census for 2010, 2012, 2013 and 2014.[15] We constructed the 2011 population estimate as the midpoint between 2010 and 2012 population for each tract. Estimates of average daily household motor vehicle trips are from the US Bureau of Transportation Statistics.[16]

RESULTS

Unadjusted fatality rates increased from about 10 per 100 000 population in the most urban zone to about 20 in the most rural zone (figure 1). This pattern was similar for the RUCA and modified Beale code definitions; the rural fatality rate was lower with the Census definition, 16 per 100 000 population.

After controlling for population density, household trips and proportion of teen population, rural census tracts had lower fatality rates compared with urban census tracts, but this was statistically significant for only levels 3 and 4 of the modified Beale code continuum. The rate ratios for these levels were 0.84 (95% CI 0.7 to 1.0) and 0.82 (95% CI 0.7 to 0.9), respectively (figure 1).

For the urban–rural continuum based on the RUCA code definition, census tracts with high levels of commuting that are located outside of core metro areas had a rate ratio 1.5 times (95% CI 1.2 to 2.0) the adjusted fatality rate of the most rural census tracts. These higher risk exurban tracts were coded as RUCA 2.0, 2.1, 3.0, 4.1, 4.1, 5.1, 5.2 and 6.1.

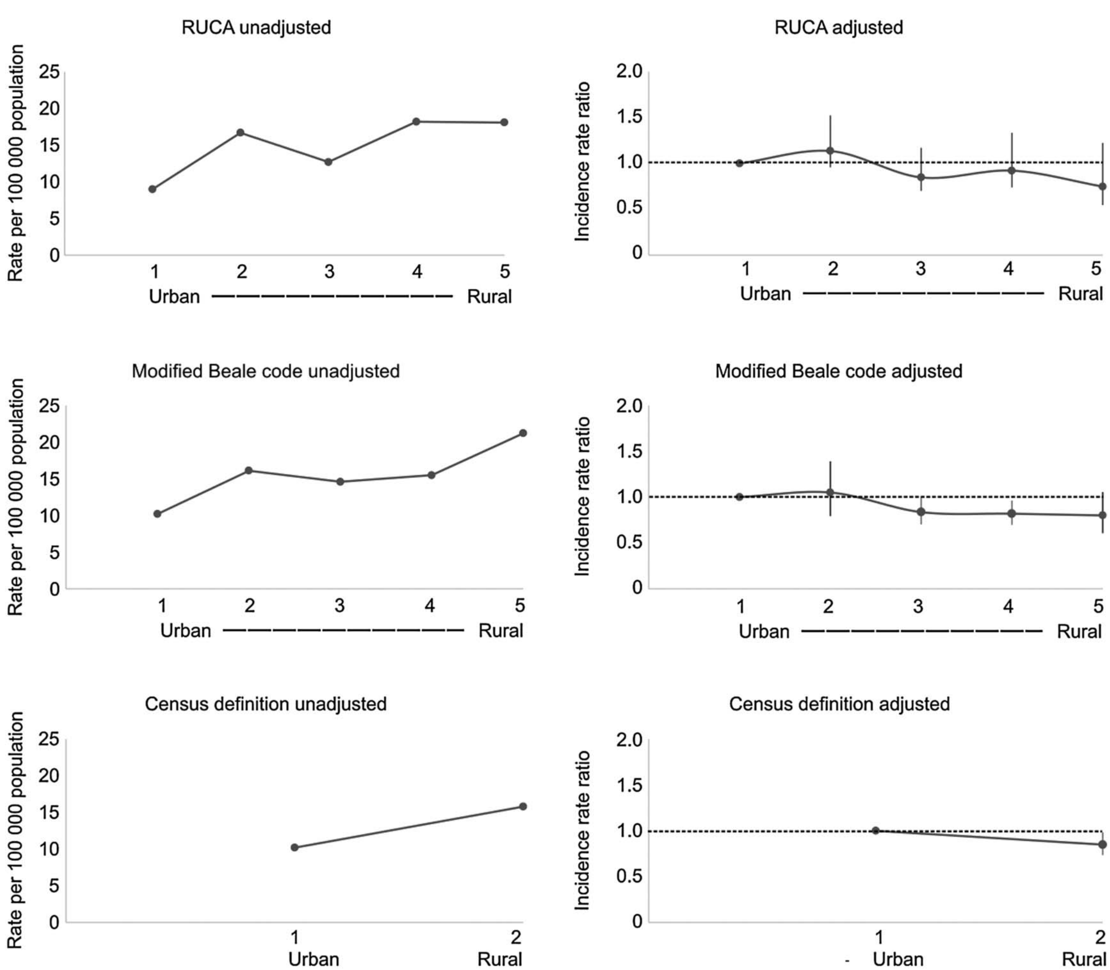

Figure 1 Unadjusted and regression-adjusted motor vehicle occupant fatality rates by urban–rural zone, Wisconsin, 2010–2014. RUCA, rural–urban commuting area.

The parameter estimates for population density and the proportion of teens in the population were significant in all three models ($p<0.0001$ for all); population density had a negative association with motor vehicle occupant fatality rates, and the proportion of teens in the population had a position association. Mean household daily trips had a negative association with fatality rates in all three models, but the parameter estimate was statistically significant only for the RUCA continuum ($p=0.033$ for the RUCA; $p=0.125$ for the modified Beale code; $p=0.226$ for the Census definition). Travel behaviour in Wisconsin may not vary much across different built environment settings, and the relationship between household trips and motor vehicle occupant fatality rates may be stronger for regions with more diverse transportation systems.

DISCUSSION AND CONCLUSIONS

Although it is widely believed that 'rural' places are uniquely dangerous for motorised travel, this understanding may be an artefact of inaccurate constructs. Instead, when controlling for population density (and therefore indirectly controlling for risk factors such as speed and infrastructure design), rural places are similar to urban places, and may even be safer. Population density is a more helpful way to represent transportation hazards across different types of settlement patterns, and it does a better job including suburban and exurban developments that have received less attention from policy and practice. This dilemma with operational definitions of urban and rural places in the context of injury prevention is consistent with a prior study of adolescent smoking and drinking behaviour in which the choice of operational definitions of places influenced estimates of health outcomes and behaviours in meaningful ways.[17]

Operational definitions of urban–rural continua are important for transportation safety research and practice because they enable us to characterise what people and places have higher injury risk, and therefore they also enable the prioritisation of investment and intervention. For the specific case of injury prevention practice, professionals have started to revise the definitions of urban and rural to reflect practical needs. For instance, in Minnesota, emergency medical service providers customised the definition of urban and rural places to more accurately reflect the actual costs of providing service. Also, the state of Indiana revised the way it categorises the locations of where transportation crashes occur (urban, suburban, exurban and rural).[18 19] The strength of this study is that we leveraged differences in the operational definitions of urban and rural continua to clarify their utility for transportation injury prevention across different types of settlement patterns. The results suggest that 'rural' places are not uniquely hazardous compared with more 'urban' places when accounting for settlement patterns—as represented by population density. The study area included the diverse urban–rural landscape of Wisconsin, but future work should test this framework for other geographical regions. In addition, future work should include direct measurement of the built environment and travel speeds to identify what facets of population density contribute to transportation injury risk.

Instead of understanding transportation hazards through the lens of the urban–rural dichotomy, injury prevention research, policy and programming can use population density, or similar objective measures, to understand and respond to specific hazards across a range of environments. This would enable road safety decision making to account for the consequences of regional development that influence the distribution of transportation injury risk.

What is already known on the subject

- There is an inverse relationship between population density and motor vehicle occupant fatality rates.
- Motor vehicle occupant fatality rates for rural places in the USA are more than two times those of urban places.

What this study adds

- Although it is widely believed that rural places are uniquely dangerous for motorised travel, this understanding may be an artefact of inaccurate constructs.
- Urban–rural differences in motor vehicle occupant fatality rates disappear when controlling for population density.
- Commuter suburbs and exurban places exhibit relatively high motor vehicle occupant fatality rates after adjusting for population density.
- Safety research and practice need updated constructs that better reflect true risk of existing and future settlement patterns.

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Competing interests None declared.

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Rural–urban differences in seat belt use among adults

Compared with urban residents, rural residents are at an increased risk for death from car crashes and are less likely to wear seat belts. Self-reported seat belt use ranges from 88.8% in the most urban counties to 74.7% in the most rural counties. Similar differences in age-adjusted death rates and seat belt use were observed in states with primary and secondary seat belt enforcement laws. However, enforcement also varies by state. The small percentage of drivers who do not always use seat belts account for almost half of all occupant deaths.