How do the definitions of urban and rural matter for transportation safety? Re-interpreting transportation fatalities as an outcome of regional development processes

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\textbf{A B S T R A C T}

Urban and rural places are integrated through economic ties and population flows. Despite their integration, most studies of road safety dichotomize urban and rural places, and studies have consistently demonstrated that rural places are more dangerous for motorists than urban places. Our study investigates whether these findings are sensitive to the definition of urban and rural. We use three different definitions of urban-rural continua to quantify and compare motor vehicle occupant fatality rates per person-trip and person-mile for the state of Wisconsin. The three urban-rural continua are defined by: (1) popular impressions of urban, suburban, and rural places using a system from regional economics; (2) population density; and (3) the intensity of commute flows to core urbanized areas. In this analysis, the three definitions captured different people and places within each continuum level, highlighting rural heterogeneity. Despite this heterogeneity, the three definitions resulted in similar fatality rate gradients, suggesting a potentially latent “rural” characteristic. We then used field observations of urban–rural transects to refine the definitions. When accounting for the presence of higher-density towns and villages in rural places, we found that low-density urban places such as suburbs and exurbs have fatality rates more similar to those in rural places. These findings support the need to understand road safety within the context of regional development processes instead of urban–rural categories.

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\textbf{1. Introduction}

The idea that rural places are dangerous for travel is well accepted, and the transportation injury record tends to support this claim (Blatt and Furman, 1998). For example, in 2012, 19% of the US population lived in rural areas but these areas accounted for 54% of all traffic fatalities (National Highway Traffic Safety Administration, 2014). In the UK, 70% of all traffic fatalities occurred on rural roads, and the figure is similar for Canada (The Royal Society for the Prevention of Accidents, 2010; Transport Canada, 2011). Explanations of urban-rural road safety disparities focus on dangerous roads, behavioral factors, delays in emergency medical care, and differences in law enforcement. In the US, explanations also posit class-based rural stereotypes of risk-taking behavior such as speeding, alcohol consumption, and not using seat belts.

Yet, there is no agreed-upon definition of “rural” and “urban” places, and applying a simple urban-rural dichotomy can conceal their complexity in ways that matter for transportation safety analysis. For instance, during the past several decades in the US, urban residents have relocated to non-urbanized areas, beyond suburbs, that are rich in natural and recreational amenities (Johnson, 1999). The changing composition of rural populations contradicts the argument that intrinsic behavioral and cultural characteristics of “rural” residents are a primary cause of transportation injury. This problem supports further investigation of the interaction of road safety outcomes with spatial, social, economic, and demographic factors.

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Our central question is whether transportation fatality differentials are sensitive to the definition of “rural.” To answer this question, we compared urban–rural transportation fatality rate gradients for three definitions of urban–rural continua that are used in the fields of regional studies, transportation, and public health.

2. Background and literature about rural places and rural road safety

2.1. Urban-Rural transportation injury disparities

The larger problem of rural health disparities provides a broader context for this research about rural road safety. Compared to their urban counterparts, populations in rural counties in the US are more likely to have higher rates of adolescent and adult smoking, alcohol consumption, obesity, physical inactivity, infant mortality, child and young adult mortality, serious mental illness, unintentional injury, and suicide per capita (Meit et al., 2014). There are often regional variations in urban–rural health disparities, and different ways in which local cultural, community, environmental, and economic factors contribute to them (Hartley, 2004). Yet, even when accounting for local context, rural social workers have asserted that rural populations should be considered a vulnerable group because of high poverty rates, low opportunity, educational disparities, and social stigma (Riebschleger, 2007).

Rural populations in the US also have disproportionately high rates of injury, including those due to motor vehicle crashes. An extensive literature exists about the factors contributing to high transportation injury rates in rural areas. These factors include, but are not limited to:

- Lack of investment in general and trauma-related health care resources and training in rural areas to successfully treat transportation injuries (Rutledge et al., 1994);
- Delay in crash discovery and emergency medical care (MacKenzie et al., 2006; National Highway Traffic Safety Administration, 2005, 2012);
- Road design characteristics such as two-lane highways, lack of shoulders, and limited sight distance (National Highway Traffic Safety Administration, 2005; Tay, 2015);
- High travel speeds and high speed limits (National Highway Traffic Safety Administration, 2005, 2014);
- Risk-taking behaviors such as alcohol consumption and lower seat belt and child restraint use (National Highway Traffic Safety Administration, 2005, 2014; Rakauskas et al., 2009; Ward, 2007; Donaldson et al., 2006); and
- Lack of safety-related law enforcement (Peek-Asa et al., 2004).

Taken together, this literature suggests two root causes of rural transportation injury. The first is environmental: rural road infrastructure lacks sufficient protection, travel speeds are high, and emergency medical services and trauma care in low-density areas are limited. The second root cause is behavioral: people who live in rural areas exhibit more risk-taking behaviors.

2.2. Reasons to reconsider the rural road safety framework

Despite the clear evidence of urban–rural health and safety disparities, there are reasons to reconsider the idea that rural populations are a disadvantaged group with a cohesive set of transportation safety vulnerabilities. Research about rural health has called attention to the variation in health outcomes and behaviors among rural residents. For example, a literature review of urban-rural health disparities that included studies from Australia, New Zealand, Canada, the US, the UK, and certain western European countries, did not find a consistent pattern in urban–rural differences in health outcomes. In addition to variation across countries, the review found that the “intra-rural health differential can be as pronounced as those between rural and urban areas” (Smith et al., 2008).

Similarly, with respect to injury risk factors, Zwerling et al. (2005) found that behavioral risk factors for injury are not uniformly distributed among rural residents. Residents of Keokuk County, Iowa (n = 1583) varied in their likelihood of wearing seat belts, consuming alcohol, firing a gun, driving an all-terrain vehicle, and riding a bike depending on their gender and residential location (whether they lived in town, in the country, or on a farm).

Literature from rural studies and regional science offers additional reasons to reframe the problem of rural health disparities. During the past 30 years rural populations and landscapes have transformed as a result of increasing peri-urban employment and housing, changes in agricultural production, and tourism-based economic development strategies (Johnson, 1999; Fuguit, 1995; Beale and Johnson, 1998; Johnson and Beale, 2002; Ottone, 2006; Chi and Marcouiller, 2012). Such changes result in the conversion of forest and agricultural lands into commercial, residential, and recreational land uses, and major roads are often the “point of entry” for this type of development (Ottone, 2006; Chi and Marcouiller, 2012). Therefore, in facilitating larger economic and demographic phenomena, travel behavior, traffic patterns, and road infrastructure may also change in ways that matter for safety outcomes.

2.3. Implications for rural road safety research

The operational definition of “rural” is also an important facet of the validity of research about rural places (Hart et al., 2005; Hall et al., 2006). For instance, a study of the prevalence of teenage smoking behavior in urban, suburban, and rural places compared four different operational definitions of urban and rural, and found that the estimates of smoking prevalence depended on which definition was used (Brady and Weitzman, 2007).

Outside of research, road safety and emergency medicine professionals have been revising the urban–rural dichotomy to reflect contemporary needs. The state of Indiana created a new place-based categorization of transportation injuries (urban, suburban, exurban, and rural) based on a location’s distance from core urban areas (Newby, 2011). Emergency medical service providers in Minnesota created a new definition of rural places that aligned with the actual costs of providing emergency medical service (Rural Health Resource Center, 2004). These examples demonstrate a practical need to define rural in ways that capture underlying spatial, social, and functional relationships.

3. Data and methods

3.1. Study area

The study area is the state of Wisconsin (population 5.7 million) in the United States and the study period is from 2001 to 2009 (US Census, 2016). Wisconsin has important large and small urban regions, as well as significant rural industrial and agricultural economies and natural resources. Wisconsin’s population continues to urbanize, and the fastest growing areas of development are located at the edge of the region’s larger cities (Wisconsin Department of Natural Resources, 2006).

3.2. Metrics to define urban-rural continua

Because “urban” and “rural” are social constructs, we need to convert them into operational definitions for this analysis. Our
The selection of operational definitions is informed by attributes of place that are associated with transportation safety hazards and exposure to them (Hartley, 2004; Hart et al., 2005; Hall et al., 2006). For this analysis, we use three definitions of urban-rural continua based on: (1) a system from regional economics designed to represent popular impressions of urban, suburban, and rural places; (2) population density; and (3) the intensity of commute flows to core urbanized areas (see Fig. 1).

Each of the three urban–rural continuum definitions has six levels and the first and most urban level is held constant to represent the city of Milwaukee (excluding its suburbs), Wisconsin’s largest city. We defined the most urban level this way because over 70% of Wisconsin’s African-American population lives in Milwaukee, and the population’s experience of segregation and poverty is closely tied with transportation, land use, and health disparities, including transportation injury (Wisconsin Department of Health and Human Services, 2008). Beyond Milwaukee, the other five levels of the continuum intuitively correspond to (2) urban places (not Milwaukee); (3) suburban places; (4) peri-urban places adjacent to rural places; (5) rural exurban places; and (6) remote rural places.

We applied these definitions by classifying each ZIP Code Tabulation Area (ZCTA) in Wisconsin into one of the six categories, based on the characteristics of the ZCTA. We use ZCTAs because they are the smallest geographic unit for which we can combine administrative safety, travel, and population data. We constructed the continua to have roughly the same number of residents per level across the three definitions. The exact composition of these populations varies according to how the ZCTAs are distributed within each definition.

3.2.2. Definition 2: population density

The second urban–rural continuum definition we apply is based on population density. Population density is relevant to road safety because places that are nominally rural may also include towns and villages with relatively high population densities. In Wisconsin, many towns and villages were built before motorization and have built environments that are similar to those found in urban places that were also developed before mass motorization.

We used the 2000 US Census to calculate population density for each ZCTA in the study area based on total population and land area. We determined the cutoff points for each level in this continuum by making each level’s population equal to the corresponding level in the modified Beale code created by Chi and Marcouiller.

3.2.3. Definition 3: commute flows

The third urban–rural continuum definition we apply is based on commute flows into urban areas. Commute flows are represented by Rural-Urban Commuting Area (RUCA) codes (WWAMI RUCA Rural Health Resource Center, 2016). RUCA codes indicate
underlying functional and economic relationships between places, primarily the relationship between the location of jobs and housing in regions. In addition, RUCA codes reflect the economic integration of places, but not necessarily their urban form. This is important for safety analysis because this definition represents socio-economic aspects of places that may not be expressed by characteristics of the physical environment.

The RUCA system includes 33 categories that can be aggregated. We aggregated RUCA according to the quantity of people commuting to urbanized areas and the size of the urbanized area as defined by the RUCA system.

3.3. Safety and transportation data

Safety data are from the Fatality Analysis Reporting System (FARS), a national database of police-reported transportation fatalities. We used a geographic information system to spatially join these accident data with the ZCTA polygons. In this analysis we focus on fatalities as an important subset of all motor vehicle crashes. Prior research has shown that urban-rural differences in motor vehicle safety are driven by differences in fatal injury rather than the crash injury rate or the crash incidence density (Zwerling et al., 2005).

The source of travel information is the 2001 Wisconsin Add-On to the National Household Travel Survey (NHTS). The Wisconsin add-on has a uniquely large sample size: an unweighted sample of 17,000 households and 160,000 unlinked person trips. With respect to creating representative estimates of motor vehicle travel across the urban-rural continuum, the survey’s sampling strategy was designed to represent travel for the entire state as well as for ten regions within it, and these estimates account for survey non-response bias. In addition, the sampling frame was constructed such that urban and rural travel patterns could be compared (Proussaloglou et al., 2004).

The most rural levels of the different continua have the fewest survey respondents: \( N_{\text{Rural}} = 248 \); \( N_{\text{Scale}} = 197 \); \( N_{\text{Density}} = 258 \). Our main assumption is that the travel patterns of these respondents can capture sufficient variation in travel in these most rural areas. The limitations of the survey’s ability to represent very rural populations is probably similar to those of recruiting other groups considered to be isolated, marginalized, or vulnerable, who are also underrepresented in other transportation data. Other levels of the urban–rural continua included more respondents, including about 551 for level 1 (Milwaukee) and between 2631 and 5990 for the other levels.

As an example of how travel patterns differ across the urban–rural continuum, Table 1 presents a summary of the motor vehicle travel data for Wisconsin residents organized by the RUCA code continuum. On average, residents in Milwaukee made the fewest trips by car (976 trips per capita), traveled the fewest miles per year (9475 miles per capita), and made shorter trips on average (9.7 miles per trip) than any other RUCA code category. Residents in rural adjacent places made the most trips per year by car (1325 trips), and those living in greater metropolitan areas traveled the most miles per year (16,495 miles per capita) and the most miles per trip (14.3 miles).

With respect to travelers’ exposure to different levels of the urban–rural continuum, Table 2 summarizes motor vehicle travel between urban and rural places based on the RUCA code continuum. The vast majority of a household’s travel occurs in places with the same RUCA code; the maximum was 96% in urban areas and the minimum was 75% in greater metropolitan areas. Households in Wisconsin’s greater metropolitan areas make about 20% of their trips in relatively more urban places and about five percent of their trips in relatively more rural places.

Because of the missing data for trip destinations (available for only 65% of observations), in this study we estimate representative travel by sex and age using the ZIP Code associated with each traveler’s residential location. Only 12 of approximately 17,000 households were missing ZIP Code information. The implication of this decision is that our estimates of exposure are likely high for rural places because rural residents are more likely to travel across the urban–rural continuum, but this is a conservative assumption because the bias reduces the differential between urban and rural places.

This study received human subjects review and approval from the Colorado Multiple Institutional Review Board. All computation was carried out in SAS 9.4 and QGIS 2.8.

3.4. Analytical methods

3.4.1. Agreement/disagreement of the ZCTAs included in each continuum

To assess whether the three definitions of urban–rural continua included different ZCTAs – and therefore different populations, fatality counts, and built environments – we used the weighted kappa coefficient and Krippendorff’s alpha indicators of agreement. Both metrics are commonly used to assess inter-rater reliability, and can be applied to ordinal data such as an urban–rural continuum.

The weighted kappa and Krippendorff’s alpha statistics take on values between −1 and 1. When the observed agreement among categories is greater than what would be expected by chance, the statistics are positive, and when there is systematic disagreement among categories the statistics are negative (Hayes and Krippendorff, 2007; Viera and Garrett, 2005). The difference between these two metrics is that the weighted kappa coefficient is calculated based only on levels of agreement, whereas Krippendorff’s alpha also accounts for disagreement across categories. We use two different metrics for comparison because there is no agreed-upon standard for such a measurement.

3.4.2. Field observation of the built environment

We were also interested in the experiential differences between the definitions of urban–rural continua. To “ground truth” the rurality or urbanicity of our case sites we visited the local public high school in the selected ZCTA and the school’s surrounding neighborhood. We selected public high schools because they are important civic places that we could compare across places. Only one ZCTA did not have a high school, and for this location we visited the primary school in the town. We carried out these observations in southeast Wisconsin and central Wisconsin, and Fig. 2 presents information about the sampled locations. We did field work in ZCTAs that had perfect agreement among all three definitions for a given level. We also carried out fieldwork in ZCTAs that fell into different categories within each of the three definitions (e.g., considered suburban, rural-adjacent, and rural remote).

3.4.3. Estimation of fatality rates per person-trip and person-mile of travel

Because we are interested in differences in transportation fatality risk across people and places that have different travel patterns, we estimated fatality rates using travel-based measures of exposure to account for these differences. This choice of exposure metrics is critical, both conceptually and analytically, because it ties the analysis to fundamental transportation and land use relationships that are captured in travel behavior, and that are known to vary based on social, demographic, and land use contexts. In contrast, transportation fatality rates based on population reflect the overall burden of transportation fatalities across the population, but they assume that all members of the population have the same
travel behavior on average (i.e., the same exposure to transportation hazards), and they do not represent the risk of travel.

To compare differences in transportation fatality risk across the three definitions of the urban-rural continua, we constructed fatality rate gradients for each definition. Because we have representative exposure information only for N = 6 we cannot use regression analysis to estimate incidence rates and instead we directly computed crude incidence rates for each level (Rothman and Greenland, 1998).

This approach presents us with two complications. First, because of the small number of injury events for certain populations (e.g., deaths in the most remote rural areas) confidence intervals around the rate cannot be estimated with the Poisson distribution. Instead, we calculated the 95% confidence intervals around the rates using the gamma distribution, which is appropriate for small numbers (Fay and Feuer, 1997). Second, these estimates include sampling variation in the exposure estimate (denominator). Therefore, we cannot assume that the uncertainty in the rate estimate comes only from the year-to-year variation in injury events. The solution is to use the first-order Taylor approximation for the variance of the rate (Beck et al., 2007; Fay, 1999). Therefore, the confidence interval estimates reflect the uncertainty arising from sampling variation in the travel survey as well as annual variation in the number of fatalities. We calculated the standard error of travel estimates using the replicate weights included in the NTHS survey data set.

Based on these methods, we are able to compare the rates for different levels of the urban-rural continua, and we can compare entire gradients between continua to assess whether there are statistically significant differences between urban and rural places, and between the different definitions. All of this could be done using regression analysis if one were to use population-based rates or other representative exposure measures for a larger N.

We used chi-squared tests to test the independence of the fatality rate gradients across the three definitions of urban-rural continua.

4. Results

4.1. The three definitions capture different people and places

The analysis of agreement and disagreement among the three definitions of urban-rural continua shows that, level-by-level, there is minimal systematic agreement across and between them (see Fig. 3). Agreement was highest for the “rural exurban” level [α = 0.21, 95% CI: 0.13–0.28] and for the “urban metropolitan” level [α = 0.17, 95% CI: 0.06–0.28], but no other categories had agreement statistically different from zero. This means that for each level,
these definitions of urban-rural continua capture different people and places, which is consistent with what is already known about the diversity of rural people and places. This finding is also consistent with the study by Brady and Weitzman (2007) that found that different urban/rural definitions captured different populations.

Agreement was highest when comparing all levels together across all three definitions \( [\alpha = 0.61, 95\% CI: 0.56–0.66] \). This value for alpha is approaching an “acceptable” level of agreement, which is in the range of \( \alpha \geq 0.67 \) for tentative conclusions and \( \alpha \geq 0.80 \) for drawing conclusions about legal decisions or issues with direct consequences for human lives (Krippendorff, 2004).

4.2. Fatality rate gradients are similar across the three definitions

Table 3 presents fatality rate gradients for male motor vehicle occupants. Although the three definitions of urban-rural continua included different people and places within each level, their fatality rate gradients per trip are similar to one another. This is also true for fatality rates per mile of travel, for women (not presented here), and for different age groups (not presented here). The similarity in the fatality rate gradients across the definitions suggests that motor vehicle occupant fatality rates increase with a latent factor present in all three definitions.

The results for the RUCA definition show a possible exception to this general pattern of fatality rates increasing with rurality. When fatality risk is measured per trip, people commuting from smaller towns to urbanized areas appear safer than people commuting from greater metropolitan areas (i.e., exurbs) to urbanized areas. However, this difference disappears when fatality rates are measured per mile of travel.

4.3. Fatality rate gradients differ when accounting for the presence of development

In our field observation, we found that land uses between school sites in the most rural levels of the continua were primarily agricultural and we encountered fewer settlements between towns. In contrast, when a ZCTA was relatively urban compared to other surrounding ZCTAs we observed denser street networks and more intense land development (Fig. 4).

To account for this influence of development and the related land use, infrastructure, and activity differences, we stratified each
level within the three urban-rural continua by population density. We divided every category in each urban-rural continuum into two population density levels: an above-median level and a below-median level. Thus, each continuum expanded from six levels to 12 levels. Each new category comprises all of the ZCTAs meeting that category’s population density criterion.

Table 4 presents the fatality rates for male motor vehicle occupants per trip for each the urban-rural continuum definitions stratified by population density. The patterns are similar for fatality rates estimated with person-miles of travel and for women (fatality rates for women are consistently lower than those for men).

This analysis shows three tiers of fatality rates per trip for male motor vehicle occupants. Rates for Milwaukee, other urban places, and higher-density ZCTAs within greater metropolitan areas range from 4.2 to 9.2 fatalities per 100 million person-trips. Higher-density exurban environments have fatality rates between 11.9 and 20.3 fatalities per 100 million person-trips. Lower-density exurban environments and remote rural areas have fatality rates well over 20 fatalities per 100 million person-trips. Instead of representing a clearly defined urban-rural dichotomy, or a monotonic urban-rural gradient, these indicators show the instability of urban and rural definitions. Areas with mixed urban/rural characteristics have levels of transportation injury risk that are higher than the most urban places and lower than the most rural places (see Fig. 5).

5. Discussion and conclusions

The analysis shows that the three definitions of the urban-rural continua capture different people and places. However, despite representing different people and places, the three definitions nevertheless resulted in similar fatality rate gradients. The similarity of the rate gradients suggests the definitions captured a latent, but undefined, “rural” quality associated with transportation fatalities despite the imprecision of the definitions.

The settlement-adjusted definitions produced different results, and showed that transportation fatality rates in “rural” areas are relatively low in the presence of towns and villages. Similarly, transportation fatality rates are relatively high in low-density “urban” areas. These findings are consistent with road safety studies have used measures of population density and sprawl instead of an urban-rural dichotomy and found an association between population density and transportation fatality rates (Peek-Asa et al., 2004; Fischer et al., 2012; Ewing et al., 2003, 2014; Clark, 2003; Baker et al., 1987).

We propose that exurban settlement patterns, rather than nominally urban or rural places, are more central to the conversation about rural road safety than previously acknowledged. Above and beyond injury prevention, this study is an empirical example of how spatial factors such as regional development produce health disparities. We need to understand the relationships between health and place in a regional context because urban, suburban, exurban, and rural processes shape individual-level health outcomes (Oyypuk and Acevedo-Garcia, 2010).

To further interpret this finding and to relate it to functional causes of transportation injury, we consider three factors – high travel speeds, access to emergency medical services, and infrastructure design – that are known to contribute to the relationship between settlement patterns and transportation injury. These three factors may also interact in ways that are important for injury prevention.

5.1. Travel speed as a rational response to a transportation and land use problem

Speed is widely acknowledged as the source of harmful kinetic energy that influences both the risk and severity of transportation injury (Richter et al., 2006; Elvik et al., 2004). If the goal of transportation system designers were to create a safe system, then “speed [would be] the most important factor to regulate” because its effect on injury is so significant (Elvik et al., 2004). In addition to speed itself, other factors related to speed, such as speed differentials between motorists and initial speed of travel, play a role in safety outcomes (Elvik, 2013).

Despite the fact that speed is a known safety problem, for communities in the US speed is the “solution” to a different problem—the time-space problem. High-speed travel makes low-density development economically viable, and for this reason it is difficult for system designers to reduce speed. In this way, our
Fig. 4. Selected school sites observed in fieldwork.

Interpretation of the findings departs from traditional rural road safety narratives in which speeding is understood as a behavioral problem of rural residents. Instead, speed should be understood as a rational response to geographic and economic conditions, a response that carries consequences in the form of higher transportation fatality rates.

5.2. Access to emergency medical care

The lack of accessible emergency medical services and potential delay in medical care is a function of the dispersion of activities in low-density places. A lack of access to medical care when crashes occur in remote areas involves delays in discovering a crash, longer
response times, and lack of access to specialized trauma centers (Zwerling et al., 2005).

Consistent with this proposition, prior research for the US has found that drivers involved in fatal crashes located in the 45–60-min response time coverage area of a Level 1 or Level 2 trauma center were more likely to be coded as “died at scene” than drivers within the 45-min-or-less coverage area [OR = 1.130 (1.044, 1.224)], and the relationship was stronger for fatal crashes located outside the 60-min response area [OR = 1.225 (1.139, 1.318)], controlling for a number of crash-, roadway-, and victim-related factors (National Highway Traffic Safety Administration, 2012). Moreover, treatment at Level 1 trauma centers is also more effective than treatment at centers with less specialization, and this effect is stronger for victims with more severe injuries (MacKenzie et al., 2006).

5.3. Infrastructure design and urban settlement patterns

The design of safe infrastructure is a third element of transportation safety that varies with place, and there are competing ideas in the literature about the relationship between road design and traffic safety (Ewing and Dumbaugh, 2009). Another consideration that is important for low-volume roads in remote rural places is whether

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<th>Urban-rural status</th>
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**Note:** (*) estimate of the rate is statistically different (α = 0.05) from that of the equivalent zone with lower population density. Chi-squared tests of the independence between the higher and lower density rate gradients fail to reject the null hypothesis of independence with p < 0.0001.

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**Fig. 5.** Motor vehicle occupant fatality rates per trip for male motorists by urban-rural status stratified by within-level population density.
5.4. Limitations

Because we do not have representative travel data at the level of the ZCTA, we cannot estimate fatality rates per person-trip or person-mile for each ZCTA, which would have allowed us to use regression modeling to investigate the independent effect of population density and other factors on the fatality rate gradients. Ideally, we would want to know what explains the observed gradients. Such an analysis would require using a population-based measure of exposure, which is inferior to the travel-based measure of exposure.

In addition, although the travel survey’s sampling frame was designed to produce representative estimates of travel for regions within the state of Wisconsin, including for the purpose of comparing travel in urban and rural areas, its sampling frame was not developed for the definitions of urban–rural continua that we used in this study. Our analysis is based on the assumption that we can aggregate travel in ZIP codes with the same urban–rural classification to produce representative measures of exposure. If the heterogeneity in travel within this population is not sufficiently represented by the sampled respondents, then travel estimates could be wrong. We do not know how this limitation might influence the travel and fatality rate estimates.

5.5. Study implications

An implication of this study is that a focus on urban and rural differences prevents research and policy from including questions about low-density settlement patterns. If road safety research and policy cannot acknowledge debates about sprawl and low-density urban development, then we are limited in our ability to address transportation fatality and injury risk in these lower density suburbs and exurbs.

This study points to road safety as an outcome of regional development processes rather than intrinsic characteristics of rural places or residents. A regional understanding of road safety can improve public policy responses by linking outcomes associated with urban form (e.g., speed, road design, and emergency medical response) with higher-order development decisions that are upstream to traditional design, enforcement, and behavioral interventions.

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References


