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16. Abstract

Seat belt use rates vary considerably across the United States, as do the percentages of motor vehicle traffic crash fatalities that are unrestrained. This exploratory study investigated some of the contextual and environmental characteristics of places that may influence seat belt use and, by implication, the lack of restraint in crash fatalities. Three kinds of "alcohol outlets" were examined: on-premises businesses that sell alcohol for on-site consumption such as bars and pubs, businesses that sell alcohol for off-site consumption such as liquor stores, and tourism locations. These alcohol outlets were examined for potential relationships to lack of restraint use in crash fatalities in the United States from 2012 to 2016. As expected, greater densities (locations per 1,000 county residents) of off-premises alcohol outlets were associated with increased likelihood that fatalities were unrestrained. However, greater densities of on-premises alcohol outlets and tourism places were not associated with increased likelihood that fatalities were unrestrained. When on-premises alcohol outlets were subdivided into bars, dancing, stage performance, and tasting venues, greater densities of bars and stage performance locations were associated with increased likelihood that fatalities were unrestrained.

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Executive Summary

In 2018, 47% of passenger vehicle occupants killed in motor vehicle traffic crashes in the United States were unrestrained (NCSA, 2020). However, even in States with relatively low State-level averages for percentage of unrestrained fatalities or high rates of daytime observed belt use, there is considerable variation at the county level in the percentages of all crash fatalities that are unrestrained. NHTSA was interested in exploring innovative ways to inform countermeasure deployment so States have additional tools for using their limited resources. This study investigated whether some characteristics of counties' physical environments influence seat belt use and help explain some of the significant county-level variation in the percentages of all crash fatalities who were unrestrained.

Although there are many possible features of places that may influence seat belt use and unrestrained fatalities, this study focused on the relationship between unrestrained fatalities and the densities of certain businesses using county-level estimates through North American Industry Classification System (NAICS) coding. Specifically, the study focused on businesses that sell alcohol for either on-site consumption (on-premises alcohol outlets) or off-site (off-premises alcohol outlets) consumption and businesses related to tourism because previous research suggested that increased densities of each of these place types would be associated with increased likelihood that a crash fatality was unrestrained. On-premises alcohol outlets included bars and pubs but excluded restaurants because NAICS codes did not differentiate between restaurants that did or did not sell alcohol. Off-premises alcohol outlets included wine and liquor stores but excluded grocery stores and convenience stores because NAICS codes did not differentiate between those that did or did not sell alcohol. Tourism locations included a broad cross-section of attractions like parks, museums, and golf courses. (See Appendix A: NAICS Codes Included in the Analysis for more information on business types.)

Density measures were created by calculating the number of each type of location per 1,000 residents in each county. Restraint status of crash fatalities in the United States from 2012 to 2016 was obtained through the Fatality Analysis Reporting System (FARS). A series of logistic regression models examined whether the likelihood that a fatality was unrestrained was predicted, in part, by the density of on-premises alcohol outlets, off-premises alcohol outlets, and tourism locations in the county where the crash occurred. These models also included fewer (base model) or more (expanded model) covariates representing person-, county-, and State-level demographic information. A third exploratory fully expanded multivariable logistic regression model included the densities of on-premises alcohol outlets broken into separate sub-categories—bars, dancing drinking places, stage performance drinking places, and tasting drinking places.

These analyses revealed mixed support for the predicted relationships. Results for the density measures of interest across all three statistical models are summarized in Table 1.

Table 1. Results from three logistic regression analyses for density measures of interest only

	Logistic Regression Models		
Measures of Interest	**Base Model**	**Expanded Model**	**Exploratory Fully Expanded Model**
Density of Tourism Locations	*n.s.*	↓	↓
Density of Off-Premises Alcohol Outlets	↑	↑	↑
Density of On-Premises Alcohol Outlets	↓	↓	
Density of Bars			↑
Density of Dancing Drinking Places			*n.s.*
Density of Stage Performance Drinking Places			↑
Density of Tasting Drinking Places			↓

Note. ↑ = increased density associated with increased likelihood that a crash fatality was unrestrained ($p < .05$). ↓ = increased density associated with decreased likelihood that a crash fatality was unrestrained ($p < .05$). *n.s.* = not statistically significant.

As predicted, across all three models, the more off-premises alcohol outlets per 1,000 population in a county, the more likely a crash fatality occurring in that county was unrestrained. Contrary to predictions, the density of tourism locations in a county was not associated with increased likelihood that a crash fatality was unrestrained in any model.

Contrary to predictions, the density of on-premises alcohol outlets was not associated with increased likelihood that a crash fatality was unrestrained. When on-premises alcohol outlets were disaggregated into sub-categories, increased density of bars and stage performance locations exhibited the predicted relationship with increased likelihood that a crash fatality was unrestrained. However, increased density of stage and tasting drinking places did not.

The main limitation of this study is that the density measures of interest may also reflect other local cultural and environmental characteristics of counties that independently influence seat belt use and unrestrained fatalities. Further, because of limitations in the available data sets, alcohol sales at restaurants, grocery stores, and convenience stores were not included in this analysis. While suggesting possible future directions, this study uncovers results that are not yet ready for translation to practice.

Introduction

In 2018, 47% of passenger vehicle occupants killed in motor vehicle traffic crashes in the United States (for which restraint use was known) were unrestrained (NCSA, 2020). Even in States with high rates of daytime observed seat belt use, unrestrained passenger vehicle occupants account for a disproportionate amount of fatalities. Developed using data from NHTSA's FARS database, Figure 1 shows the percentage of all crash fatalities from 2012 to 2016 who were unrestrained for each State. However, these State-level data do not capture the significant variation that exists within States. Figure 2 shows the same percentages of unrestrained fatalities by county and illustrates the considerable variability that exists within States—even in States with relatively low State-level percentages of unrestrained fatalities or high rates of daytime observed belt use (NCSA, 2020).

Figure 2 shows a single variable (percentage of all fatalities from 2012 to 2016 who were unrestrained) by county. While this figure highlights counties with high percentages of unrestrained fatalities, it does not convey information about the magnitude of the problem in terms of lives lost. For example, a sparsely populated county may have a high percentage of unrestrained fatalities but only one or two fatalities over a 5-year period. Figure 3 combines these two sources of information in a bivariate choropleth map. In bivariate choropleth maps, intensifying colors show higher incidences of each variable (percentage of unrestrained fatalities and count of fatalities from 2012 to 2016), both separately and combined. The legend for Figure 3 shows the values of each variable that demarcate the levels of tripartite splits.[1] This figure, then, can be used to visually identify counties with both high percentages of unrestrained fatalities and high numbers of crash fatalities; these counties are shown in dark green. Counties with high percentages of unrestrained fatalities but low numbers of fatalities are shown in yellow, as seen in many counties in North and South Dakota. Counties with low percentages of unrestrained fatalities but high numbers of fatalities are shown in purple, as seen in most of California's counties.

[1] The visualization in Figure 3 is relative, not objective: each variable was divided into three levels using a tripartite split, so the color levels reflect proportionate representation of the actual data values (not of the theoretically possible values of the scales used to measure them).

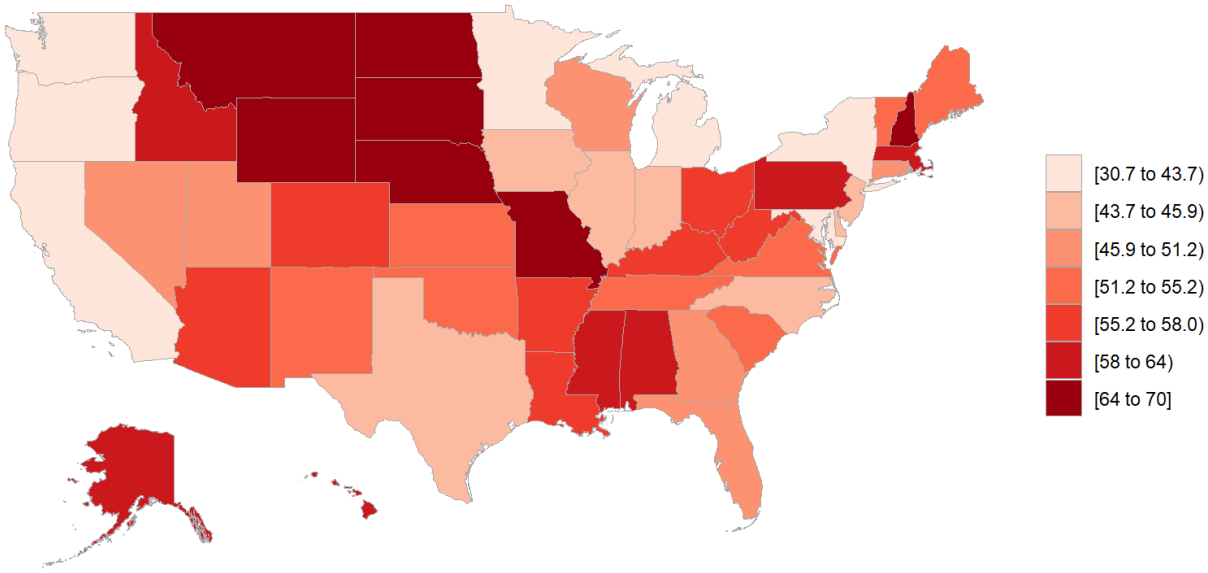

Figure 1. Percentage of unrestrained fatalities by State (relative to all State crash fatalities with known restraint status), 2012-2016.

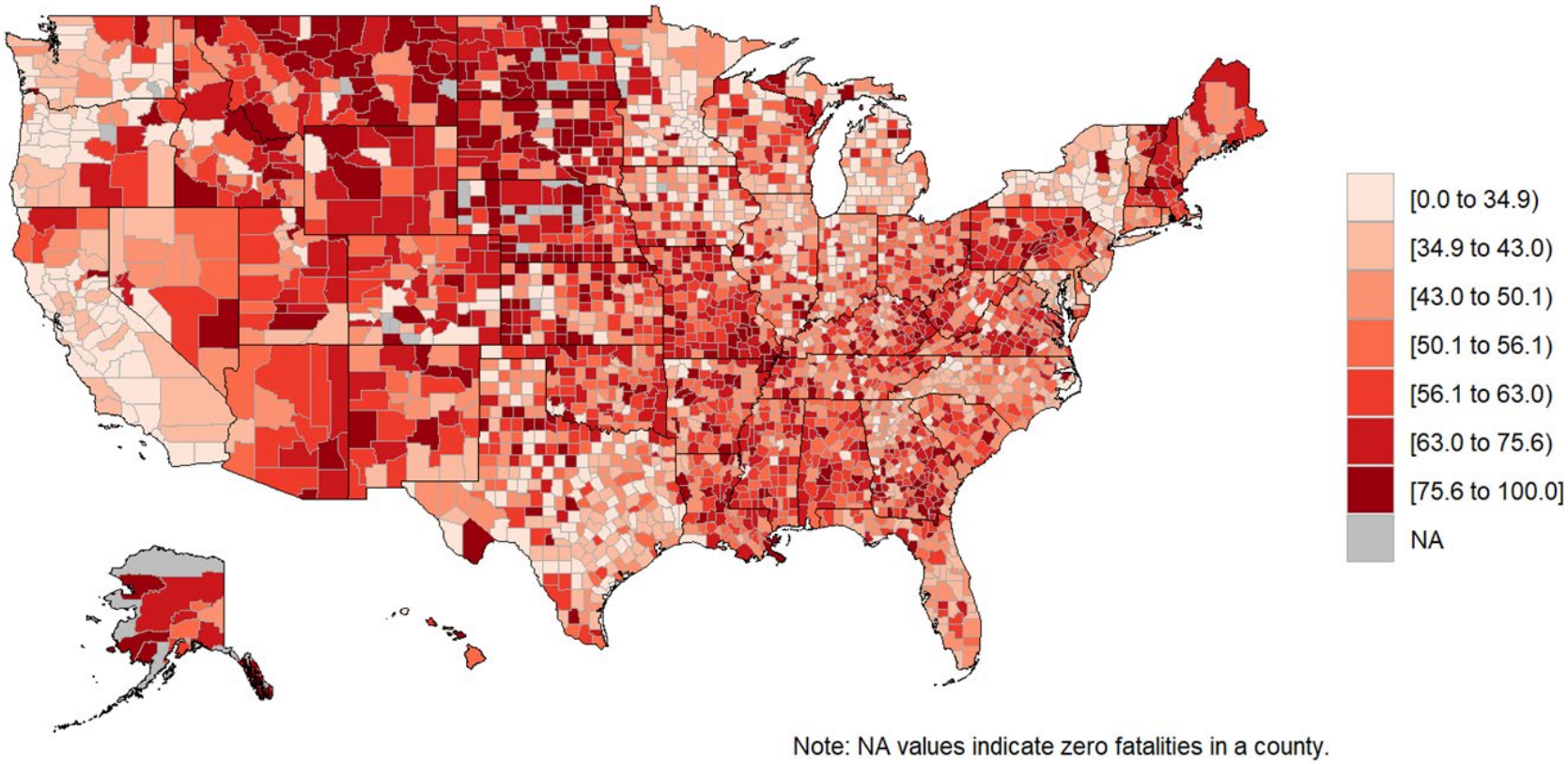

Figure 2. Percentage of unrestrained fatalities by county (relative to all county crash fatalities with known restraint status), 2012–2016.

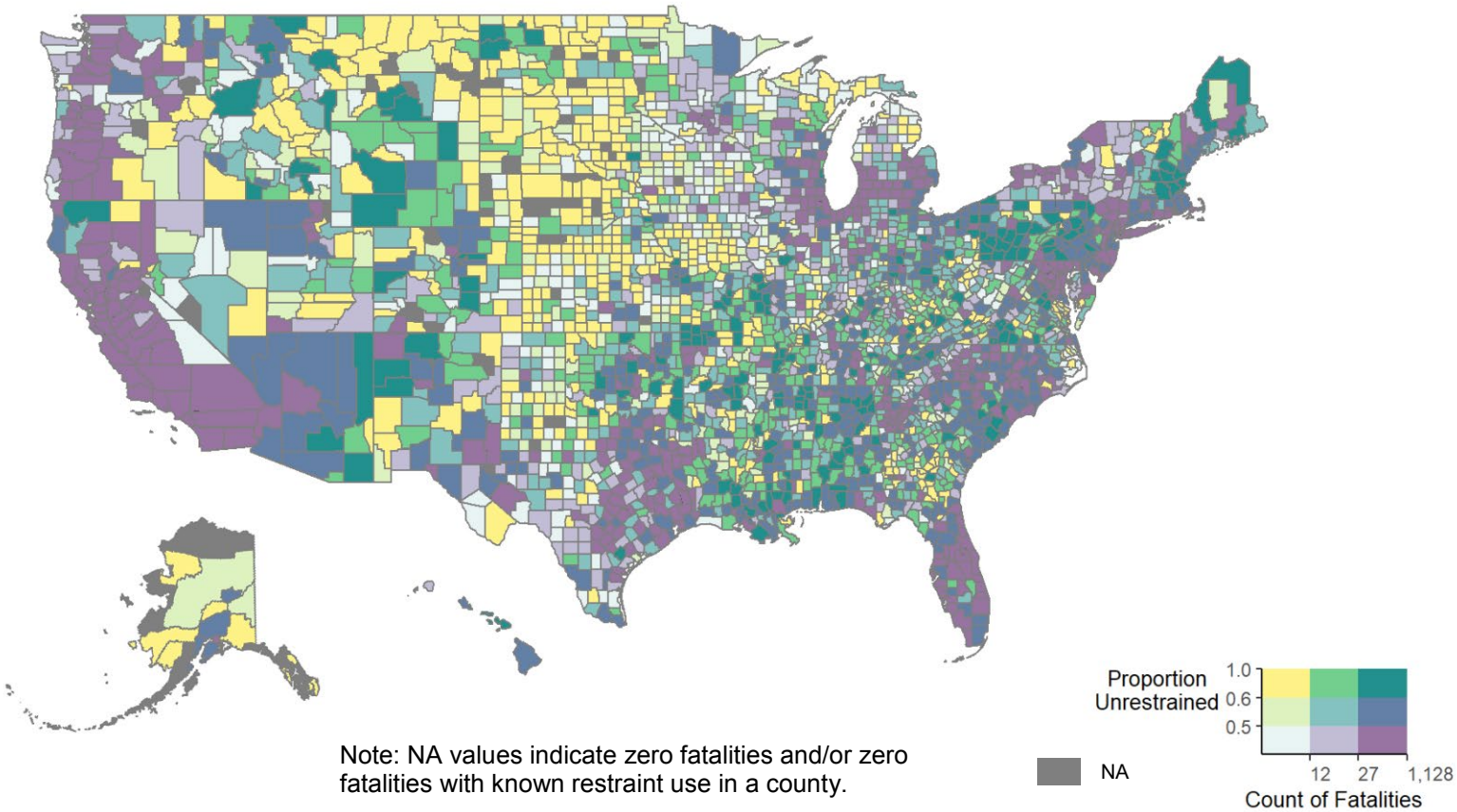

Figure 3. Proportion of unrestrained fatalities by count of all crash fatalities by county, 2012–2016.

Together, Figure 2 and Figure 3 emphasize the significant geographic variation across the United States in the percentage of unrestrained crash fatalities. Although much research has focused on characteristics of people (e.g., demographic variables like age and sex; personality traits) and the immediate environment (e.g., roadway type; presence of passengers) that influence seat belt use (for a review, see Jans et al., 2015), less is known about the contextual and environmental characteristics of *places* that may influence seat belt use—and, by implication, the percentage of unrestrained fatalities. Within public health, more generally, Haddon (1970) argued that harm reduction and prevention efforts should focus on redesigning the physical environment instead of changing individual behavior. The Social Ecological Model (Green & Kreuter, 2005) describes the ways people's behavior can be shaped by their environment. Individual behavior choices are influenced by a range of factors across five levels: individual, interpersonal (e.g., peers, parents), organizational (e.g., community organizations), community (e.g., cultural values and norms), and physical environment/public policy. Similarly, the Injury Iceberg model uses an iceberg as a metaphor for a complex ecological system and illustrates the many factors that shape behavior (Hanson et al., 2005). On this model, while individual behavior is at the visible tip of the iceberg, effectively reducing people's risk of injury may require addressing systemic environmental and sociological issues that affect individual behaviors (i.e., the much larger, unseen mass of iceberg beneath the ocean).

These social ecological concepts have been widely used in public health research to understand and investigate "sticky" problems, those where individual behavior choices are influenced by a range of factors (Green & Kreuter, 2005; Hanson et al., 2005). Similarly, the decision to wear a seat belt is influenced by people, their social relationships, the policies that inform their choices, and their interactions with the physical environments where they live, work, play, and travel. In the current study, we investigated whether characteristics of the physical environment may influence seat belt use and explain some of the significant geographic variation in the percentages of all fatalities who are unrestrained among counties across the United States. Specifically, the study focused on the county-level densities of businesses that sell alcohol for on-site (on-premises alcohol outlets) or off-site (off-premises alcohol outlets) consumption and businesses related to tourism.

Defining Terms and Measures

Seat belt use, crash fatalities, and unrestrained fatalities are distinct but related measures. To avoid confusion, we define these key measures below:

Seat belt use and non-use by motor vehicle occupants have been measured in several ways, including using self-report (e.g., Demirer et al., 2012; Spado et al., 2019) and direct observation (for example, in NHTSA's National Occupant Protection Use Survey, e.g., Enriquez, 2020). Seat belt use measurements are intended to reflect the extent to which drivers and passengers choose to employ restraints while traveling. However, while seat belts are an effective measure for reducing the risk of fatal and serious injuries in crashes, measures of seat belt use do not provide a direct measure of unrestrained injuries or fatalities.

Crash fatalities in the United States are documented annually in the FARS database. The FARS database contains all crashes on U.S. public roads in which at least one person was fatally injured and died within 30 days of the crash. Additionally, FARS records contain information about restraint use for all vehicle occupants where restraint use is known, making it possible to examine restraint use in fatal crashes.

Fatalities with known restraint use are identified by FARS using police crash reports and other documents that help determine whether the occupants involved in fatal crashes were restrained at the time of the crashes. However, in some cases, FARS analysts cannot determine restraint use from the source documents and code the fatality as "restraint use unknown." The set of crash fatalities with known restraint use (unrestrained or restrained) form the basis for the analyses in this study.

Unrestrained fatality rates are the numbers of occupants who were fatally injured in crashes and not wearing seat belts at the time of the crashes, divided by the fatalities with known restraint use in a geographic unit (e.g., a county), expressed as a percentage.

Contextual Variables

Given that unrestrained fatality rates vary by geographic location, and that people's physical and community environments can shape their decisions and actions (e.g., Green & Kreuter, 2005), this study examines whether certain environmental and contextual characteristics of places predict the likelihood that a fatality was unrestrained. The research team evaluated possible secondary data sources and determined their comparability within and across years based on their data collection, structure, and weighting methodologies. The team excluded nationally representative samples and other systems designed to produce national and State-level estimates. Secondary data sources were considered only if they provided data that were representative at the county level. After considering possibilities, the team decided to use the NAICS coding of businesses to derive county-level characteristics that provide context for or help describe the type of location. The team then selected businesses associated with alcohol sales and tourism because of previous research suggesting that increased densities of each of these place types would be associated with increased likelihood that a crash fatality was unrestrained (see below).

On- and Off-Premises Alcohol Outlets

Prior research has shown an association between alcohol involvement and seat belt use. Using police-reported crash data, Li and colleagues (1999) investigated factors that predicted seat belt use among passenger vehicle occupants involved in crashes and found alcohol involvement and driving at night to be strongly negatively associated with seat belt use, with alcohol involvement having the strongest association of all covariates considered. Further, several studies have demonstrated a relationship between contextual and geographic factors and alcohol intake – specifically, the impacts of alcohol availability and alcohol retail outlet density on increased alcohol consumption, alcohol-impaired driving, and other harmful behaviors linked to consuming alcohol and vehicle crashes. For instance, the Task Force on Community Preventive Services conducted a systematic review of scientific evidence and determined that policy changes or regulations that limit alcohol outlet density could be a successful strategy to reduce excessive alcohol drinking and some associated harms such as crime, violence, injury, and medical harms that came from excessive drinking (Campbell et al., 2009). While the review found that greater alcohol outlet density was associated with increased alcohol consumption, the relationship with motor vehicle crashes was mixed. However, of the cross-sectional studies included in the review, 80% reported a positive association between off-premises alcohol outlet density and crashes, while 67% found a positive association between on-premises outlets and crashes. As a result, the task force recommended regulations that control alcohol outlet density as

a means to reduce alcohol availability and, thus, associated harms (Task Force on Community Preventive Services, 2009).

The type of alcoholic drink, the type of alcohol outlet where the alcohol is being purchased, and the age and retail preferences of the drinker may all affect the complex relationships between alcohol consumption and crashes, fatalities, or alcohol-involved fatalities. In a study investigating the relationship between the physical availability of alcohol, alcohol sales regulations, and their effects on the rates of fatal crashes, Gruenewald & Ponicki (1995) found that greater use of alcohol increased the likelihood of alcohol-related, single-vehicle, fatal, nighttime crashes. Specifically, they found that a 1% increase in the sale of beer translated to a 1.68% increase in single-vehicle fatal nighttime crashes. Additionally, beer drinkers were more likely than drinkers of other types of alcohol to drink, drive, and consequently be in alcohol-involved crashes.

Yet, some researchers have hypothesized that limiting the availability of alcohol would *increase* the likelihood of alcohol-related crashes since people would increase their exposure by traveling greater distances to obtain alcohol. Colon (1982) conducted a cross-sectional analysis of the 50 States and Washington, DC, to examine the relationships between the frequency of packaged liquor outlets, State monopoly of alcohol distribution, and fatal, single-vehicle crashes. The study found a positive association between traffic fatalities and the frequency of alcohol outlets. However, when outlet frequency was fewer than one outlet per 1,000 people (drinking age population only), this relationship reversed (i.e., fewer outlets associated with increased fatalities); the author speculated that this was because people were forced to drive further to obtain alcohol (Colon, 1982). By contrast, an analysis of data from 77 dry counties in Alabama found that neither alcohol- nor non-alcohol-related injury crashes were positively correlated with the number of miles to legal alcohol (Giacopassi & Winn, 1995). Instead, the farther a county was from legal alcohol, the lower the rate of injury crashes.

Prior research also suggests that the type of alcohol retail outlet may differentially affect alcohol-involved crashes. For example, while the density of bars (a type of on-premises alcohol outlet) in small segments of a large metropolitan area (Melbourne, Australia) was positively related to alcohol-related crash rates in neighboring city segments, there was a negative relationship between the density of off-premises alcohol outlets and alcohol-involved crashes, and there was no relationship with the density of restaurants (Morrison et al., 2016). Additionally, a study of people's drinking preferences and patterns found that people who preferred to drink at restaurants were more likely to report drinking and driving, particularly at restaurants not in their immediate ZIP Codes (Gruenewald et al., 2002). By contrast, people who preferred to drink at bars were more likely to go to bars in the ZIP Code where they lived and to drink more, but they were not more likely to drink and drive.

Together, these studies demonstrate a relationship between alcohol availability and alcohol-related crashes, fatalities, and injuries, which may also depend on the type of alcohol retail establishment (e.g., on- or off-premises alcohol outlets). Given the influence of alcohol involvement on seat belt use, one possibility is that alcohol availability influences crashes, injuries, and fatalities through seat belt use, either directly (i.e., occupants are less likely to wear seat belts after drinking) or indirectly (e.g., other characteristics of the environments in which alcohol is available also discourage seat belt use). We hypothesize that:

- Greater density of off-premises alcohol outlets in a county will be associated with decreased likelihood of restraint use among crash fatalities that occurred in the county.
- Greater density of on-premises alcohol outlets in a county will be associated with decreased likelihood of restraint use among crash fatalities that occurred in the county.

Tourist Destinations, Including Sports, Recreational, and Social Places (Tourism Locations)

Another characteristic of places that may influence unrestrained fatality rates is the density of tourism, sports, recreational, and social places (i.e., tourism locations). Even drivers who identified as always seat belt users could name situations in which they did not buckle up (Fockler & Cooper, 1990), and situational factors like trip length and traffic density influence belt use (Richard et al., 2019). Thus, a person's decision to wear a seat belt may vary based on the occasion. Because road unfamiliarity and driving in new places influence drivers' behaviors and their propensity to be involved in crashes (Intini et al., 2019; Sleet et al., 2016), one possibility is that occupants also exhibit different seat belt use behaviors at tourist destinations than at home, which could influence the rate of unrestrained fatalities. Some researchers have tried to better understand the connections between the location where a crash happens and drivers' place of residence. For instance, Harootunian, Aultman-Hall, & colleagues (2014) analyzed 3- to 5 years of crash data from Florida, Maine, Minnesota, and Nevada and found that out-of-State drivers had increased odds of being at fault for single-vehicle crashes in Maine, Minnesota, and Nevada. This relationship held true for Florida, as well, when the driver was identified as being in-State but living outside of the county where the crash occurred. Similarly, drivers in Vermont who were more than 50 miles from home had increased odds of being at fault for single-vehicle crashes (twice as likely) and two-vehicle crashes (6.5% more likely) (Harootunian, Lee, et al., 2014). Recreationally linked variables, such as being a non-owner or driving on Fridays, weekends, or during the summer also increased drivers' odds of being at fault. Finally, although most fatal crashes that occurred in rural areas involved rural residents, drivers and passengers from urban areas had higher risk of fatality in rural versus urban crashes relative to rural residents (Donaldson et al., 2006).

Other studies on the influence of route familiarity on crashes also suggest a possible link between tourism locations and unrestrained fatalities (Intini et al., 2018, 2019). In a review of previous research, Intini and colleagues (2018) suggested that a driver's unfamiliarity with a route increased crash risk and driving errors due to unexpected road features or driving situations. Additionally, in an empirical study, the authors found that high traffic volume, tourist season, non-commuting-related travel, and other factors predicted whether a driver unfamiliar with a route was more likely to be involved in a crash.

Together, these studies suggest that crashes, injuries, and fatalities are more likely when drivers are unfamiliar with the roads or driving in areas that are not near their places of residence. Given that situational factors affect seat belt use, it is possible that route familiarity and driving out-of-town may also affect seat belt use, and one reason drivers and passengers travel is to visit tourism or recreational places. Thus, we hypothesize that:

- Greater density of tourist destinations in a county will be associated with decreased likelihood of restraint use among crash fatalities that occurred in the county.

Method

This study examined whether the densities of on- and off-premises alcohol outlets and tourism locations in a county were associated with decreased likelihood of restraint use among crash fatalities that occurred in the county, using a series of regression models. The regression models included the following.

- Logistic regression models predicting restraint use among crash fatalities for the variables of interest (i.e., on- and off-premises alcohol outlet density and density of tourism locations);
- A base multivariable logistic regression model predicting restraint use among crash fatalities that included all three density variables of interest, as well as person-level, county-level, and State-level demographic variables as covariates;
- An expanded multivariable logistic regression model predicting restraint use among crash fatalities that included all three density variables of interest, covariates from the base model, and additional person-level, crash- and vehicle-level, county-level, State-level, and regional-level covariates; and
- Based on the results of the expanded model, an exploratory further expanded multivariable logistic regression model predicting restraint use among crash fatalities that included all the same covariates as the expanded model but including sub-categories of on-premises alcohol retail locations.

Variables and Data Sources

Dependent Variable: Restraint Use Among Crash Fatalities

The dependent measure for all analyses was the restraint use (known restrained or known unrestrained) of all fatally injured passenger vehicle occupants in the United States from 2012 to 2016. The source for the fatality data was the FARS database, which contains detailed information on fatal motor vehicle traffic crashes in the United States. FARS is a census; all qualifying fatalities are identified from State-specific police crash reports and supporting documentation, such as Department of Motor Vehicle records, emergency medical service records, medical examiner and coroner reports, and death certificates. To be included in FARS, the fatality must have occurred within thirty days of the date and the time of the crash, and the victim's death must have been a direct result of an injury sustained in the crash (NCSA, 2018). The crash must have involved at least one motor vehicle that was in-motion on a trafficway customarily open to the public and must have resulted from an unstabilized situation and not deliberate intent or a natural disaster.

To analyze the relationship between restraint use in fatal crashes and the contextual variables of interest, we focused on occupants in passenger vehicles where the injury severity was fatal, and a restraint system was either known used or not used. Data for FARS years 2012 to 2016 were included in the analysis.[2] Passenger vehicles were defined by vehicle body type and included passenger cars, SUVs, pickup trucks, vans, and other light trucks. Passenger vehicle occupants included drivers, passengers, and occupants where driver/passenger type was unknown. Restraint

[2] Data for FARS years 2012 to 2016 was selected because only the 2016 FARS final file was available when the research team began data analysis in spring 2019.

systems included lap belts, shoulder belts, lap and shoulder belts, child safety seats, and booster seats, either properly or improperly worn (NCSA, 2018).

The analysis data set was defined by criteria based on established NHTSA definitions that use FARS data categories and have been applied in previous research (NCSA, 2018). Each case fulfilled the following criteria.

- The person was an occupant of a motor vehicle involved in a crash on a public road,
- The motor vehicle was a passenger vehicle (e.g., not a motorcycle or large truck),
- The person was fatally injured, and
- The person's restraint use (or lack thereof) was known.

The data used were accessed through NCSA's research and data website (NCSA, 2018). Crash-level, person-level, and vehicle-level SAS datasets for the 5-year period 2012 to 2016 were downloaded and merged in SAS software. The cases that matched the analysis criteria were extracted to produce the analysis dataset. In total, 110,405 fatalities met the first three criteria listed above. However, as discussed previously, some cases (n = 9,016, or 8%) were missing restraint data, which yielded 101,389 fatalities for analysis.

Independent Variables

County-level density of on- and off-premises alcohol outlets and tourism locations

The independent variables of interest were the county-level densities (number of locations per 1,000 people in a county) of on-premises alcohol outlets, off-premises alcohol outlets, and tourism locations. To create these density variables, business location data obtained through the Environmental Systems Research Institute's Business Analyst software were queried by NAICS code to obtain a census of locations for each place type for each county for 2018. The NAICS codes and associated business types in tables in Appendix A (NAICS Codes Included in the Analysis) were used to extract the locations by place type.[3]

The contextual variable of alcohol retail outlet density was measured with two types of alcohol outlet locations. On-premises alcohol outlets allow the consumption of alcohol on-site, such as bars, pubs, discotheques, comedy clubs, etc. On-premises locations selected for this study were bars and pubs (62%), wineries and vineyards (16%), breweries (8%), cocktail lounges (7%), night clubs (5%), and other similar places (2%). While many restaurants also sell alcohol on-site, they were excluded because NAICS codes did not differentiate between restaurants that did or did not sell alcohol. That said, in many jurisdictions restaurants, unlike bars, must derive a proportion of their sales from food or non-alcohol sales. Furthermore, the intent of this variable is not to measure alcohol sales but rather to provide a context to the location of where the crash occurred that focuses on businesses that are typically associated with on-site drinking.

Off-premises alcohol outlets offer alcohol for retail sale and do not serve alcohol on-site, such as wine stores and liquor stores (State-run and privately owned/operated). Off-premises locations selected for this study included liquor stores (80%) with the remainder selling just beer or wine. Like restaurants, grocery stores and convenience stores were excluded from the analysis because

[3] NAICS provides some business locations by point location and places others at the county centroid. Because density measures were calculated at the county level, the current analyses were unaffected.

NAICS codes did not differentiate between those that did or did not sell alcohol, but this variable provides a context that focuses on businesses typically associated with off-site alcohol sales.

Tourism locations included a broad cross-section of attractions, including sports stadiums, concert venues, theaters, museums, zoos, national parks, and monuments, etc. Parks (24%), museums (18%), and golf courses (16%) make up the largest categories of tourism locations in the country. Specific and complete codes included in the definitions of business types, as well as the distributions of the definitions, can be found in Appendix A (NAICS Codes Included in the Analysis).

Three density variables were created based on the number of places by type (on-premises alcohol outlets, off-premises alcohol outlets, and tourism locations) for each county. These population-based density variables were calculated by dividing the number of locations by county population estimates and multiplying by 1,000 to generate the density of places by type, i.e., number per 1,000 residents. County population totals were obtained from 2010 U.S. Census data (United States Census Bureau, 2010).

To explore any interrelationships among these three place density variables, we calculated correlations between them among counties with at least one passenger vehicle fatality with known restraint status during the study period (n = 3,042 of 3,143). The Pearson correlation coefficients for the relationships between the three place densities were all less than or equal to 0.51, indicating that none of the three variables were highly correlated. The most strongly correlated pair of variables was the density of tourism locations and the density of on-premises alcohol outlets (r = .51). Off-premises alcohol outlet densities were weakly associated with tourism location densities (r = .27) and on-premises alcohol outlet densities (r = .23.)

Figure 4, Figure 5, and Figure 6 show the densities of on-premises alcohol outlets, off-premises alcohol outlets, and tourism locations. Additional figures appear in Appendix B (Additional Visualizations) and illustrate the raw numbers of each type of place by county. Descriptive statistics appear in Table 2.

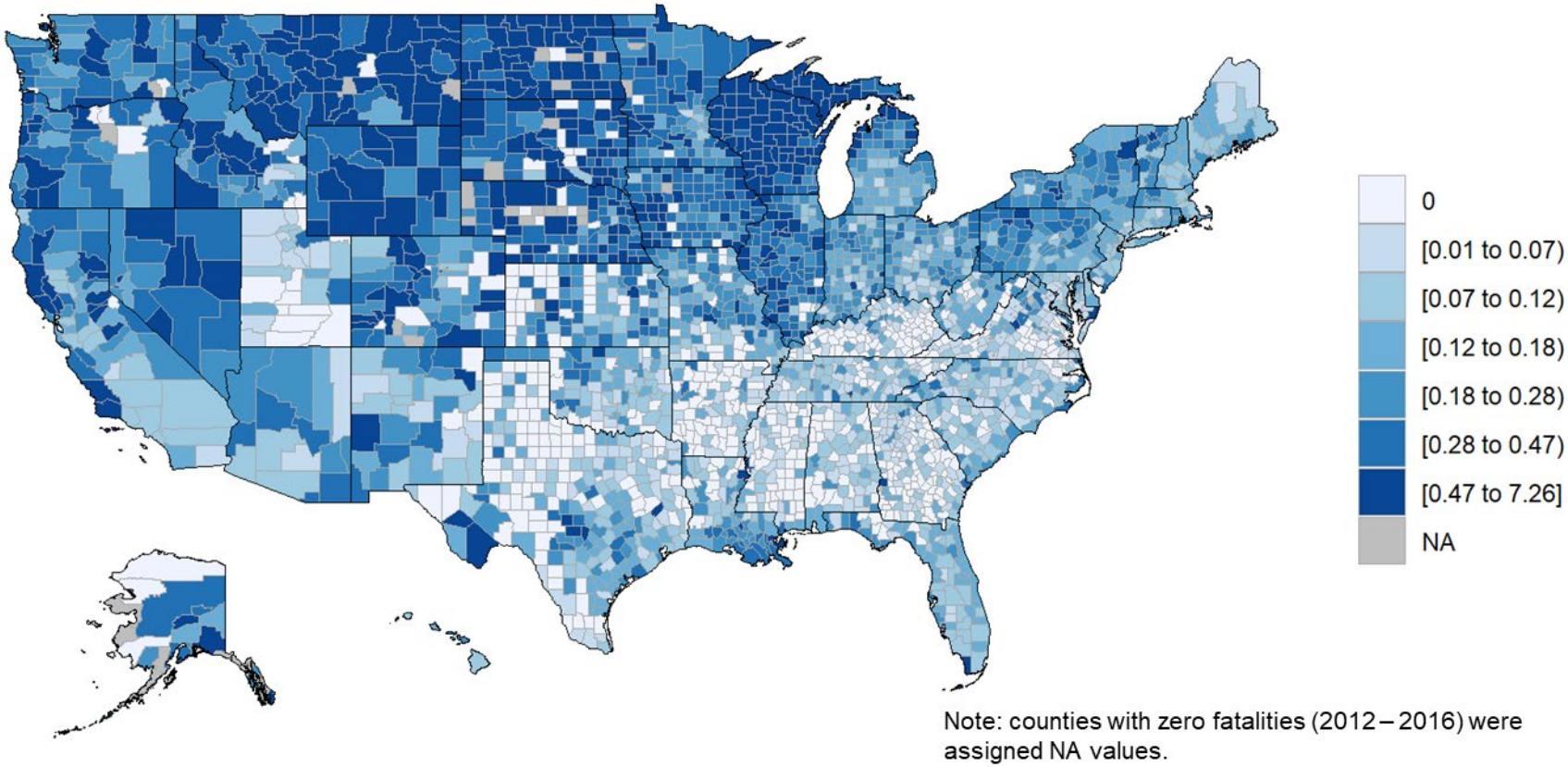

Figure 4. Density (number per 1,000 county residents) of on-premises alcohol outlets.

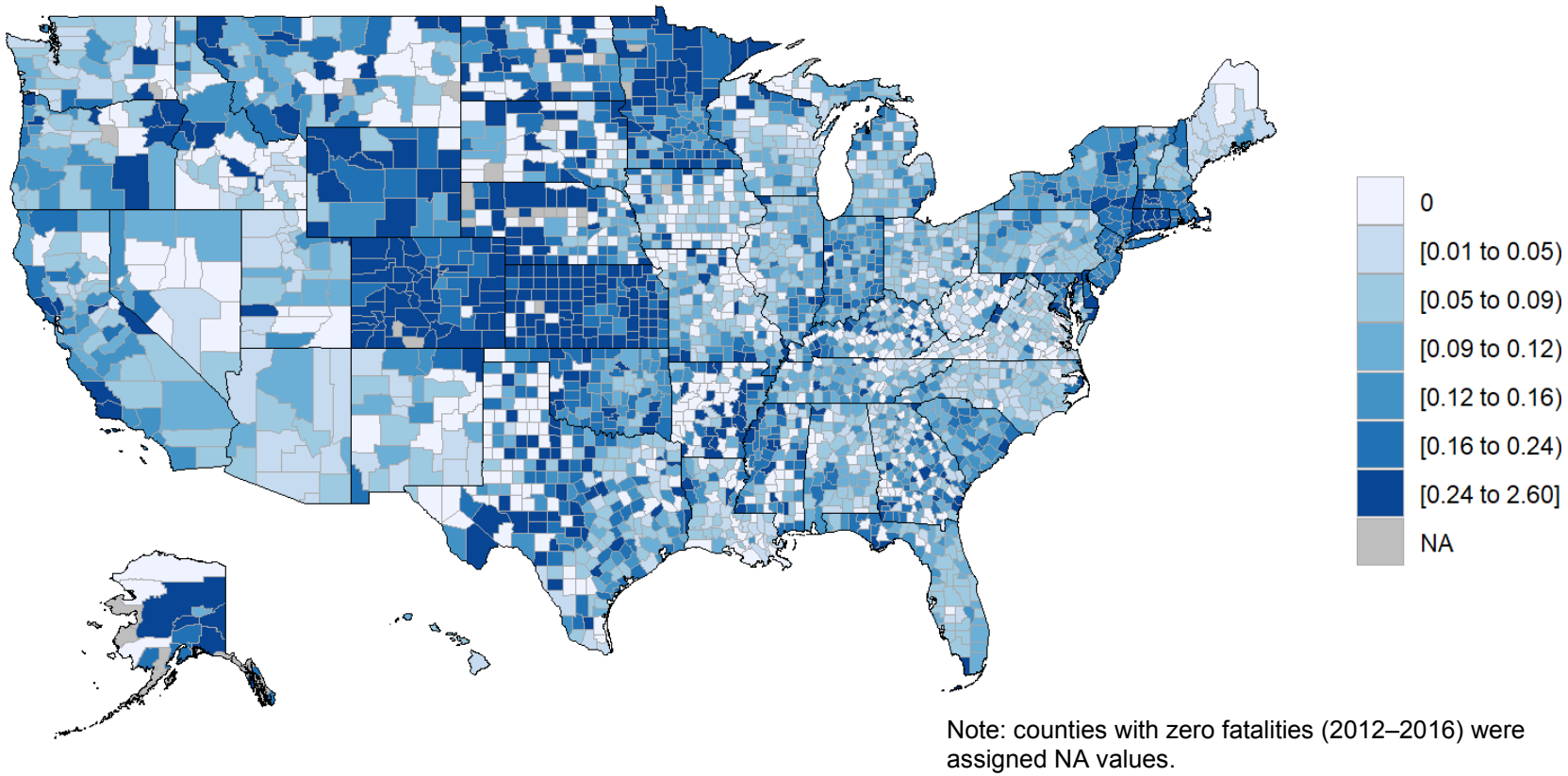

Figure 5. Density (number per 1,000 county residents) of off-premises alcohol outlets.

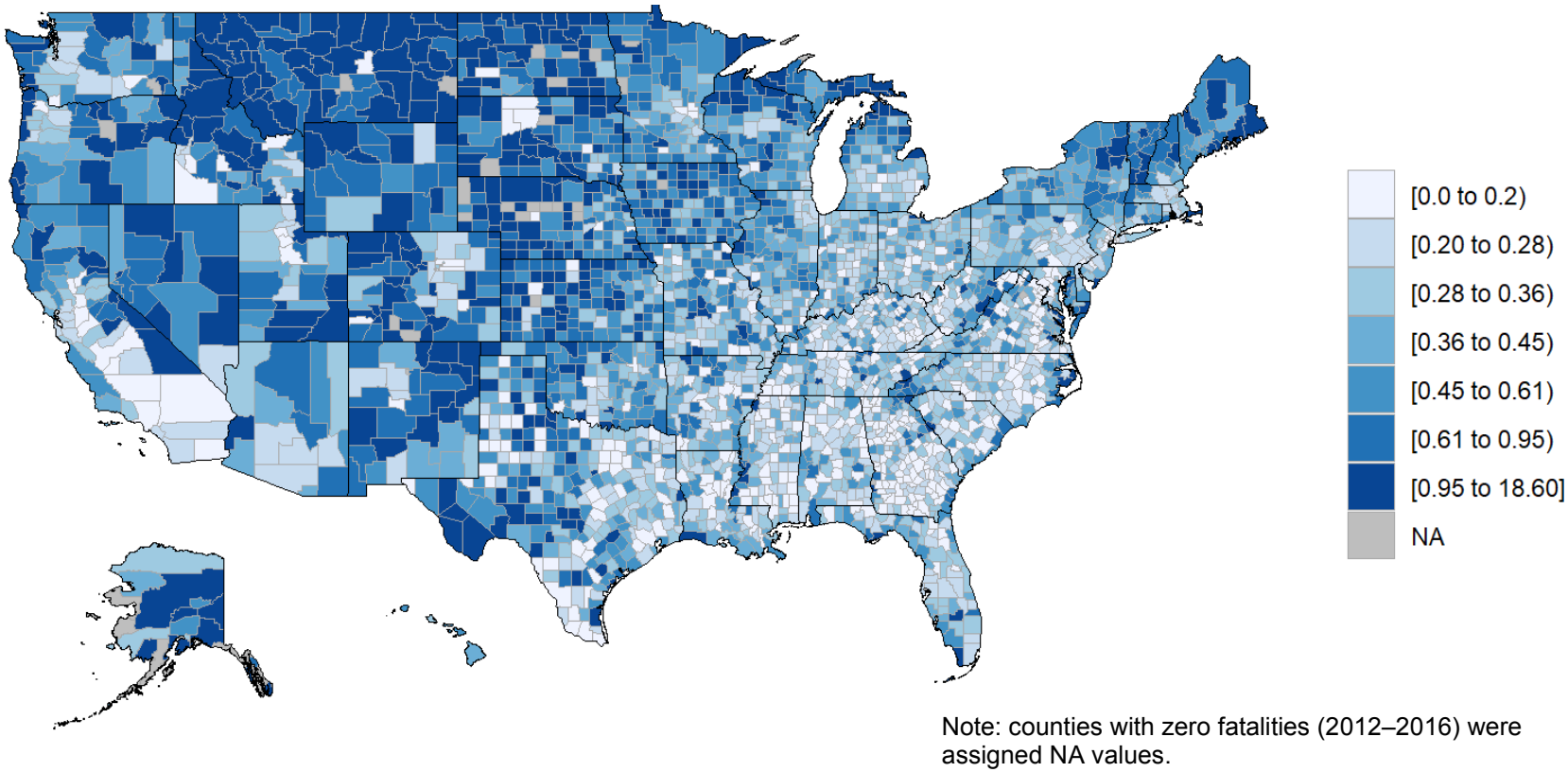

Figure 6. Density (number per 1,000 county residents) of tourism locations.

Table 2. Descriptive statistics for place types by county

	Range of densities among counties		Counties with no places of this type[1]	Fatalities in counties with no places of this type[2]	Density in counties with fatalities
Place type	***min***	***max***	***n***	***n***	***mean***
Tourism locations	0	18.6	60	393	0.35
Off-premises alcohol outlets	0	2.6	589	7,154	0.11
On-premises alcohol outlets	0	7.3	595	8,543	0.18

[1] N = 3,143 counties in the United States [2] N = 101,389 fatalities.

Covariates for base logistic regression model

In addition to the three county-level density measures of interest (on- and off-premises alcohol outlet and tourism location densities), additional covariates were included in the base logistic regression model to improve model fit and to decrease omitted variable bias for the estimators of interest. Previous research indicates that seat belt use is associated with demographic characteristics like age, sex, income, and race (e.g., Lerner et al., 2001), education and the presence of children in the home (e.g., Shinar, 1993), and by the policy set by the State for enforcement of seat belt laws (e.g., Beck & Shults, 2009). Thus, the following additional variables—along with the density measures of interest—were included as covariates in the base model predicting the likelihood of restraint use among crash fatalities.

- Person-level covariates: FARS (NCSA, 2019) provided the **Age** and **Sex** of the fatally injured person.
- County-level covariates: the U.S. Census American Community Survey (ACS) provided 5-year estimates (2012 to 2016) for: the percentage of county residents 25 or older who held at least a high school degree or general equivalency diploma (**% High School Graduates**); were unemployed (**% Unemployed**); self-reported as non-Hispanic, Black race only (**% Non-Hispanic Black**) or Hispanic, any race (**% Hispanic**);[4] the county's median household income (**Median Household Income**); and mean number of people in the household (**Average Household Size**) (United States Census Bureau, 2016).
- State-level covariates: States were categorized as having **Primary Enforcement in Front Seat** present for seat belt requirements, or Primary Enforcement not present. New Hampshire, which has no seat belt requirement for adults, was characterized as Primary Enforcement not present.

For the base logistic regression model, 88 cases were excluded due to missing information about peoples' age and/or sex. Additionally, 387 cases were excluded for missing values on continuous covariates to which a log-transform was applied (described below in the Statistical Analyses section and excluding the density measures). Thus, the total number of

[4] We selected these race/ethnicity measures both because of prior research on their relationship to seat belt use (e.g., Lerner et al., 2001) and because of the likelihood of many counties with zero values for other race/ethnicity groupings.

cases for the base logistic regression analyses was $N = 100{,}914$. Descriptive statistics for covariates in the base model are shown in Table 2.

Table 3. Descriptive statistics for covariates included in base logistic regression model

Variable	Values or Range Among Cases	Mean or Distribution Among Cases
Person-level covariates		
Age	1–115	42
Sex	Female/Male	34.8% Female
County-level covariates		
% High school graduates	8.2%–54.6%	30.8%
% Unemployed	0%–29.9%	7.7%
Median household income	$18,972–$125,672	$51,965
% Non-Hispanic Black	0%–86.1%	12.4%
% Hispanic	0.1%–98.9%	14.4%
Average household size	1.7–4.8	2.6
State-level covariates		
Primary enforcement in front seat	Present/Not present	78.8% Present

$N = 100{,}914$ cases in base logistic regression model. *Note.* See Appendix C: Covariate Sources for more information on data sources

Covariates for expanded logistic regression model

The base logistic regression model used some person-, county-, and State-level demographic variables as covariates. However, additional factors have been shown to affect seat belt use, including being the driver versus passenger (Lerner et al., 2001), sitting in the front or back seat (NCSA, 2020), the involvement of alcohol (Jewett et al., 2015), and time of day (Tison et al., 2010). In addition, rurality and geographic region are associated with restraint use (Beck et al., 2017; Strine et al., 2010; Watson & Austin, 2021. Other crash characteristics such as the number of vehicles involved and speed limits also relate to restraint use in fatal crashes. Thus, in the expanded logistic regression model, the following covariates were added to the base model.

- Person-level covariates: For each person involved in a fatal crash, FARS (NCSA, 2019) provides information about **Seating Position** (recoded as front seat, back seat, or other) and indicates **Person Type** (passenger or driver).
- Crash-level and vehicle-level covariates: For each crash, FARS provides information about the number of vehicles in the crash, recoded as **Single-Vehicle Crash** (yes or no), and the **Light Condition** at the time of the crash (recoded as daylight, dawn/dusk, or dark). For each vehicle, FARS provides the **Speed Limit** on the road just prior to the crash, the year the vehicle was manufactured (from which **Vehicle Age** can be derived), whether there is sufficient information to conclude that the vehicle's driver was drinking (**Driver Drinking**), and the State of residence on the license of the vehicle's driver. The vehicle driver's State of residence was compared to the State where the crash occurred to determine whether the vehicle's driver was in his or her home State (**Driver Local**). For crash- and vehicle-level covariates, values are the same for all individual fatalities involved in the same crash or within the same vehicle.

- County-level covariates: the U.S. Department of Agriculture provides Rural-Urban Continuum Codes (RUCC), a 1 to 9 rating of the **Rurality** of each county, with 1 being the least and 9 being the most rural (United States Department of Agriculture, 2013). The U.S. Census Bureau (2016) provides county population information that, along with county size in square miles, can be used to calculate the **Population Density** of each county. Additionally, the Environmental Protection Agency (EPA) provides **Vehicle Miles Traveled (VMT) per 1,000 People in County** (EPA, 2015).
- State-level covariates: laws vary in their approach to seat belt requirements for back seat passengers. Some have a requirement for use by adults in the back seat (**State Requires Adult Use in Back Seat**), and some allow **Primary Enforcement in Back Seat** belt use requirements.
- Regional-level covariates: the U.S. Census (2019) provides **Census Region** classifications (Southern, Northern, Western, Midwestern).

For the expanded logistic regression model, 7,591 additional cases were excluded for missing/unknown values on covariates, including missing values on continuous covariates to which a log-transform was applied (excluding the density measures, see the Statistical Analysis section). Thus, the total number of cases for the expanded logistic regression analyses was 93,323 fatalities. Descriptive statistics for covariates in the expanded model are shown in Table 4.

Table 4. Descriptive statistics for covariates included in expanded logistic regression model

Variable	Values or Range Among Cases	Mean or Distribution Among Cases
Person-Level covariates		
Seating Position	Front/Back/Other	91% Front/8% Back/1% Other
Person Type	Driver/Passenger	19% Passengers
Crash- and Vehicle-Level Covariates		
Single Vehicle Crash	Yes/No	49% Yes
Light Condition	Daylight/Dark/Dawn or Dusk	51% Daylight/45% Dark/4% Dawn or Dusk
Speed Limit	55–85 mph	51.3 mph
Vehicle Age	0–99 years old	2.3 years old
Driver Drinking	Yes/No	31% Driver drinking
Driver Local	Yes/No	90% Yes
County-Level Covariates		
Rurality (RUCC)	1–9	3 ("Counties in metropolitan area of fewer than 250,000 population)
Population Density	0.03–71,239 people per sq. mile	682 people per sq. mile
VMT per 1,000 People in the County	835,238–1,646,783,335	5,637,512
State-Level covariates		
Primary Enforcement in Back Seat	Yes/No	42% Yes
State Requires Adult Use in Back Seat	Yes/No	57% Yes
Region-Level Covariates		
Census Region	South/Northeast/Midwest/West	50% South/10% Northeast/ 21% Midwest/19% West

N = 93,323 cases in expanded logistic regression model. *Note*. See Appendix C: Covariate Sources for more information on data sources

Statistical Analysis

Analyses were conducted using SAS software version 9.4. Visualizations were produced using the *R* statistical software (R Core Team, 2019), including the *choroplethr* (Lamstein, 2018) and *tidyverse* (Wickham, 2017) modules.

A series of regression models tested the relationships between the densities of on- and off-premises alcohol retail and tourism locations and restraint use by fatally injured passenger vehicle occupants in FARS motor vehicle crashes. As described above, the set of regression models included single-variable models, multivariable base and expanded models, and an exploratory multivariable fully expanded model.

For all multivariable models, natural log transformations were applied to all continuous covariates (excluding the density measures of interest, discussed below) to correct for skew, reduce potential outlier effects, and allow for interpretation in terms of percentage differences. Since zeros cannot be natural log-transformed, zero values were excluded from the model. These excluded cases represented 6.7% of individual fatalities in the data set. However, the three density variables of interest were *not* log transformed. Log transformations would have

eliminated cases with zero values (e.g., no locations in a county) and would have substantially changed the data set and the interpretation of results. For the single-variable models, the final data set included 101,389 fatalities for analysis. For the multivariable base logistic regression model, the final data set included 100,914 fatalities. For the multivariable fully expanded model, the final data set included 93,323 fatalities.

Potential multicollinearity was assessed by inspecting the Pearson correlation coefficients of the variables in the model, as well as by computing the Variance Inflation Factors (VIF) of the independent variables in the model. The highest correlation in the Pearson correlation coefficients was 0.56 (Natural Log of Average Household Size in the County and Natural Log of % Hispanic in a County). The highest VIF in the models was 4.30 (Population Density). Models were run with and without Population Density. The resulting pattern of results was the same in both runs with the exception of VMT Per 1,000 County Residents: a significant relationship was reduced below significance when Population Density was excluded from the model. The next highest VIF present in any of the models was 2.79 (Natural Log of the Median Household Income in the expanded model), which is below commonly used thresholds for problematic multicollinearity (Hair et al., 2009).

Results

Single-Variable Logistic Regression Models

Pairwise relationships were measured with single-variable logistic regression models, using each of the three county-level densities of interest as a predictor and restraint use by individual fatally injured occupants as the outcome. These single-variable models (Table 5) demonstrated a statistically significant positive relationship between the density of tourism locations and the lack of restraint use among crash fatalities. No statistically significant relationships were found between the densities of off-premises or on-premises alcohol locations and the lack of restraint use among crash fatalities.

Figure 7, Figure 8, and Figure 9 show bivariate choropleth maps of tourism locations, off-premises alcohol outlets, and on-premises alcohol outlets per 1,000 county residents with the proportion of crash fatalities in a county who were unrestrained (2012–2016). In these maps, purple counties are those with high densities of a location type and low proportions of unrestrained fatalities. Yellow counties have low densities of a location type but high proportions of unrestrained fatalities. Dark green counties are those with high densities of a location type and high proportions of unrestrained fatalities. Although the single-variable models were calculated at the level of individual crash fatalities rather than at the county-level, stronger positive relationships between the densities of interest and the lack of restraint use among crash fatalities should appear in the choropleth maps as more counties with colors along the positive diagonal (i.e., light, medium, and dark teal). Counties with zero fatalities or zero fatalities with known restraint use (2012 to 2016) appear in dark grey.

Table 5. Single-variable logistic regression models predicting restraint non-use in crash fatalities, 2012-2016

	Model 1		**Model 2**		**Model 3**	
Variable	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Density of Tourism Locations	1.23*	1.19 - 1.27				
Density of Off-Premises Alcohol Outlets			0.89	0.76 - 1.03		
Density of On-Premises Alcohol Outlets					0.98	0.93 - 1.03

N = 101,389 cases. *Note*: $^{*}p < 0.05$. OR = odds ratio. CI = confidence interval.

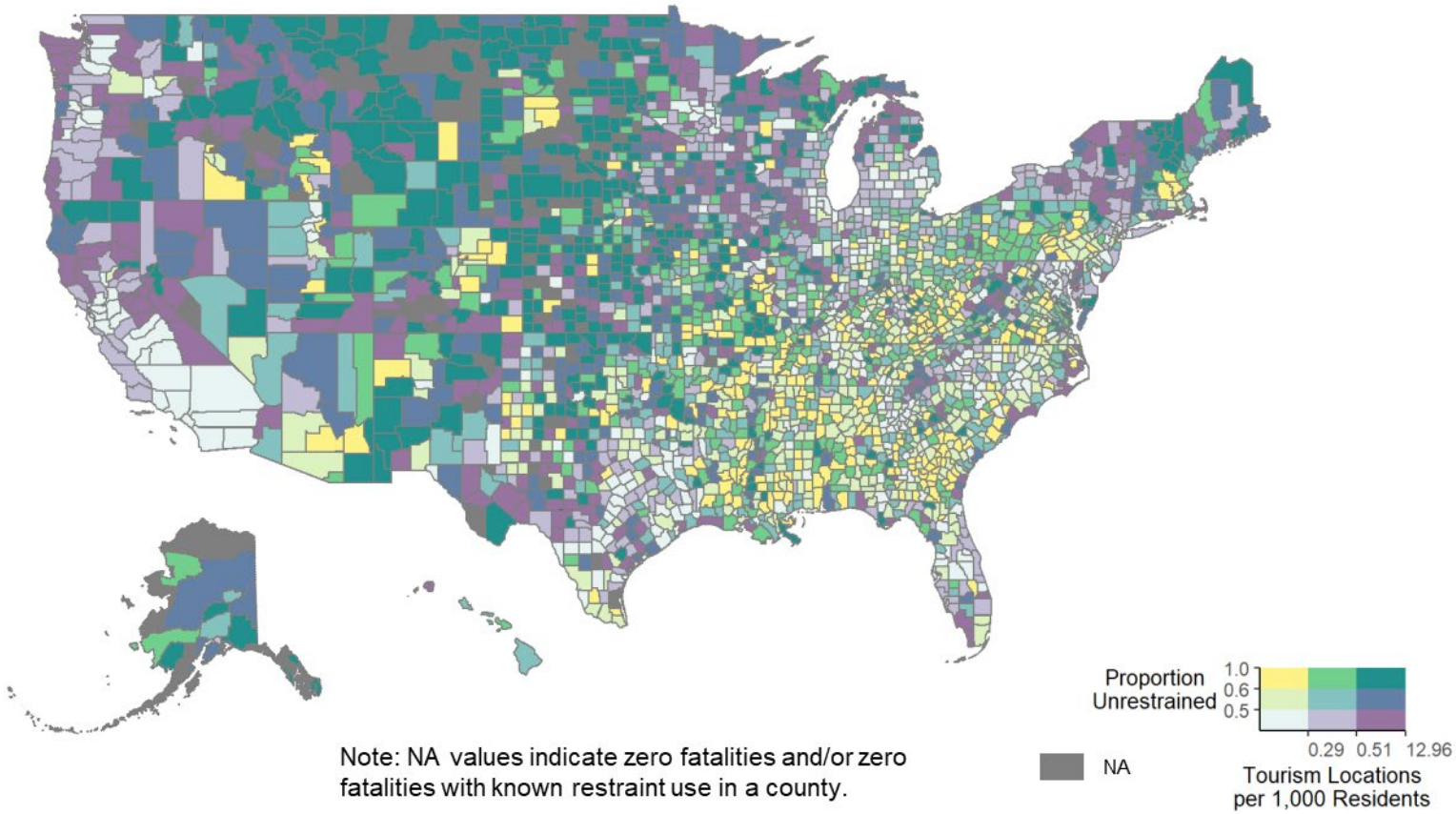

Figure 7. Proportion of crash fatalities in a county who were unrestrained by tourism locations per 1,000 county residents (2012–2016).

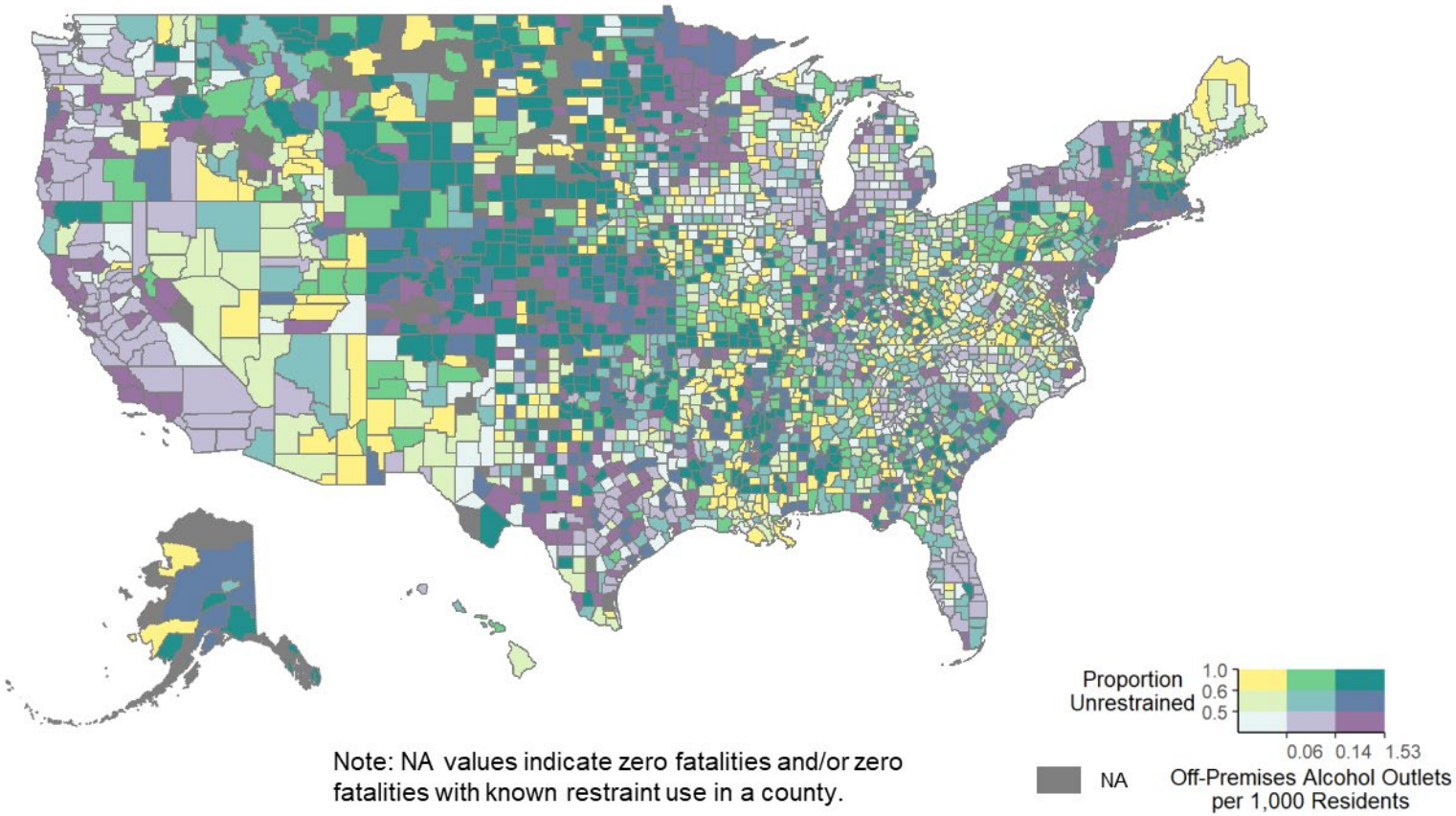

Figure 8. Proportion of crash fatalities in a county who were unrestrained by off-premises alcohol outlets per 1,000 county residents (2012–2016).

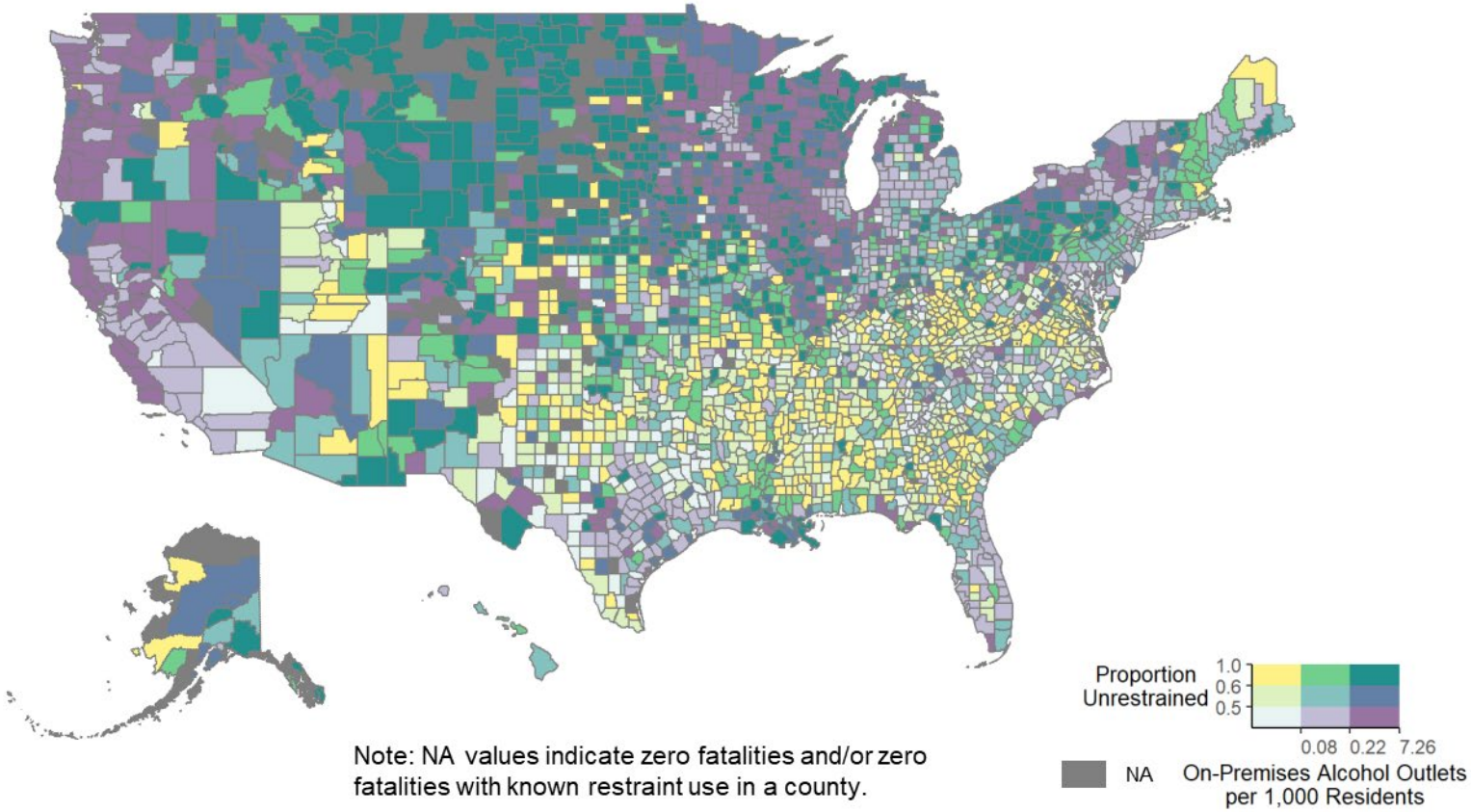

Figure 9. Proportion of crash fatalities in a county who were unrestrained by on-premises alcohol outlets per 1,000 county residents (2012–2016).

Base Logistic Regression Model

In addition to the density variables of interest, the multivariable base logistic regression model included the following covariates: Age and Sex (person-level covariates); % High School Graduates, % Unemployed, Median Household Income, % Non-Hispanic Black, % Hispanic, Average Household Size (county-level covariates); and Primary Enforcement in Front Seat (State-level covariate).

The Akaike Information Criterion (AIC) of the multivariable model was less than the AICs in the single-variable models, indicating that the model was a better fit than the single-variable logistic regression models.[5] With these added covariates, the relationship between the density of tourism locations and the lack of restraint use among crash fatalities was no longer statistically significant (Table 6). However, the relationship of the density of on-premises alcohol outlets with lack of restraint use was statistically significant and negative, and the relationship of the density of off-premises alcohol outlets with lack of restraint use was statistically significant and positive. Effects plots for lack of restraint by on- and off-premises alcohol outlets are presented in Figure 10 and Figure 11 and show the predicted probabilities of restraint non-use (plotted as a line) and 95% confidence intervals (shaded areas) for these variables.

Counties with higher densities of off-premises alcohol outlets were associated with a higher likelihood that someone fatally injured in a crash would be unrestrained. On-premises alcohol locations showed the opposite relationship: counties with higher densities of on-premises alcohol outlets were associated with a lower likelihood that a fatally injured person would be unrestrained.

[5] AIC is a measure of fit commonly used to compare a set of models with a common dataset and dependent variable. The model with the lowest AIC is considered the most parsimonious—the model with the greatest explanatory power with the fewest number of variables—of all the models tested (Christensen, 2018).

Table 6. Multivariable logistic regression models predicting likelihood of restraint non-use in crash fatalities, 2012-2016

	Base Model (*N* = 100,914)		**Expanded Model (*N* = 93,323)**		**Exploratory Fully Expanded Model (*N* = 93,323)**	
Variable	**OR**	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Density Measures of Interest						
Density of Tourism Locations	1.02	0.97–1.08	0.91*	0.85–0.98	0.87*	0.81–0.93
Density of Off-Premises Alcohol Outlets	1.38*	1.18–1.61	1.62*	1.35–1.93	1.77*	1.48–2.12
Density of On-Premises Alcohol Outlets	0.91*	0.85–0.96	0.88*	0.82–0.95		
Density of Bars					1.13*	1.01–1.27
Density of Dancing Drinking Places					0.74	0.22–2.44
Density of Stage Performance Drinking					2.68*	1.24–5.81
Density of Tasting Drinking Places					0.73*	0.66–0.80
Person-Level Covariates						
Age (ln)	0.67*	0.65–0.69	0.94*	0.92–0.96	0.94*	0.92–0.96
Sex						
Male (ref) vs. Female	0.60*	0.58–0.61	0.74*	0.72–0.76	0.74*	0.72–0.76
Seating Position						
Front (ref) vs. Back			1.98*	1.86–2.10	1.98*	1.87–2.10
Front (ref) vs. Other			14.17*	10.36–19.39	14.27*	10.43–19.53
Person Type						
Driver (ref) vs. Passenger			1.04	1.00–1.08	1.04	1.00–1.08
Crash- and Vehicle-Level Covariates						
Single Vehicle Crash						
No (ref) vs. Yes			2.43*	2.36–2.50	2.44*	2.37–2.51
Light Condition						
Daylight (ref) vs. Dark			1.42*	1.37–1.46	1.41*	1.37–1.46
Daylight (ref) vs. Dawn/Dusk			1.25*	1.17–1.35	1.25*	1.17–1.34
Speed Limit (ln)			0.70*	0.66–0.74	0.70*	0.66–0.74
Vehicle Age (ln)			1.37*	1.35–1.40	1.38*	1.35–1.41
Driver Drinking						
No (ref) vs. Yes			2.03*	1.96–2.10	2.02*	1.96–2.09
Driver Local						
No (ref) vs. Yes			1.22*	1.16–1.28	1.22*	1.16–1.28

Variable	Base Model (*N* = 100,914)		Expanded Model (*N* = 93,323)		Exploratory Fully Expanded Model (*N* = 93,323)	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
County-Level Covariates						
% High School Graduate (ln)	1.24*	1.15–1.33	1.19*	1.08–1.31	1.16*	1.05–1.27
% Unemployed (ln)	0.80*	0.76–0.84	0.77*	0.73–0.82	0.78*	0.74–0.83
Median Household Income (ln)	0.48*	0.45–0.52	0.52*	0.47–0.57	0.52*	0.47–0.58
% Non-Hispanic Black (ln)	1.04*	1.03–1.05	1.02*	1.01–1.04	1.02*	1.00–1.03
% Hispanic (ln)	0.89*	0.88–0.91	0.93*	0.91–0.95	0.93*	0.91–0.94
Average Household Size (ln)	1.74*	1.45–2.10	1.89*	1.55–2.36	2.00*	1.60–2.50
Rurality			1.00	0.99–1.01	1.00	0.99–1.01
Population Density (ln)			0.94*	0.93–0.96	0.94*	0.92–0.96
VMT per 1,000 People in County (ln)			0.92*	0.87–0.97	0.92*	0.87–0.97
State-Level Covariates						
Primary Enforcement in Front Seat						
Primary (ref) vs. Not Primary	1.75*	1.69–1.81	1.87*	1.78–1.95	1.86*	1.77–1.94
Primary Enforcement in Back Seat						
No (ref) vs. Yes			0.95*	0.90–0.98	0.94*	0.90–0.98
State Requires Adult Use in Back Seat						
No (ref) vs. Yes			1.05*	1.01–1.10	1.04	1.00–1.09
Region-Level Covariates						
Census Region						
South (ref) vs. Midwest			0.91*	0.87–0.95	0.88	0.84–0.92
South (ref) vs. Northeast			0.92*	0.86–0.98	0.91*	0.86–0.97
South (ref) vs. West			0.69*	0.65–0.73	0.67*	0.64–0.72
Constant	7.87*	7.50–8.24	7.74*	6.77–8.71	7.68*	6.71–8.66
Log Likelihood	-67,303.01		-56,657.79		-56,635.01	
Akaike Inf. Crit.	134,224.16		113,039.21		113,001.25	
Accuracy	60.4%		67.4%		67.3%	

Note: $^{*}p < 0.05$. ref = reference level for categorical variables. ln = natural log-transformed.

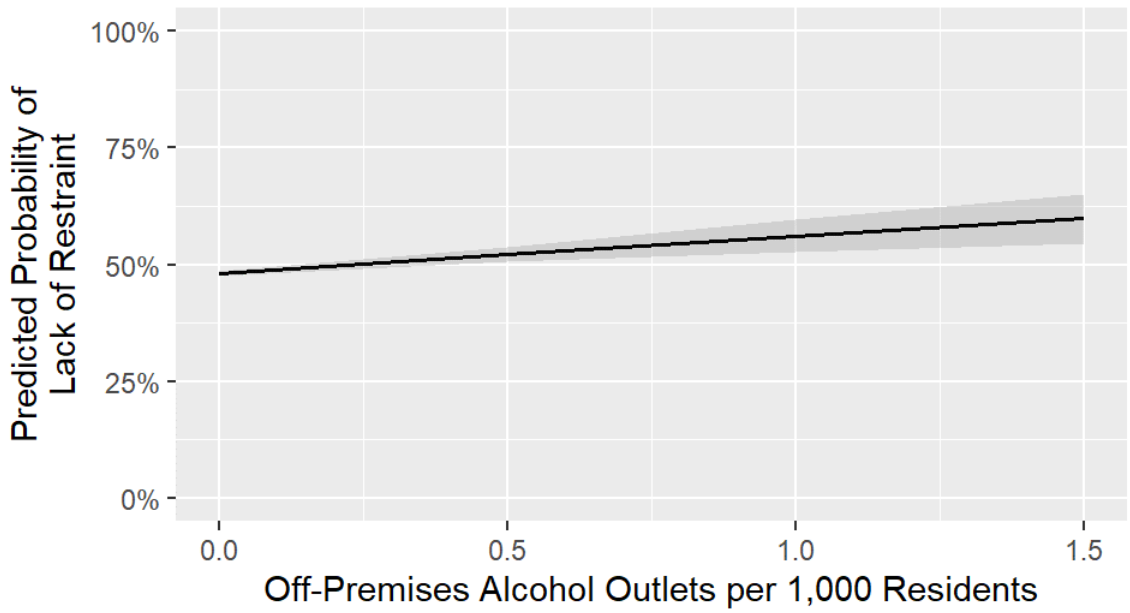

Figure 10. Predicted probability of lack of restraint by off-premises alcohol outlets per 1,000 county residents.

Figure 11. Predicted probability of lack of restraint by on-premises alcohol outlets per 1,000 county residents.

Expanded Logistic Regression Model

The multivariable base logistic regression model used simple individual characteristics and demographics to clarify the relationships between the density variables and lack of restraint use in fatalities. However, additional variables predict restraint use, including being the driver (Lerner et al., 2001), front-row seating (NCSA, 2020), alcohol involvement (Jewett et al., 2015), and light condition at the time of the crash (NCSA, 2020 April). In addition, rurality and regionality are known to predict restraint use (Strine et al., 2010). Thus, in the multivariable expanded logistic regression model, the following covariates variables were added: Seating Position and Person Type (person-level covariates); Single-Vehicle Crash, Light Condition, Speed Limit, Vehicle Age, Driver Drinking, and Driver Local (crash- and vehicle-level covariates); Rurality, Population Density, and VMT per 1,000 People in County (county-level covariates); Primary Enforcement in Back Seat and State Requires Adult Use in Back Seat (State-level covariates); and Census Region (region-level covariates).

The multivariable expanded logistic regression model had a lower AIC than the single-variable or base logistic regression models, making it the most parsimonious (i.e., best fit with the fewest variables) model (Table 6). The density of tourism locations was significantly negatively related to the lack of restraint use by those fatally injured in a motor vehicle crash. That is, in counties with higher densities of tourism locations, fatally injured people were more likely to be restrained.

The relationship of the density of on-premises alcohol outlets with lack of restraint use was also statistically significant and negative. That is, in counties with higher densities of locations that serve alcohol (e.g., bars, nightclubs, etc.), fatally injured people were more likely to be restrained. This finding is contrary to prior studies finding that alcohol consumption is associated with less restraint use (e.g., Li et al., 1999). As discussed in the Introduction, research findings have been mixed regarding the relationship between alcohol outlet density and motor vehicle crashes (e.g., Campbell et al., 2009), but Morrison and colleagues (2016) found a strong positive relationship between bar density and alcohol-related crashes.

Finally, the density of off-premises alcohol outlets was significantly related to the lack of restraint use in crash fatalities. In counties with higher densities of off-premises alcohol outlets (e.g., liquor stores, wine shops,) fatally injured people were less likely to be restrained. This result is consistent with previous literature that found higher densities of off-premises alcohol outlets to be positively associated with traffic injuries (Gruenewald et al., 2010).

Exploratory Fully Expanded Logistic Regression Model

In the multivariable expanded logistic regression model, both the density of tourism locations and density of on-premises alcohol outlets were associated with decreased likelihood of lack of restraint use, i.e., increased likelihood of restraint use among crash fatalities. Given prior studies on the relationship between alcohol consumption and seat belt use, and on density of bars and alcohol-related crashes, the latter finding is particularly surprising. To understand whether this contradictory finding was being specifically driven by a sub-type of on-premises alcohol outlet, the research team conducted an exploratory fully expanded logistic regression model in which the category of on-premises alcohol outlets was broken down into the following subcategories (by NAICS codes).

- Bars: Bars, Pubs, and Daiquiri Shops;
- Dancing Drinking Places: Discotheques and Nightclubs;
- Stage Performance Drinking Places: Cabarets, Comedy Clubs, Karaoke Clubs; and
- Tasting Drinking Places: Vineyards, Brewers, Wineries, Distillers, Tasting Rooms.

Bars were locations that provided alcohol for on-premises consumption and where drinking alcohol was presumed to be the primary function of the business. Dancing Drinking Places provide music for dancing, as well as serve alcohol. Stage Performance Drinking Places were those that offered entertainment (amateur or professional) in venues along with serving alcohol. Tasting Drinking Places might or might not produce alcohol. All on-premises alcohol outlet sub-categories, like the original on-premises alcohol outlet category, were density measures, i.e., number per 1,000 residents of the county. Basic descriptive statistics for these sub-categories can be seen in Table 7.

Table 7. Descriptive statistics on subcategories of on-premises alcohol outlets

	Range of densities among counties		**Counties with no places of this type[1]**	**Fatalities in counties with no places of this type[2]**	**Density in counties with fatalities**
Place type	*min*	*max*	*N*	*n*	*mean*
Bars	0	3.83	793	12,714	0.11
Dancing Drinking Places	0	0.33	2,416	51,073	0.007
Stage Performance Drinking Places	0	1.9	2,237	46,051	0.01
Tasting Drinking Places	0	7.17	1,510	26,571	0.04

[1]*N* = 3,143 counties in United States [2]*N* = 93,323 cases in expanded logistic regression model.

The final column of Table 6 shows the exploratory fully expanded model results. The density of dancing drinking places was not significantly related to the likelihood that crash fatalities would be unrestrained. The density of tasting drinking places was significantly negatively related to the lack of restraint in crash fatalities, i.e., higher densities of tasting locations in a county were associated with a lower likelihood of fatally injured people being unrestrained. Density of bars and density of stage performance drinking places, however, were both significantly positively related to the lack of restraint use by people fatally injured in crashes; a higher density of bars, and/or a higher density of stage performance drinking places, in a county was associated with a higher likelihood of fatally injured people being unrestrained. Figure 12, Figure 13, and Figure 14 show bivariate choropleth maps for each type of on-premises alcohol outlet that exhibited a significant relationship with the likelihood of a crash fatality being unrestrained.

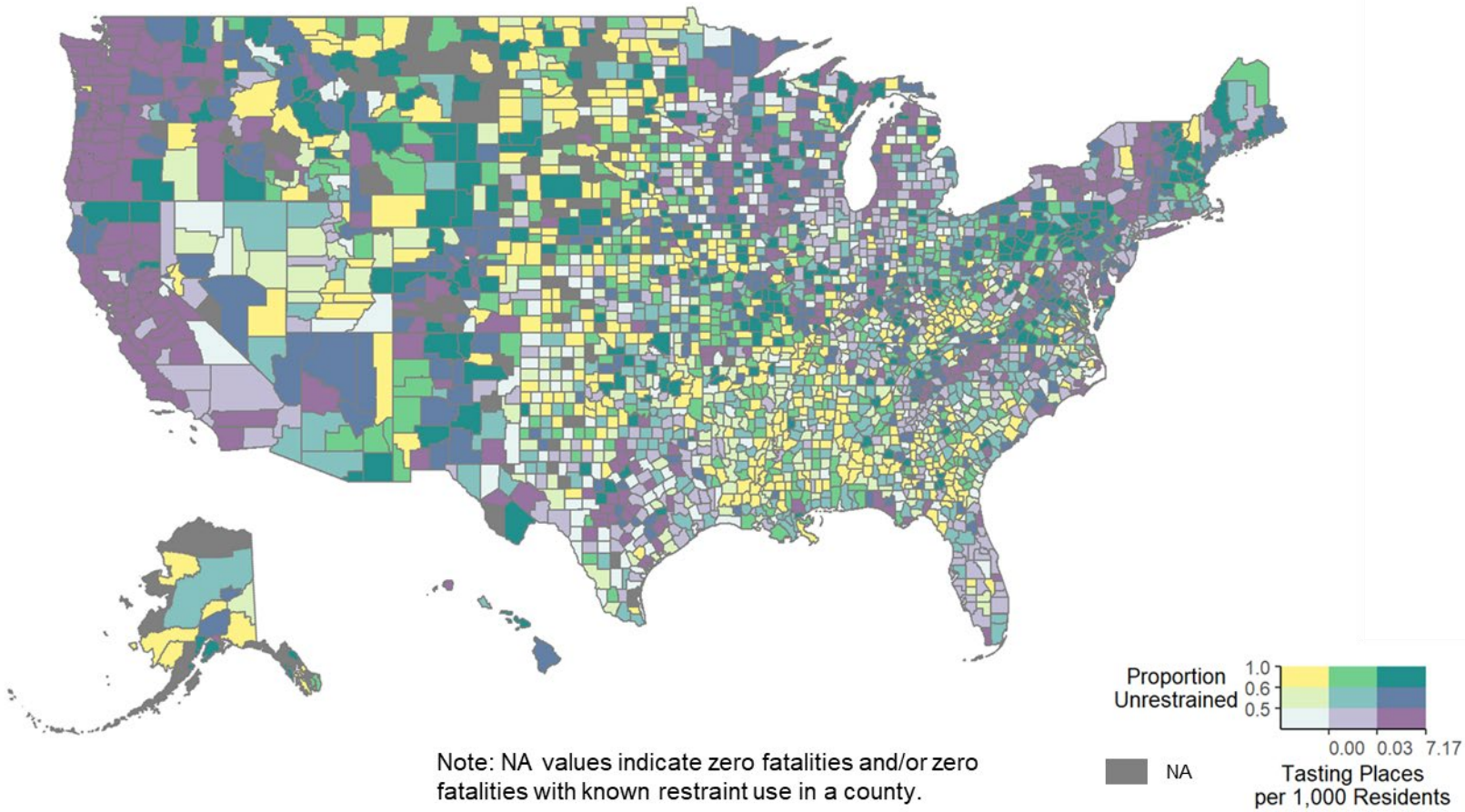

Figure 12. Proportion of crash fatalities in a county who were unrestrained by tasting drinking places per 1,000 county residents (2012–2016).

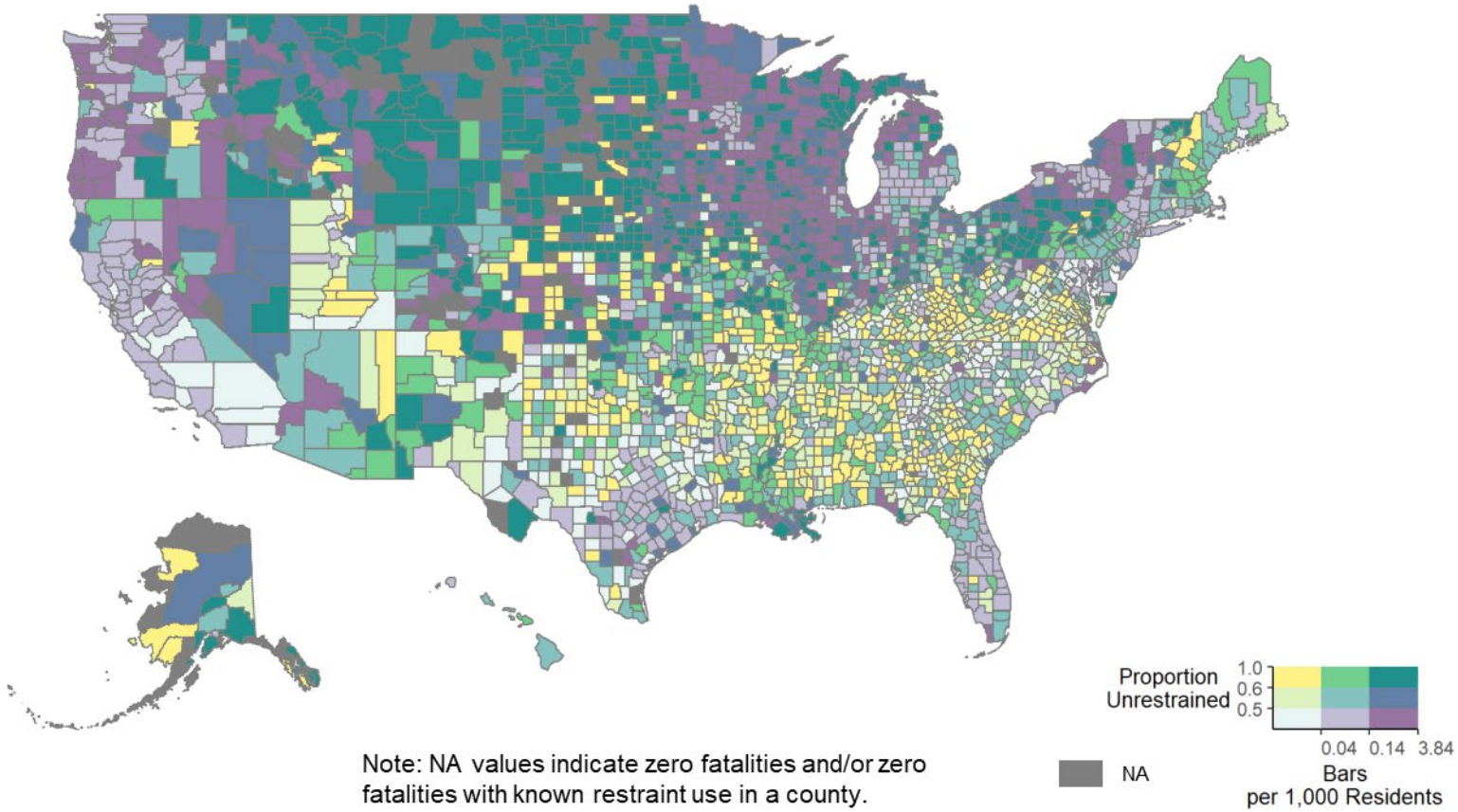

Figure 13. Proportion of crash fatalities in a county who were unrestrained by bars per 1,000 county residents (2012–2016).

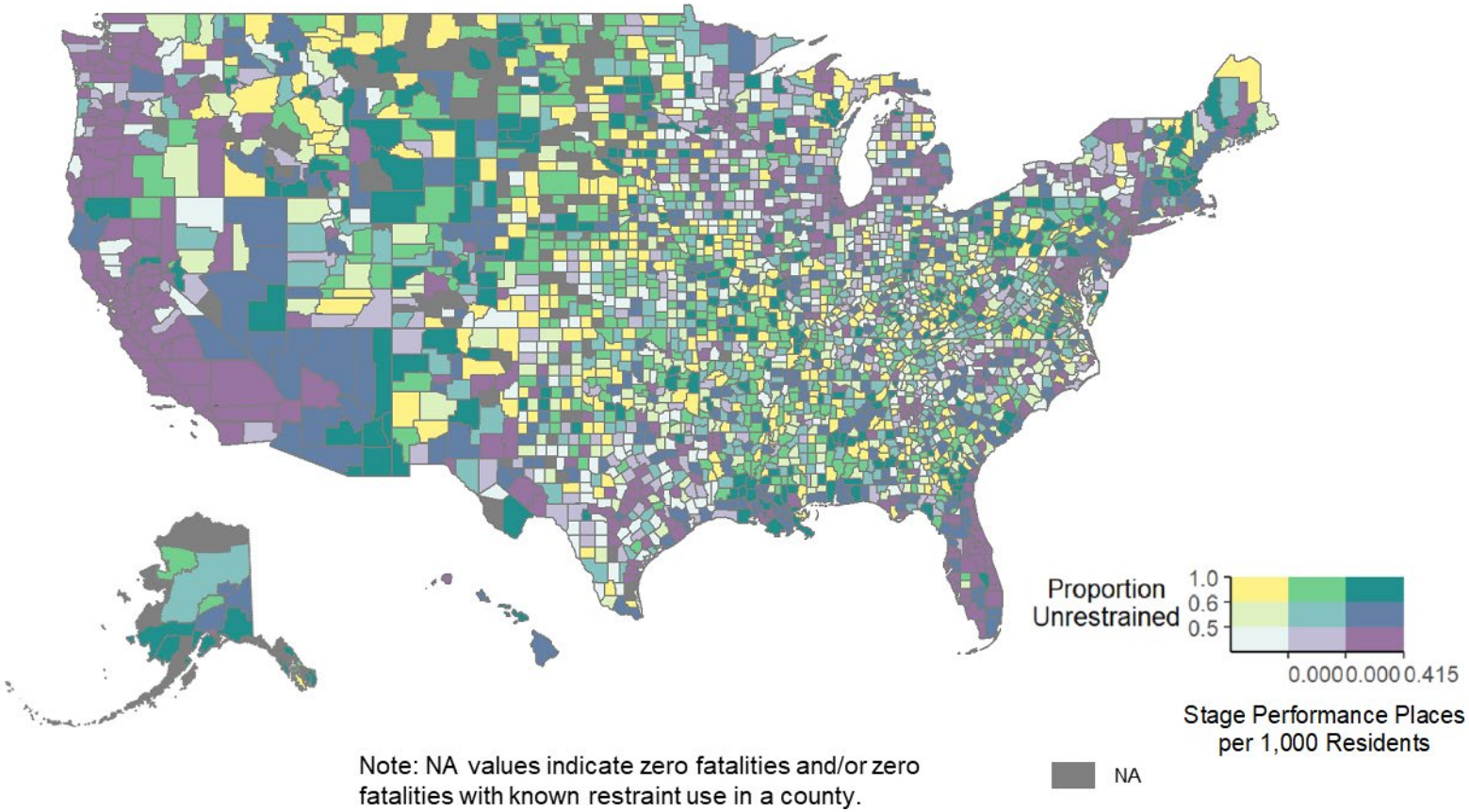

Figure 14. Proportion of crash fatalities in a county who were unrestrained by stage performance drinking places per 1,000 county residents (2012–2016).

Discussion

Given that unrestrained fatality rates vary significantly in counties across the United States, and that people's physical and community environments can shape their decisions and actions (e.g., Green & Kreuter, 2005), the current study sought to examine whether certain environmental and contextual characteristics of places predict restraint use among crash fatalities. In particular, the study examined the relationship between the densities of on-premises alcohol outlets, off-premises alcohol outlets, and tourism locations across counties and the likelihood that a crash fatality was unrestrained. Higher values on all three density measures were hypothesized to be associated with increased likelihood of unrestrained fatalities; however, support for these hypotheses was mixed.

Density of Off-Premises Alcohol Outlets Associated With Increased Likelihood of Unrestrained Fatality

Across the three multivariable models, the density of off-premises alcohol outlets in a county was positively related to the lack of restraint use in fatal motor vehicle crashes. This relationship remained even in the expanded model that included a covariate for whether the driver had been drinking (which itself was also positively related to likelihood of a fatality being unrestrained). One explanation for this result is that the density of off-premises alcohol outlets may be *indirectly* related to the lack of restraint use in crash fatalities. That is, counties with increased densities of off-premises alcohol outlets may also be associated with different cultural, environmental, or other characteristics that are themselves associated with lower rates of seat belt use—and increased likelihood of unrestrained fatalities.

Due to the retrospective nature of the current study, we cannot know whether increased densities of off-premises alcohol outlets in a county causally influence the likelihood that a fatality is unrestrained. Further, given the exclusion of restaurants, grocery stores, and convenience stores from the analyses, we cannot know whether the density of these establishments causally influences restraint use. However, prior research suggests that policy changes or regulations that limit alcohol outlet density could be a successful strategy to reduce excessive alcohol drinking and some associated harms such as crime, violence, injury, and medical harms (Campbell et al., 2009). In Western Australia, Chikritzhs and colleagues (2007) conducted a feasibility study to determine whether a model could be developed to inform regulatory control of the physical availability of alcohol using existing data to effectively measure the impacts of changes to licensed alcohol outlets. While recognizing the limitations of such a model and each community's uniqueness, Chikritzhs's group outlined models that could inform decisions about the number and location of licensed premises.

Density of Tourism Locations Associated With Decreased Likelihood of Unrestrained Fatality

Based on prior research we had hypothesized that the density of tourism places would be associated with increased likelihood of a fatality being unrestrained. This hypothesis was based on studies indicating that driving errors increase when a driver is unfamiliar with a route (e.g., Intini et al., 2019) and on the assumption that people visiting tourism locations may be unfamiliar with the area. However, the relationship between the density of tourism locations to the likelihood of unrestrained fatality was nonsignificant as a single predictor, significant and negative in the base model, and significant and negative in the expanded model. Therefore,

higher densities of tourism locations in a county were not associated with a higher likelihood that a fatally injured person was unrestrained.

Density of On-Premises Alcohol Outlets Associated With Decreased Likelihood of Unrestrained Fatality

In the current study both the base and expanded multivariable models found that increased density of on-premises alcohol outlets in a county was not associated with increased likelihood that a crash fatality was unrestrained—an unexpected result given prior research on the relationship between on- and off-premises alcohol outlet densities and crashes and risky behaviors. To explore this result, we used the fully expanded logistic regression model to determine if the observed association differed by sub-categories of on-premises outlets, i.e., bars, dancing drinking places, stage performance drinking places, and tasting drinking places. In this post-hoc, exploratory analysis, we found that the densities of bars and stage performance drinking locations—like off-premises alcohol outlets—were associated with increased likelihood of a fatality being unrestrained. On the other hand, increased dancing and tasting drinking places density in a county were not associated with increased likelihood that a fatality was unrestrained. Although preliminary, the results of our exploratory analysis suggest that the unexpected relationship between increased on-premises alcohol outlet density and decreased lack of restraint use in crash fatalities may reflect the results from a specific type of on-premises outlet, tasting drinking places.

The exploratory analysis found that the density of bars and stage performance drinking locations exhibited the expected association with increased likelihood of a crash fatality being unrestrained. The density of bars and stage performance drinking locations was associated with increased likelihood of unrestrained fatality offers an opportunity for the development of targeted interventions. Specifically, well-designed, well-executed, carefully evaluated mass media campaigns, when combined with other impaired-driving activities like high-visibility enforcement (HVE), are associated with a 13% reduction in alcohol-related crashes (Elder et al., 2004). The association between density of bars, stage performance venues, and off-premises alcohol outlets with increased likelihood of unrestrained fatality—over and above what is explained by knowing whether the driver was drinking—suggests that evaluation of mass media campaigns related to seat belt use be targeted at people visiting these types of alcohol outlets would be worthwhile.

Additionally, there is some evidence that changes to the density of on-premises alcohol outlets are associated with positive changes in alcohol-related behaviors. In the Buckhead neighborhood of Atlanta, researchers assessed the impact of reduced density (due to closure) of on-premises alcohol outlets, coupled with restrictions on when alcohol could be sold and increased enforcement of alcohol sales to minors (Zhang et al., 2015). Over 4 years a 3% reduction of on-premises alcohol outlet density was spatiotemporally associated with a reduction in violent crime exposure by nearly double. Although the measured outcome was not belt use, unrestrained fatalities, or even alcohol-related crashes, the study offers preliminary evidence that there may be public health benefits to reducing alcohol outlet density, in tandem with efforts to reduce alcohol availability.

Limitations

This study had several limitations. First, causality cannot be inferred from the retrospective, correlational analyses conducted. Because group membership cannot be randomly assigned, causality cannot be deduced and might, in fact, rest in one or more unmeasured variables. For example, vehicles were not randomly assigned to drive to tourism locations. Though a perception of unfamiliarity and increased risk might lead fatally injured vehicle occupants to use seat belts, it is also possible that tourism locations attract visitors who have characteristics often associated with seat belt use. It is also possible that the densities of interest in the current study reflect local cultural or environmental characteristics that are unmeasured but influence seat belt use. Critically, this limitation implies that reductions in the densities of off-premises alcohol outlets, bars, and stage performance drinking places may not necessarily reduce the likelihood that a crash fatality is unrestrained.

Another limitation of the current study is that place determinations by NAICS codes were defined broadly. For example, on-premises alcohol outlets included not just bars but also comedy clubs, karaoke clubs, wineries that offer tasting, cabarets, and nightclubs, and excluded restaurants. Tourism destinations included national parks, water parks, haunted houses, golf courses, marinas, concert venues, race tracks, museums, etc. The broad nature of these definitions may have created enough imprecision to mask more focal effects. For example, as seen in the exploratory fully expanded model, sub-categories of a place category may have different relationships with restraint use among crash fatalities. While the category of on-premises alcohol outlets offered some clear sub-categories for investigation, it is less clear what subcategories of tourism locations might be relevant.

Definitions of specific types of businesses also varied across States. Because of variation in State and local laws, a business that is considered a restaurant in one State might be considered a bar in another. Laws regarding alcohol vary across States and localities, and, like the broad definitions of locations, imprecision may obscure true effects.

Conclusions

In the current study, we found that increased density of off-premises alcohol outlets (i.e., businesses like liquor stores, where alcohol is purchased for off-site consumption) in a county was, as predicted, associated with increased likelihood that a crash fatality in the county was unrestrained. Contrary to our predictions, however, increased density of both tourism locations and on-premises alcohol outlets (i.e., businesses like bars, where alcohol is purchased for on-site consumption) in a county were not associated with increased likelihood that a crash fatality in the county was unrestrained. The post-hoc analysis found that while densities of bars and stage performance drinking locations exhibited the expected relationship with increased likelihood that a crash fatality was unrestrained, dancing and tasting drinking locations were not associated with increased likelihood that a fatality was unrestrained. Importantly, the observed association between lack of restraint use in a fatal crash and increased densities of off-site alcohol outlets, bars, and stage performance venues may reflect other local cultural or environmental characteristics that were not measured in the current study. However, these results suggest that awareness campaigns or seat belt enforcement at areas with higher densities of off-premises alcohol outlets, bars, and stage performance venues, potentially alongside alcohol-impaired driving efforts already focused on these areas, could be explored as a countermeasure for preventing unbelted fatalities.

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Appendix A: NAICS Codes Included in the Analysis

Off-Premises Alcohol Outlets

NAICS Code	Business type/description	Frequency in U.S.	Percentage of total
44531001	Beer & Ale-Retail	2213	6%
44531002	Cocktail Mixes	32	0%
44531004	Liquors-Retail	29202	80%
44531005	Wines-Retail	4875	13%

On-Premises Alcohol Outlets

Sub-Category	NAICS Code	Business type/descriptio	Frequency in U.S.	Percentage of total	Percentage of sub-
Tasting Places	111332	Vineyards	1659	3%	12%
	312120	Brewers (Mfrs)	4732	8%	33%
	312130	Wineries (Mfrs)	7100	13%	49%
	312140	Distillers (Mfrs)	628	1%	4%
	445310	Tasting Rooms	258	0%	2%
Bars	445310	Daiquiri Shops	19	0%	0%
	722410	Bars	34091	61%	98%
	722410	Pubs	592	1%	2%
Stage Performance	722410	Cocktail	4083	7%	93%
	722410	Comedy Clubs	254	0%	6%
	722410	Karaoke Clubs	40	0%	1%
Dancing	722410	Discotheques	27	0%	1%
	722410	Night Clubs	2771	5%	99%

Tourism Locations

NAICS Code	Business type/description	Frequency in U.S.	Percentage of total
56152001	Bicycle Tours	113	0%
56152002	Expeditions-Arranged & Outfitted	23	0%
56152003	Float Trips	6	0%
56152005	Skiing Tours	51	0%
56152011	Winery Tours	131	0%
56152013	Farm Tours	35	0%
56152014	Art Tours	2	0%
56152016	Golf Tournaments	38	0%
56152017	Bear Viewing	5	0%
56152018	Motorcycle Tours	7	0%
71111006	Theatres-Dinner	92	0%
71111007	Theatres-Live	6121	6%
71111011	Amphitheaters	49	0%
71119002	Carnivals	1767	2%
71119008	Fairgrounds	581	1%
71121203	Race Tracks	2594	3%
71121204	Motorcross Facilities	12	0%
71131001	Concert Venues	457	0%
71131002	Jai-Alai Frontons	3	0%
71131003	Stadiums Arenas & Athletic Fields	4860	5%
71131005	Event Centers	765	1%

NAICS Code	Business type/description	Frequency in U.S.	Percentage of total
71211001	Museums	17873	18%
71211005	Art Centers	867	1%
71211006	Planetariums	97	0%
71211007	Cultural Centres	158	0%
71212001	Historical Places	1724	2%
71212002	National Monuments	487	0%
71213006	Zoos	349	0%
71213007	Gardens	238	0%
71219001	Aquariums-Public	124	0%
71219004	Parks	23585	24%
71219005	Picnic Grounds	78	0%
71219006	Playgrounds	341	0%
71219007	Tourist Attractions	1042	1%
71219008	Forest Land	16	0%
71219009	Fishing Lakes & Ponds	432	0%
71311001	Amusement Places	1032	1%
71311002	Water Parks	286	0%
71311003	Haunted Houses	111	0%
71311004	Amusement & Theme Parks	376	0%
71311005	Corn Maze	3	0%
71312001	Arcades	468	0%
71321001	Casinos	2246	2%
71329006	Gaming Centers	60	0%
71391002	Golf Courses	16044	16%
71393007	Marinas	4670	5%
71393013	Boat Clubs	199	0%
71394003	Auditoriums	64	0%
71394005	Beach & Cabana Clubs	22	0%
71394010	Halls & Auditoriums	3687	4%
72119910	Skiing Centers & Resorts	622	1%
72121102	Recreational Vehicle Parks	2221	2%
72121407	Fishing Camps	171	0%
72121408	Fishing & Hunting Lodges	202	0%

Appendix B: Additional Visualizations

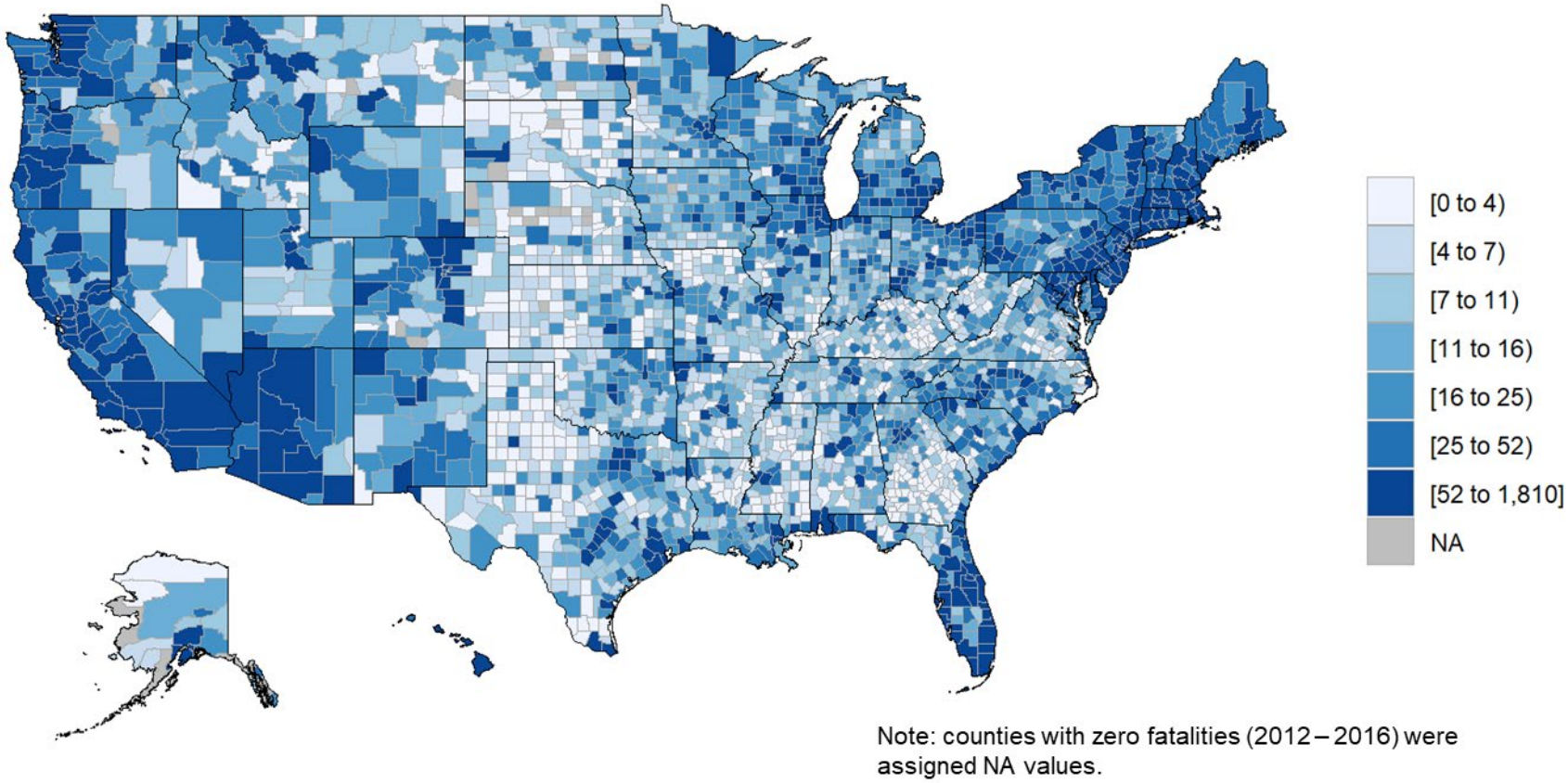

Figure B1. Raw number of tourism locations by county.

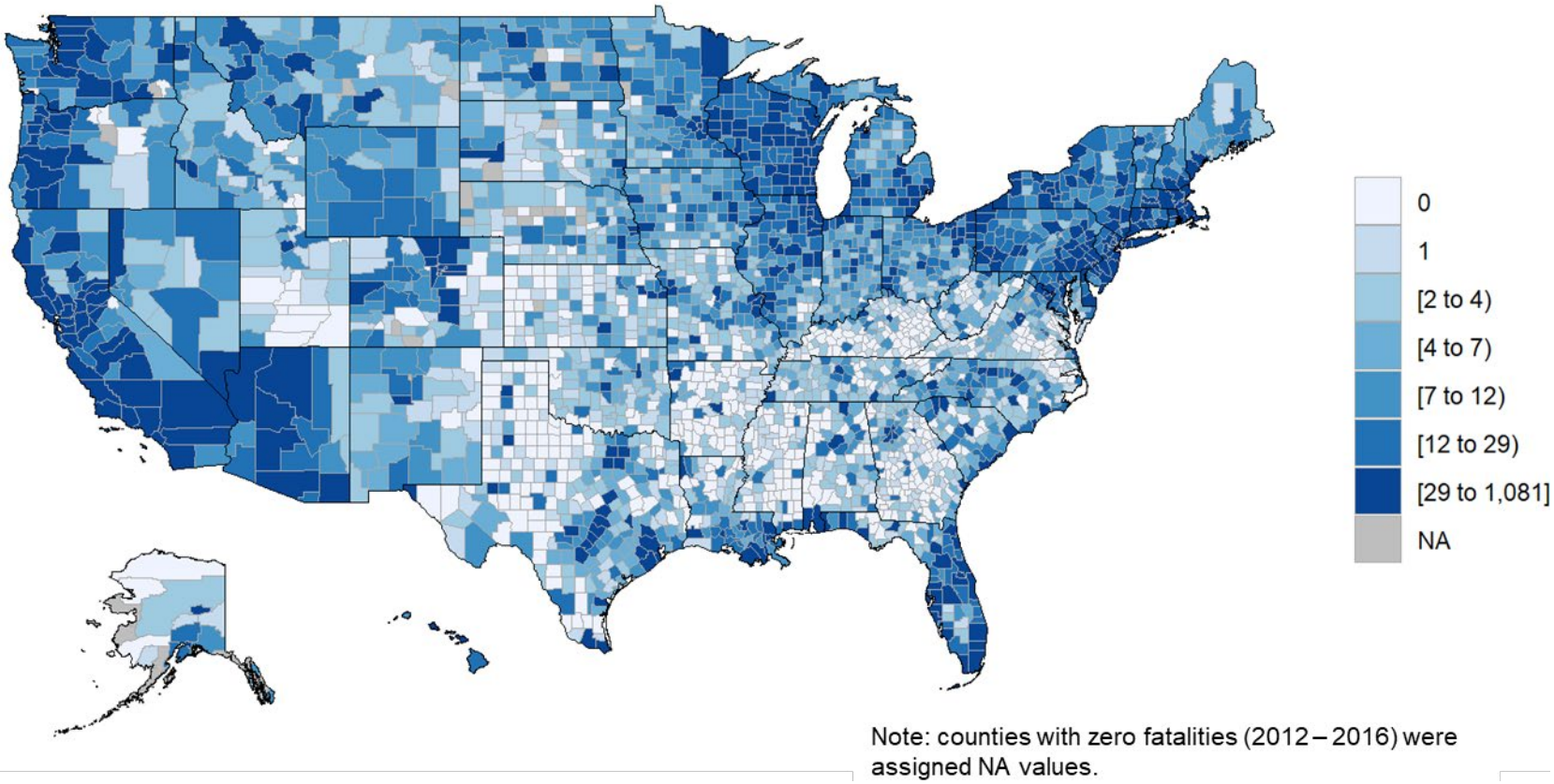

Figure B2. Raw number of on-premises alcohol outlets by county.

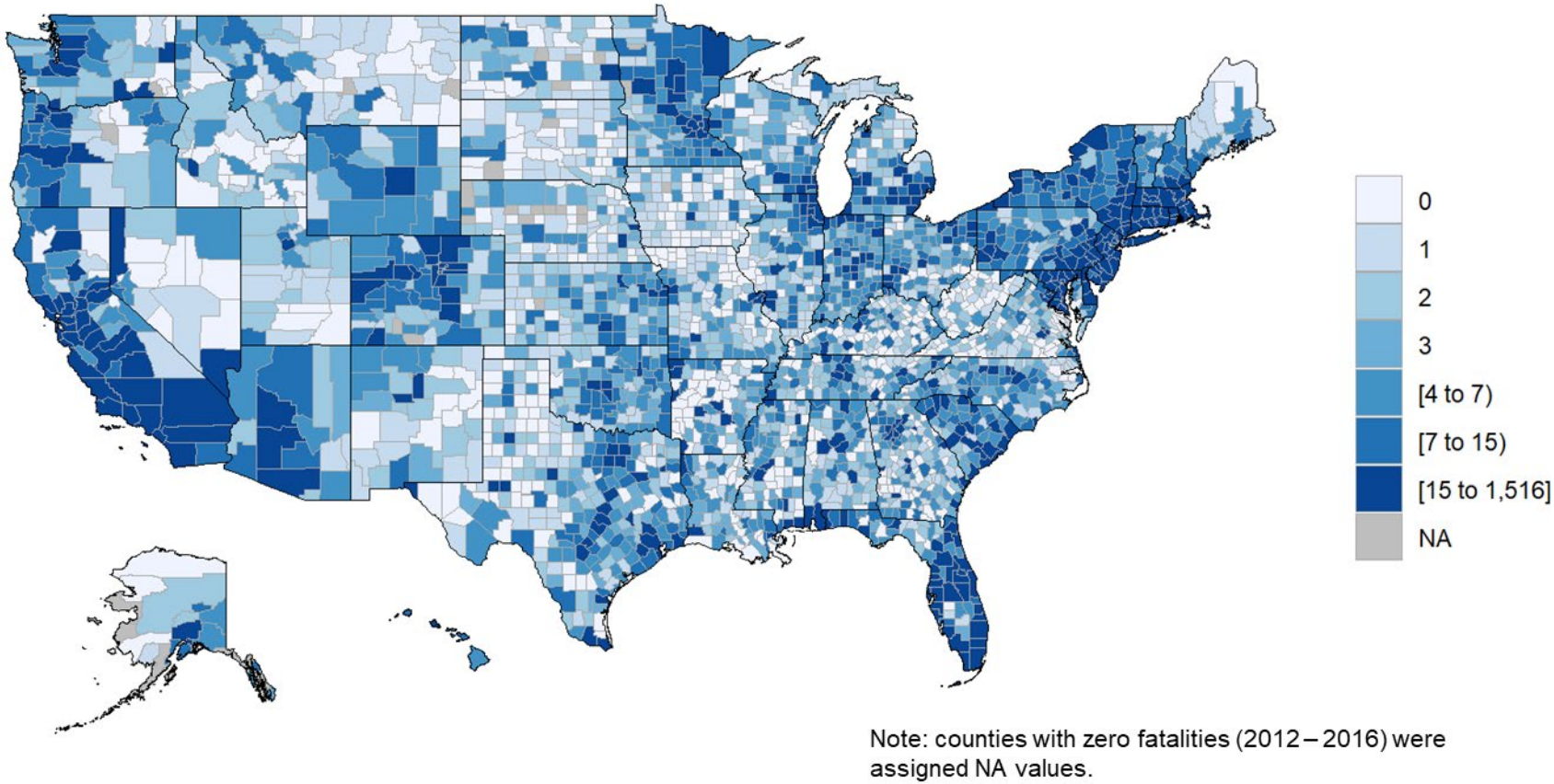

Figure B3. Raw number of off-premises alcohol outlets by county.

Appendix C: Covariate Sources

Variable	Source
Log of Age	FARS Data, variable P5/NM5 Age
Sex [Female, Male]	FARS Data, Variable P6/NM6 Sex
Seating Position	FARS Data, Variable P9 Seating Position (SEAT_POS). Combination of the row of the car and the position in the row; Either: -Front seat -Back seat -Other
Driver Drinking [Yes, No]	FARS Data, Variable V151 Driver Drinking (DR_DRINK)
Log of Speed Limit	FARS Data, Variable PC7 Speed Limit (VSPD_LIM)
Log of Vehicle Age	FARS Data, Variable V12 Vehicle Model Year (PMODYEAR) Created by subtracting this value from year of the crash
Driver Local [Yes, No]	FARS Data, This variable equals to "1" when the driver license state (Variable D5 Driver's License State (L_STATE)) is the same as the State in which the crash occurs (Variable P1/NM1 State Number (STATE))
Log of Unemployment Rate in County	2016 American Community Survey 5-year Estimates: Table S2301: EMPLOYMENT STATUS, Variable HC04_EST_VC01
Log of Percent Black in County	2016 American Community Survey 5-year Estimates: Table B02001: RACE, Created by dividing variable HD01_VD03 by variable HD01_VD01
Log of Percent Hispanic in County	2016 American Community Survey 5-year Estimates: Table B03003: HISPANIC OR LATINO ORIGIN, Created by dividing variable HD01_VD03 by variable HD01_VD01
Log of Percent High School Graduates in County	2016 American Community Survey 5-year Estimates: Table S1501: EDUCATIONAL ATTAINMENT, Created by dividing variable HC01_EST_VC11 by variable HC01_EST_VC08
Log of Median Household Income [in $1,000s] in County	2016 American Community Survey 5-year Estimates: Table B19013: MEDIAN HOUSEHOLD INCOME IN THE PAST 12 MONTHS (IN 2005 INFLATION-ADJUSTED DOLLARS), Variable HD01_VD01
Log of Average Household Size in County	2016 American Community Survey 5-year Estimates: Table S1101: HOUSEHOLDS AND FAMILIES, Variable HC01_EST_VC03
Census Region	U.S. Census Bureau

Variable	Source
Rurality	USDA Rural-Urban Continuum Codes (2013 Vintage)
Seat Belt Enforcement [Not Primary, Primary]	Governors Highway Safety Association, retrieved from: www.ghsa.org/state-laws/issues/Seat-Belts
Log of Population Density in County	Created Variable, population and county squared miles are sourced from Census data
Person Type [Passenger, Driver]	FARS Data, Variable P7/NM7 Person Type
Light Condition [Daylight, Dark, Dawn/Dusk]	FARS Data, Variable C25 Light Condition (LGT_COND)
Backseat Primary Enforcement in State [Yes, No]	Governors Highway Safety Association, retrieved from: www.ghsa.org/state-laws/issues/Seat-Belts
State Requires Adult Use in Backseat [Yes, No]	Governors Highway Safety Association, retrieved from: www.ghsa.org/state-laws/issues/Seat-Belts
Single Vehicle Crash [Yes, No]	FARS Data, Created from variable C4A Number of Motor Vehicles in Transport (MVIT) (PVE_FORMS). If PVE_FORMS=1, then crash was considered a single vehicle crash
Log of VMT per 1,000 County Residents	EPA's Motor Vehicle Emission Simulator (MOVES) System, MOVES2014b

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