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The relative risk of involvement in fatal crashes as a function of race/ethnicity and blood alcohol concentration

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Abstract

Introduction—The literature presents a puzzling picture of Latinos being overrepresented in alcohol-related crashes, but not in noncrash drinking and driving. This report examines if, like other demographic variables in which some groups are at a higher crash risk than others (e.g., young drivers), different racial/ethnic groups face different crash risks

Method—This study compares blood-alcohol information from the 2006–2007 U.S. Fatality Analysis Reporting System (FARS) with control data from the 2007 U.S. National Roadside Survey. Logistic regression, including a dual interaction between BAC and race/ethnicity, was used to estimate crash risk at different BAC levels.

Results—It was found that, although Hispanic and African-American drivers were less likely to be involved in single-vehicle crashes than their White counterparts, all drivers face similar BAC relative crash risk regardless of their group membership. The overrepresentation of Latino drivers in alcohol-related crashes could be explained by differences in patterns of consumption, driving exposure, lack of awareness of driving rules, and/or socioeconomics.

Keywords

Crash risk; drinking and driving; BAC; alcohol-related crashes; race/ethnicity

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1. Introduction

Despite the gains made in traffic safety over the past 20 years, some racial/ethnic groups in the United States are overrepresented in motor-vehicle fatalities (Hilton, 2006; Romano, Voas, & Lacey, 2010). There is ample evidence that the likelihood of involvement in alcohol-impaired driving events is not uniform across racial/ethnic groups. Whereas studies on the rates of impaired crashes have been consistent for American Indians and Asians, with elevated rates for the former and lower rates for the latter (e.g., Braver, 2001; Campos-Outcalt, Prybylski, Watkins, Rothfus, & Dellapenna, 1997; Schiff & Becker, 1996), contradictory findings have been published for African Americans and Hispanics (Romano, et al., 2010).

Reasons for such a discrepancy across racial/ethnic groups are unclear. Sociocultural elements—such as education or income (Caetano, Ramisetty-Mikler, & Rodriguez, 2008)—and cultural/ethnic factors—such as level of acculturation that may influence adherence to traffic laws (e.g., Cherpitel & Tam, 2000; Hunter, Wong, Beighley, & Morral, 2006), machismo attitudes of male drivers (Fiorentino, Berger, & Ramirez, 2007), religious beliefs about own destiny has been predetermined, fatalism beliefs (Byrd, Cohn, Gonzalas, Parada, & Cortes, 1999; Peltzer, 2003; Sanchez, Dillon, Ruffin, & De La Rosa, 2012), poor understanding of driving-under-the-influence (DUI) laws (e.g., Fiorentino, et al., 2007), or erroneous risk perceptions (e.g., Caetano & Clark, 1998; Cherpitel & Tam, 2000)—have been found or at least suggested to have contributed to the unequal representation by racial/ethnic groups in impaired-driving events. Genetically-based differences in alcohol sensitivity between Asians and Caucasians have been well documented. Differences in the prevalence of two enzymes, alcohol dehydrogenase (ADH) and acetaldehyde dehydrogenase (ALDH), could lead to racial differences in how the alcohol is metabolized (e.g., Chan, 1986; Ramchandani, 2013). Some researchers have suggested that differences in the rates of impaired driving across racial/ethnic groups are related, among others, to differences in the way members of different racial/ethnic groups perceive the associated risk. For example, Hispanics are less likely to consider impaired driving a safety problem (Caetano & Clark, 1998) or are less likely to believe they will be arrested or punished for impaired driving (Cherpitel & Tam, 2000). Fatalism (the perception by the driver that she/he has no control over the likelihood of a crash) has been reported more often among Hispanics and African Americans and is, therefore, another possible contributor to the impaired-driving problem (Caetano & Clark, 1998). Another suggestion indicates machismo as the reason for the much larger prevalence of impaired driving among Hispanic males (than among Hispanic females; Cherpitel & Tam, 2000). Misinterpretation of current traffic laws and regulations is another possible contributor to impaired-driving disparities (Voas, Torres, Romano, & Lacey, 2012; Zador, Krawchuk, & Voas, 2000b).

Interestingly, however, self-reported data paint a different picture for Latinos than that coming from crash or arrest data. In their review of the literature (Ross, Howard, Ganikos, & Taylor, 1991; Voas, et al., 2012), these scientists reported that the estimates of the prevalence of drinking and driving among African Americans (Ross et al., 1991) and Hispanics (Romano et al., 2010) tend to be smaller when based on self-reported data than when based on arrest or crash data. Drew, Royal, Moulton, Peterson, and Haddix (2010)

using the National Survey of Drinking and Driving Attitudes and Behaviors, Caetano and McGrath (2005) using the National Household Survey on Drug Abuse, and Chou et al. (2005, 2006) using the National Epidemiologic Survey on Alcohol and Related Conditions reported that the self-reported prevalence of driving-under-the-influence (DUI) events, such as “2 hours after drinking” or “driving after too much to drink,” was significantly lower for Hispanics than for Whites. Also using self-reported data, Quinlan, Brewer, Siegel, Sleet, Mokdad, Shults, and colleagues (2005) using the 1993, 1995, and 1997 Behavioral Risk Factor Surveillance System (BRFSS) found that African-American and Hispanic drivers reported drinking and driving in the past month less and as often as White drivers, respectively.

It has been argued that the reduced prevalence estimates of drinking and driving among Hispanics compared to that often coming from crash and arrest data could be caused by self-reported bias, with Hispanics underreporting drinking and driving more often than Whites (Bond & Cherpitel, 2004; Ross et al., 1991). However, data coming from the 2007 National Roadside Survey (NRS), a national survey of alcohol and drug use among U.S. drivers, supports the self-reported finding that Hispanics do not drink and drive more often than Whites. The 2007 NRS found no difference between the blood alcohol concentrations (BACs) of Hispanic, African-American, or White drivers (Lacey et al., 2009). Furthermore, self-report bias does not seem to occur when Hispanics self-report rates of DUI arrest, for the resulting prevalence was found to correspond to actual arrest data (Caetano & Clark, 2000).

Why does such a divergent prevalence among arrest and self-reported drinking and driving exist? It has been argued that Latinos and African Americans are overrepresented in DUI arrests, not because they drink and drive more often than Whites, but because of the stronger presence of law enforcement in areas where Hispanic Americans and African Americans often drive (Caetano, 1984a; Caetano & Clark, 1998; Herd, 1994; Hyman, Helrich, & Besson, 1972; Lapham, Skipper, Chang, Barton, & Kennedy, 1998; Wallace, 1999). An alternative explanation could be that Hispanics and African Americans tend to drink and drive less frequently but consume a higher volume per occasion, therefore more often being highly intoxicated when they drink and drive than members from other groups. This argument also could explain the already-noted racial/ethnic discrepancies between DUI driving and DUI arrests. Evidence for this “drink and drive less often/but highly intoxicated when done” argument is highly contradictory, as revealed in a literature review by Romano, Voas, and Lacey (2010).

Not considered in the previous discussion is the possibility that the overrepresentation of Latinos and other groups in alcohol-related crashes (but not on actual driving) is caused by them being riskier drinking drivers than are drivers of other groups. In other words, it is possible to argue that inaccurate risk perception and driving inexperience may induce some drivers to be more prone to a crash with a positive BAC than others. Erroneous risk perceptions associated with DUI have been shown to be present among Hispanics (e.g., Lacey et al., 2009; Voas et al., 2012). To our knowledge, the intriguing possibility that drivers of different racial/ethnic membership may face a different crash risk at identical BAC levels has never been examined. The relevancy of such examination is apparent, for its

outcome could indicate the relative importance of the alternative arguments previously discussed. For instance, compared with drivers of other groups, Hispanic and African-American drivers were found at a higher crash risk when driving at high BAC levels. Thus, differences in exposure to drinking and driving (e.g., Hispanic and/or African-American drivers drinking and driving less frequently but consuming a higher volume per occasion) should not be viewed as the main cause for the observed discrepancies. On the other hand, if all drivers regardless of their racial/ethnic membership were found to be facing similar crash risk when driving at high BAC levels, then the importance of an exposure-based argument should not be minimized. Examining differences in crash risk is the focus of this effort.

More specifically, the aims of this manuscript are twofold. First, we examine and test whether drivers of different racial/ethnic membership are at a different risk of being killed in a fatal crash. Second, we analyze whether the BAC-based relative crash risk (RR) curve (i.e., if the crash risk a driver face at a certain positive BAC relative to that at BAC=.00) is the same for drivers of any racial/ethnic group, after adjusting by demographics. Thus, the first aim focuses on examining overall racial/ethnic differences in crash risk, and the second aim analyzes the possible role of alcohol on those differences.

To pursue the manuscript's aims, we will follow Zador and colleagues (2000a) and Voas et al., 2012). Following these efforts, this study combines U.S. data from the 2007 NRS with contemporaneous data from the Fatality Analysis Reporting System (FARS) to determine the RR of crash involvement as the driver's BAC rises from BAC = .00%. Neither Zador et al. (2000b) nor Voas et al. (2012), however, examined the role that race and ethnicity may play in shaping the BAC RR curve. This manuscript addresses that gap.

2. Methods

The analytical strategy applied by this effort follows closely that applied by Voas et al. (2012). As such, data for this study were obtained by merging driving information collected by the 2007 NRS (Lacey, et al., 2009, 2010) with comparable crash data from the 2006 and 2007 FARS.

2.1 Crash Exposure

The 2007 NRS collected information on nighttime drivers of noncommercial motor vehicles on Fridays and weekend nights in survey sites selected from 60 primary sampling units (PSUs) of the National Analysis Sampling System/General Estimates System (NASS/GES) of NHTSA. Survey locations were selected by placing a 1-mile grid over the area patrolled by the police department and randomly selected square-mile areas that contained safe off-road locations to conduct the survey. Drivers were randomly selected from the traffic flow and recruited for participation in the survey (Lacey, Kelley-Baker, Furr-Holden, Voas, & Romano, 2008). Surveys were conducted during 2-hour periods from 9:30 to 11:30 a.m. and 1:30 to 3:30 p.m. on Fridays, and from 10 p.m. to midnight and 1 to 3 a.m. on Fridays and Saturdays. Among other characteristics, the 2007 NRS collected information on the drivers' demographics (age, gender, race, and ethnicity). Also, it used a preliminary breath-test (PBT) device to measure BACs. Approximately 5% of the BAC information in the target population of the 2007 NRS was missing because of refusals to participate or logistical

problems. The missing BACs were imputed using a single imputation technique based on a two-stage procedure as described in Lacey et al. (2009). A total of 6,659 drivers from the 2007 NRS were available for this study.

2.2 Crash Data

The 2006 and 2007 FARS, a census of motor-vehicle traffic crashes that resulted in a fatality within 30 days of the crash, served as the source of cases for this pseudo case-control study. In addition to the drivers' characteristics collected in FARS, the database informs about the drivers' BACs. In 2006 and 2007 FARS, about 40% of the BACs in the target population (drivers involved in fatal crashes) are missing. Rubin, Schafer, and Subramanian (1998) suggested multiple imputation as a technique to handle missing BACs. Accordingly, the 2006 and 2007 FARS databases include separate files with the 10 imputed BAC values for each year. To make both databases comparable, FARS records were selected according to the 2007 NRS inclusion criteria. As such, we considered only FARS records for drivers of four-wheeled passenger vehicles (a) who were between the ages of 16 and 97 years; (b) who were involved in crashes that occurred on Fridays and Saturdays between 10 p.m. and 3 a.m.; (c) whose crash occurred outside of Indian country on paved roads not classified as an Interstate, other urban freeway, or expressway; and (d) whose crash occurred in counties with a population of at least 20,000 in 2006 and 2007. Crash risk was separately estimated for single-vehicle, two-vehicle, and any number of vehicle fatal crashes. A detailed description of the methodology appears in Voas et al. (2012).

2.3 Race/Ethnicity

We applied the following categories for race/ethnicity: *Latino, Non-Latino Black, Non-Latino White,* and *Other Race and Non-Latino*. For the 2007 NRS, information on race/ethnicity was largely self-reported. About 2.3% of the participants (n=138) failed to provide this information. For these drivers, an observational estimation of the drivers' race and ethnicity was used. To confirm the adequacy of this imputation, we applied a Goodman and Kruskal's lambda (λ) to measure the association between the self-reported and the observed racial/ethnic variables. Albeit not perfect, a symmetric lambda coefficient of 0.53 suggests that the observed race/ethnicity can adequately be used to impute the missing self-reported data, particularly because it only affects 2.3% of the 2007 NRS database. For 2.3% of the drivers in the 2007 NRS, neither self-reported nor observed information was available. Those drivers were excluded from our analyses.

For the 2006–2007 FARS, race/ethnicity and Hispanic origin information has been collected only for fatalities since 1999 (Watt, 2004). Nonetheless, in the 2006–2007 FARS, about 14% of the drivers' records used in this study have no race/ethnicity and Hispanic origin information. Those records were also excluded from the analyses. Interestingly, we found no significant difference in the BAC distribution between drivers who provided race/ethnicity information and those who did not provide that information in the FARS (chi-square p-values for testing significant differences between the BAC distributions for both groups are about .80 for single-, two-, and all-vehicle crashes).

2.4 Logistic Regression Models

As in the Voas et al. (2012) study, we applied logistic regression to estimate the odds ratio (OR) of a fatal vehicle crash given the explanatory variables. Odds ratios provide accurate estimates of RR when the frequency of the targeted disease (e.g., crashes) is small relative to the exposed population (Agresti, 2002). Here a fatal crash is considered a "rare" event given the drivers' exposure, such as Voas et al. (2012) argued. In this manuscript, we therefore use the acronym "RR" or "OR" interchangeably when referring to results from our logistic regressions. The dependent variable was defined by a driver being in a crash (case) or exposure (control) file. The probability of being in a fatal crash was modeled as a function of the driver's BAC, controlling for possible confounders, such as gender, age, and race/ethnicity. Main effects and all dual interactions were examined. Dual interactions between the continuous BAC and the variables of interest (race/ethnicity) were included to test the hypotheses of interest. If declared significant, the dual interaction would indicate that the drivers' BAC RRs vary with their race/ethnicity.

An aspect worth mentioning is that the BAC exhibits a semi-continuous distribution with a point-mass at zero BAC and a right-skewed distribution for positive BAC values for both controls and crashes. The point-mass at zero is about 88% and 6% in controls and crashes, respectively (see Table 2). To handle this asymmetric and non-smooth distribution , we also (a) fit the models using a categorical version of the BAC, and (b) fit the models by truncating some points lying far away from the space design (i.e., potential high-leverage points). However, the final conclusions when considering these alternative models were not different to those mentioned in the manuscript, therefore, the results of these models are not further discussed.

Estimates of coefficients and standard errors in the logistic models incorporated the sampling weights and the sample design in 2007 NRS, as described in Voas et al. (2012). Appropriate handling of the multiple imputed BACs from 2006–2007 FARS were also considered by estimating the standard errors of the model coefficients using the suggested formulas from multiple imputation theory (Subramanian, 2002). These formulas take into account the variation generated by estimating 10 possible BAC values for each driver. That is, the coefficients in the logistic regression models to estimate the OR of a fatal injury were estimated for each imputed data set. The resulting estimates from the 10 imputed data sets were combined to obtain the final estimates reported in Table 4.

3. Results

The distribution of drivers in single-vehicle crashes, two-vehicle crashes, and any number of vehicle crashes (2006–2007 FARS) and controls (2007 NRS) by race/ethnicity in the matched file is given in Table 1. The plurality of noncrashed drivers was White (47%), followed by Latinos (23%), and African Americans (18%). The race/ethnic distribution of drivers involved in single-vehicle and two-vehicle crashes is significantly different from that for noncrashed drivers (chi-square p-value < .0001 for single-vehicle crashes, and chi-square p-value < .0001 for two-vehicle crashes). Compared to control drivers, White drivers are overrepresented in single-vehicle, two-vehicle, and all crashes, whereas Latino and African-

American drivers are somewhat underrepresented in single-vehicle crashes, but they exhibit similar representation in two-vehicle crashes when compared to control drivers.

Thus, our initial, unadjusted examination of racial/ethnic differences in crash risk (first aim of this effort) shows an overrepresentation of White drivers (and an underrepresentation of Latino and African-American drivers) in single-vehicle crashes and a less remarkable underrepresentation of White drivers (and slightly higher representation of Latino and African-American drivers) in two-vehicle crashes. Because of the larger presence of alcohol in single-vehicle crashes than in other crashes, it could be argued that the noted racial/ethnic differences in single-vehicle crashes are related largely to the level of the BAC. This possibility, which is central to the manuscript's second aim, is explored in Tables 2 and 3.

Table 2 presents the percentage of drivers in single-vehicle crashes for each of the racial/ethnic groups and the following BAC categories: .00%, .001%–.079%, and .08% and higher. Those percentages were calculated separately for the exposure and crashed drivers, taking into account the 2007 NRS sampling weights and the multiple imputation procedures suggested by the FARS manual (NHTSA, 2010). The prevalence of BAC-positive (BAC > .00%) drivers among the exposed (noncrashed) Latino, African-American, and White drivers was statistically nonsignificant (chi-square *p*-value = 0.76). About 12% of the exposed (noncrashed) Latino, African-American, and White drivers had a positive BAC (i.e., BAC > .00%). No statistical difference in the prevalence of BAC ≥ .08% drivers among these groups was found (chi-square *p*-value = 0.95). Thus, the broad racial/ethnic differences we noted among exposed and single-vehicle crashed drivers in Table 1 do not occur for alcohol (Table 2).

A first analytical effort of the data for single-vehicle crashes presented in Table 2 produces some crude estimates of the OR of a fatal crash for the two positive BAC categories (e.g., .001%–.079%, ≥.08%) relative to sober drivers (BAC = .00%) from the same race/ethnicity. The unadjusted estimates and their respective 95% confidence intervals are shown in Table 3. Based on these unadjusted point estimates and compared to the crash risk drivers face at BAC=.00%, it seems that Latinos driving at BAC ≥ .08% face a higher crash risk (OR = 186.9) than that faced by other racial/ethnic groups (OR = 173.2 and 171.2 for African Americans and Whites, respectively). However, a more detailed examination of the confidence intervals of these OR estimates does not support the statement of differential OR among racial/ethnic groups. Adjusted analyses presented in Table 4 confirm this result.

Table 4 lists the outcome of the logistic regression, the coefficient estimates, and their respective standard errors. Three models were fitted. Models 1, 2, and 3 in Table 4 inform about crash risk associated to fatal crashes in which either a single vehicle (Model 1), two vehicles (Model 2), or any number of vehicles were involved in the crash (Model 3). Table 4 shows main effects of gender, age group, race/ethnicity, continuous BAC, and some dual interactions. Although all dual interactions were examined in each of the three models, those not involving BAC were excluded from Table 4 because they were not significant. When studying the possible interaction between race/ethnicity and BAC, we considered the BAC as both a continuous and a categorical variable (.00%, .001–.079%, and .08% and higher).

The latter case aimed to explore the role of BAC without assuming a specific functional form (e.g., linear).

Table 4 reproduces some well-known results, such as women (particularly in single-vehicle crashes) and older drivers being less likely to be involved in crashes than men and underage drivers (i.e., aged 16 to 20 years), respectively. As expected, BAC also is a significant contributor to crash risk in any type of model. The significant factor "0<BAC<0.019, age 21+" represents the effect of low BACs (< .019%) and underage drivers. The last term is called the "dip effect" in the Grand Rapids study (Carr, Borkenstein, Perrine, van Berkom, & Voas, 1974), and it serves to adjust the RR between drivers who have low BACs (< .019%) and drivers who are sober belonging to the underage group (Zador et al., 2000a).

Regarding the contribution of the different racial/ethnic groups to crash risk (first aim of this effort), the outcome of the regression analyses largely mimics the findings of the bivariate analyses (Table 1): Hispanic and African-American drivers were less likely to be involved in single-vehicle crashes than were their White counterparts. Among two-vehicle crashes, no difference between Hispanic and White divers was found.

For the second aim of this effort (i.e., to examine whether the crash risk a driver faces at any positive BAC relative to that at BAC = .00% is the same for drivers of any racial/ethnic group), we tested the significance of the BAC by racial/ethnic interaction. If that dual interaction were statistically significant, then we could assume that given a certain BAC, drivers of different racial/ethnic membership face a different crash risk. Table 4 shows that no BAC by race/ethnicity was statistically significant in any of the models. We therefore found no evidence that the RR of a fatal crash as a function of BAC changed with the driver's race/ethnicity. This result coincides with the discussion based on the crude estimates of OR given in Table 3.

Finally, the model for single-vehicle crashes fits better than the model for two-vehicle crashes and any number of crashed vehicles. For single-vehicle crashes, the max-rescaled R^2 for the logistic model in Table 4 is about 0.70, and it is 0.38 for two-vehicle crashes and 0.65 when all crashes are considered. This finding emphasizes once more that single-vehicle crashes and two-vehicle crashes are determined by an array of factors, some of which are particular to each crash type. Further, the model we applied in this effort captured most of the variations in single-vehicle crashes but some factors remained unaccounted for in the two-vehicle or any-vehicle crashes. Such a difference between the model fitting for single-vehicle and two-vehicle crashes relates to the higher prevalence of drinking and driving among drivers in single-vehicle crashes. In other words, although alcohol explains much of the variation in single-vehicle crashes, the relative lower prevalence of alcohol in two-vehicle crashes left some of the variation unexplained for these crashes. This is partly confirmed by the larger predictive power of a model containing only BAC as a predictor in single-vehicle crashes when compared to that in two-vehicle crashes (max-rescaled R^2 = 0.69 and 0.35 for a logistic model with BAC only for single-vehicle and two-vehicle crashes , respectively).

4. Discussion

This report explores the hypothesis that the crash risk drivers face at specific BAC levels relative to BAC = .00% is similar across racial/ethnic groups. We found no evidence to reject this hypothesis. Our finding points out that whatever the reasons, the overrepresentation of some groups in alcohol-related crashes does not occur because drivers of some groups tend to be riskier at specific BAC levels than other drivers.

Although apparently a trivial finding (i.e., alcohol has a similar deleterious impact on all drivers, regardless of their race and ethnicity), our finding departs from what has been reported for other demographic variables. There is ample evidence showing that drivers of different ages face dissimilar crash risk at similar BAC levels. There is ample evidence showing that young drinking drivers face a higher crash risk than older ones (e.g., Peck, Gebers, Voas, & Romano, 2008; Voas, et al., 2012). Regarding gender,Zador et al. (2000a) reported that at similar BAC levels, young female drivers tend to be at a higher crash risk than their male counterparts. Although such a gender gap seems to have been erased recently (Voas et al., 2012), the evidence shows that at similar BAC levels, drivers of different ages and genders (particularly the former) are at different alcohol-related crash risk. That is not the case for drivers of different racial/ethnic groups.

As mentioned in the introduction, one of the merits of this effort is to assess the relative importance of alternative arguments that were proposed to explain extant contradictions in the literature. Of particular interest was the examination of the validity of arguments that favor racial/ethnic differences in drinking-and-driving exposure as the main reason for the observed discrepancies in alcohol-related crashes. As we argued, if compared with drivers of other groups, Hispanic or African-American drivers had been found at a higher crash risk when driving at high BAC levels, then differences in exposure to drinking and driving could not be regarded as the main cause for such discrepancy. By finding that all drivers face similar crash risk when driving at high BAC levels regardless of their racial/ethnic membership, we argue that the importance of exposure-based explanations for their divergent involvement in alcohol-related crashes should not be discarded.

The question then remains: Why are drivers of some racial/ethnic groups more represented in alcohol-related fatal crashes than are others? According to our findings, the reasons for this discrepancy could be found in differences in drinking-and-driving exposure. For African Americans and Latinos, their patterns of lower frequency but higher volume of alcohol consumption described for African-American and Latino groups (e.g., Byrd et al., 1999; Caetano & Clark, 1998; Cherpitel & Tam, 2000; Fiorentino et al., 2007; Hunter et al., 2006; Peltzer, 2003) may explain why these groups are overrepresented in alcoholrelated crashes (and DUI arrests), despite facing similar levels of crash risk as their White counterparts. Sociocultural elements—such as education or income (Caetano, 1984b)—and cultural/ethnic factors—such as level of acculturation (e.g., Caetano & Clark, 1998; Herd, 1994), machismo (Hyman et al., 1972), religious and fatalism beliefs (Lapham et al., 1998; Sanchez et al., 2012; Wallace, 1999), poor understanding of DUI laws (e.g., Fiorentino et al., 2007), or erroneous risk perceptions (e.g., Caetano & Clark, 1998; Cherpitel & Tam, 2000)—also have been found or at least suggested to have contributed to the unequal representation by

racial/ethnic groups in drinking-and-driving and alcohol-related crashes. It also has been argued that Latinos and African Americans may appear to be overrepresented in DUI arrests due to racial profiling by law enforcement officials. All the arguments summarized herein are plausible, and in this study, we do not deny or reject any of them. This study adds to the literature by pointing out that unlike age and gender, at specific BAC levels, no subgroup within the racial/ethnic demographic construct is at a higher risk than others are. The observed overrepresentation of drivers of some racial/ethnic groups in alcohol-related crashes is therefore explained only by differences in patterns of alcohol consumption (as previously summarized), driving exposure, and socioeconomic factors (e.g., drivers from low-income groups driving old, less safe vehicles than those from more affluent groups).

The policy implications of our finding are evident. Although age-based variations in crash risk has induced policy makers to enact laws and policies aimed to curb drinking and driving among the population at the highest risk (young drivers), laws enacted to curb impaired driving among the general population of drivers (e.g., per se laws) are equally efficient for drivers of any racial/ethnic backgrounds. Efforts to curb racial/ethnic disparities in alcohol-related crashes need to focus on correcting misperceptions about the broad risks associated with alcohol consumption, the elimination of dangerous patterns of consumption (e.g., high levels of consumption per drinking, even if less often), and misconceptions regarding driving safety and drinking and driving (e.g., regarding seatbelt use, alcohol-risk perceptions, understanding traffic laws).

This study presents several limitations, including the always-ambiguous definition of what is a race and what is an ethnicity, uncertainties about proper case-control designs, and our focus on fatal crashes. Race and ethnicity are intrinsically arbitrary constructs that, although useful for demographic and policy analyses, may not always have a meaningful representation of individuals' cultural and behavioral realities. Although a well-accepted study design, ultimately case-control designs are techniques developed to circumvent the impossibility to randomize drivers into crash and noncrash groups. Further, by focusing only on fatal crashes, it might be possible that the findings reported in this effort may not be reproduced if examined on nonfatal crashes. A limitation of this study is that measures of BAC have been imputed for a substantial proportion of the crash data. Although it has never reported and there is no indication of its existence, bias could have occurred if there was substantial variation in the multi-imputation measures by racial/ethnic membership. Another limitation of this study is that it fails to account for the potentially confounding contribution of drugs other than alcohol to crash risk. The possibility that drivers of different racial/ethnic group membership show different patterns of drugged driving suggests the possibility of bias if those patterns are left unaccounted. Nevertheless, recent studies have shown the contribution of drugs other than alcohol to crash risk to be much smaller than that by alcohol (Bernhoft, 2011; Hargutt, Krüger, & Knoche, 2011; Hels et al., 2011; Romano & Pollini, 2013; Romano & Voas, 2011; Romano, Voas , Torres-Saavedra, & Lacey, 2013, in press), therefore reducing the potential bias that failing to account for drugs other than alcohol may have on alcohol-related risk estimates. Finally, our study implicitly assumes that all drivers follow similar time-based patterns of drinking as well as of drinking and driving, regardless of their racial and ethnic membership. That might not be the case, with drivers of some groups being more likely to drink and drive at different hours than others. If that were the

case (e.g., if compared to others, drivers of some groups were more likely to drink heavily on nighttime weekends) then our sample of nighttime weekend drivers might be biased accordingly. Despite these limitations, we believe the findings of this study are useful to policy makers and researchers in both traffic safety and health disparities arenas.

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Biographies

Pedro Torres-Saavedra is a Ph.D. candidate in statistics from North Carolina State University. He has accepted an assistant professor position at the Department of Mathematical Sciences at the University of Puerto Rico starting in July 2013. Before starting graduate school, he worked at PIRE, where as a young statistician he participated in several research efforts aimed to curb impaired driving in the country. During that period, he participated in several collaborations that allowed him to gain expertise in the field of traffic safety, impaired driving in particular. The collaboration with PIRE also has extended to

recent years, during which he has co-authored several manuscripts (published, currently under review, and in preparation). During his graduate school, he also spent a couple years as a statistical consultant for nonclinical and drug development studies in the pharmaceutical industry. His current research interests focus on the development and applications of statistical methods to solve problems in epidemiology, biology, and medicine. In his more recent methodological research, he developed inferential methods for quantile regression when the response variable is not measurable accurately. These methods can be used, among other applications, to construct biometric charts that serve as reference values for a given population.

Eduardo Romano is a Senior Research Scientist at PIRE in Calverton, Maryland, where he contributes to research projects as an Economist and Epidemiologist. His past work involved estimating the incidence and cost of national and state intentional and unintentional injuries, and the evaluation of Mexican policies aimed to deter binge drinking by young American visitors in Tijuana (Mexico). As a Principal Investigator (PI), he has participated in NIH-funded efforts to evaluate the involvement in crash-risk situations of women and different minority groups, as well in a NHTSA-funded project to study the involvement in traffic violations of recent immigrants to the United States. He is currently involved in a NIH-funded project looking at estimating alcohol-related and drug-related relative risks and in another project to study the impact of alcohol-related laws and policies on teens' impaired driving. Dr. Romano holds a Ph.D. in Agricultural and Applied Economics from the Virginia Polytechnic Institute and State University.

Robert B. Voas, Ph.D. (a Senior Research Scientist with PIRE and Director of the Impaired-Driving Center, PIRE, in Calverton, Maryland) has been involved in research on alcohol and highway safety for 35 years. Initially, he was the director of the National Highway Traffic Safety Administration's Office of Program Evaluation, and more recently, he is a principal investigator for government research programs in drinking-driving and community alcohol-problem prevention. Dr. Voas is a Fellow of the American Psychological Association and a Past President of the International Council on Alcohol, Drugs, and Traffic Safety. He is also a member of the Committee on Alcohol and Drugs, the National Safety Council, and the Committee on Alcohol and Other Drugs of the National Transportation Research Board, and has served on the National Board of Mothers Against Drunk Driving.

John H. Lacey is the Director of PIRE's Calverton Center. He has been involved in research on highway safety and impaired-driving issues for the 30 thirty years. Before joining PIRE, he was Principal Scientist at Mid-America Research Institute in Shepherdstown, West Virginia. He also spent 20 years at the University of North Carolina, Highway Safety Research Center. In the alcohol field, his interests have included implementation and evaluation of laws, enforcement, public information and other countermeasures to deter drunk driving, screening techniques for problem drinkers and effectiveness of various sanctions and sanction practices in reducing recidivism. John Lacey is the Principal Investigator on the NHTSA-funded 2007 and 2013 National Roadside Surveys, as well as on the 2010 Crash Risk Case-Control study.

Mario De La Rosa, Ph.D. is a tenured Professor in the Robert Stempel College of Public Health and Social Work at Florida International University and a past member of the National Advisory Council of the National Center on Minority Health and Health Disparities. He is a pioneering scientist with more than two decades of experience and expertise in building the research capacity of Florida International University to conduct behavioral research on the causes and consequences of Latino substance abuse, HIV/AIDS, violence, delinquency, and health disparities, while accounting for cross-cultural factors and issues. Dr. De La Rosa serves as Director of the Center for Research on U.S. Latino HIV/AIDS and Substance Abuse (CRUSADA), recognized as one of the nation's leading academic centers of health disparity research. Among CRUSADA's many distinctions is that it houses a National Institutes of Health (NIH), National Institute on Minority Health and Health Disparities (NIMHD) P20 Exploratory Center of Excellence, titled Center for Substance Use and HIV/AIDS Research on Latinos in the United States (C-SALUD; P20MD002288), recently refunded under a competitive 5-year continuation award. Dr. De La Rosa serves as Principal Investigator of C-SALUD, which focuses on substance abuse and HIV/AIDS among Latinos. Within the new scope of this grant, his community-based research focuses on Latino women, specifically on recent immigrants and farmworkers, two Latino subgroups at high risk for HIV infection that have been impacted by the HIV epidemic. These studies aim to increase our understanding of the role that social and cultural determinants of health have on substance abuse and HIV risk behaviors of Latinos, particularly Latinas, so that effective evidence-based prevention interventions can be developed. The work of CRUSADA builds on ongoing collaborations with community-based organizations that have a longstanding history of providing health and social services to Latinos at risk for HIV infection and substance abuse, as well as to other underserved Latino populations in South Florida. To date, as Principal Investigator, Dr. De La Rosa has been awarded more than $19 million in funding since joining the faculty of the School of Social work at FIU.

Highlights

- Blood-alcohol information from the 2006–2007 U.S. Fatality Analysis Reporting System was compared with control data from the 2007 U.S. National Roadside Survey.
- Crash-risk estimates for different racial/ethnic groups were estimated.
- Latino and African-American drivers were found less likely to be involved in single-vehicle crashes than their White counterparts.
- All drivers face similar BAC relative crash risk regardless of their group membership.

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Table 1

Distribution of drivers by race/ethnicity for exposed and fatally injured drivers in single-vehicle, two-vehicle, and all-vehicle crashes

			Crashes (Cases)		
Race and Ethnicity		**Exposure (Controls)**	**Single Vehicle**	**Two Vehicles**	**All Vehicles**
Latino		22.5%	11.7%	22.5%	14.9%
Non-Latino African-American		18.3%	13.3%	16.4%	14.1%
Non-Latino White		46.7%	73.0%	57.2%	68.4%
Non-Latino Other		12.4%	2.1%	3.9%	2.7%
Total	*n*	6659	2166	711	3009
	%	*100*	*100*	*100*	*100*

Percentages in controls are weighted according to the sampling weights from 2007 NRS.

Exposure: Self-reported or observed race/ethnicity from 2007 NRS.

Crashes: Recorded race/ethnicity from 2006-07 FARS (U.S. Fatality Analysis Reporting System).

The driver group “All vehicles” includes fatal crashes with any number of vehicles.

Table 2

Distribution of BAC by race/ethnicity for exposed and fatally injured drivers in single-vehicle crashes

Race/Ethnicity	Exposure				Crashes			
	BAC				BAC			
	0%	.001% – .079%	≥0.08%	Total (n)	0%	.001% – .079%	≥0.08%	Total (n)
Latino	88.0	9.9	2.2	1,153	4.7	16.8	78.5	252
Non-Latino								
African-American	88.0	9.9	2.1	1,122	8.0	17.9	74.0	287
Non-Latino White	87.5	10.2	2.3	3,852	6.5	17.0	76.5	1,581
Non-Latino Other	89.1	9.0	1.9	555	2.5	25.7	71.8	44
Total	–	–	–	6,682	–	–	–	2,164

The BAC distribution for crashes (cases) is based on the observed and imputed BAC values from 2006–07 FARS. Percentages in controls are weighted according to the sampling weights from 2007 NRS. The total number of drivers in Exposure is larger than that reported in Table 1 because n=23 drivers had BACs but did not report race/ethnicity information.

Table 3

Unadjusted OR estimates (and 95% confidence intervals) of a fatal crash for BAC in SV crashes

	OR BAC[a]	
Race/Ethnicity	**.001% – .079%**	**≥0.08%**
Latino	2.49 (1.27, 4.87)	186.90 (111.66, 312.86)
Non-Latino African-American	3.97 (2.34, 6.75)	173.24 (104.06, 288.41)
Non-Latino White	3.28 (2.55, 4.21)	171.19 (133.47, 219.59)
Non-Latino Other	*b*	131.01 (31.59, 326.43)

[a] Unadjusted OR of a fatal crash for a BAC category vs. 0.00% BAC for a driver with the same race/ethnicity based on data from Table 2.

[b] Sample size is too small to compute the OR.

Table 4

Logistic regression coefficients (standard errors) in models for risk of driver fatalities in singlevehicle crashes, in two-vehicle crashes, and in all crashes as a function of variables for age, gender, race/ethnicity, and BAC. Data are from the 2006–2007 FARS and 2007 National Roadside Survey

	Model 1 (n=8,823)	**Model 2 (n=7,370)**	**Model 3 (n=9,664)**
	Single-vehicle crashes	**Two-vehicle crashes**	**All crashes**
Factor	**Estimate (SE)**	**Estimate (SE)**	**Estimate (SE)**
Intercept	**−2.240 (0.177)**	**−2.890 (0.187)**	**−1.787 (0.101)**
Female	**−0.813 (0.067)**	−0.213 (0.064)	**−0.546 (0.094)**
Age 16–20	**1.012 (0.105)**	**0.587 (0.092)**	**0.871 (0.123)**
Age 35+	**−0.319 (0.080)**	0.252 (0.063)	0.016 (0.112)
Age 21–34 (Ref.)			
Latino Non-Latino African-	**−1.191 (0.200)**	−0.278 (0.203)	**−0.681 (0.126)**
American	**−0.489 (0.240)**	**−0.340 (0.250)**	**−0.425 (0.13)**
Non-Latino Other	**−2.004 (0.341)**	**−1.267 (0.324)**	**−1.502 (0.214)**
Non-Latino White (Ref.)			
BrAC	**0.035 (0.004)**	**0.025 (0.003)**	**0.032 (0.003)**
0<BAC<0.019, Age 21+	**−0.663 (0.151)**	**−1.437 (0.147)**	**−0.943 (0.35)**
Age 16–20, BrAC	0.003 (0.005)	0.005 (0.005)	0.004 (0.005)
Age 35+, BrAC	−0.002 (0.004)	−0.002 (0.003)	−0.004 (0.003)
Age 21–34, BrAC (Ref.)			
Latino, BrAC	−0.001 (0.004)	0.000 (0.004)	−0.003 (0.003)
Non-Latino African-			
American, BrAC	0.001 (0.004)	0.003 (0.004)	0.002 (0.003)
Non-Latino Other, BrAC	0.003 (0.004)	0.002 (0.004)	0.000 (0.004)
Non-Latino White, BrAC (Ref.)			
Max-rescaled R^2	0.728	0.376	0.646

Model 1 includes single-vehicle crashes only. Model 2 examines two-vehicle crash models. Model 3 includes any number of vehicle crashes. Standard Errors are estimated taking into account the sampling design in 2007 NRS and the multiple imputation process in 2006–07 FARS. The fit statistic value corresponds to the average based on the 10 imputed versions of the BAC in the FARS data set. BrAC (breath alcohol concentration) is the rescaled BAC: BrAC = BAC × 1000. Ref. = reference group: Male ages are 21–34 years. Age ≥ 21 refers to ages 21 and older.

Coefficients in bold are statistically significant (5%). Sample sizes (n) used in each model do not add up to totals in n 1 due to missing demographic information (e.g., gender, age).