### Title

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# Acceptance of drinking and driving and alcohol-involved driving crashes in California

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## Abstract

**Background—**Alcohol-impaired driving accounts for substantial proportion of traffic-related fatalities in the U.S. Risk perceptions for drinking and driving have been associated with various measures of drinking and driving behavior. In an effort to understand how to intervene and to better understand how risk perceptions may be shaped, this study explored whether an objective environmental-level measure (proportion of alcohol-involved driving crashes in one's residential city) were related to individual-level perceptions and behavior.

**Methods—**Using data from a 2012 cross-sectional roadside survey of 1,147 weekend nighttime drivers in California, individual-level self-reported acceptance of drinking and driving and past-year drinking and driving were merged with traffic crash data using respondent ZIP codes. Population average logistic regression modeling was conducted for the odds of acceptance of drinking and driving and self-reported, past-year drinking and driving.

**Results—**A non-linear relationship between city-level alcohol-involved traffic crashes and individual-level acceptance of drinking and driving was found. Acceptance of drinking and driving did not mediate the relationship between the proportion of alcohol-involved traffic crashes and self-reported drinking and driving behavior. However, it was directly related to behavior among those most likely to drink outside the home.

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**Discussion—**The present study surveys a particularly relevant population and is one of few drinking and driving studies to evaluate the relationship between an objective environmental-level crash risk measure and individual-level risk perceptions. In communities with both low and high proportions of alcohol-involved traffic crashes there was low acceptance of drinking and driving. This may mean that in communities with low proportions of crashes, citizens have less permissive norms around drinking and driving, whereas in communities with a high proportion of crashes, the incidence of these crashes may serve as an environmental cue which informs drinking and driving perceptions. Perceptual information on traffic safety can be used to identify places where people may be at greater risk for drinking and driving. Community-level traffic fatalities may be a salient cue for tailoring risk communication.

### Keywords

alcohol; drinking and driving; risk perception; traffic crashes

## Introduction

Alcohol-impaired driving was the cause of nearly 11,000 deaths in 2009, with an estimated $64 billion in associated social costs in 2008 (Compton & Berning, 2009; Shults et al., 2009). This behavior accounts for nearly a third of all U.S. traffic-related fatalities (31%; National Highway Traffic Safety Administration [NHTSA], 2013). Substantial improvements in alcohol-related fatal driving crashes were observed in the U.S. during the 1980s and 1990s (Bergen, Shults, Beck, & Qayad, 2012; NHTSA, 2010; Williams, 2006). It has been estimated that 44% of the reduction in alcohol-related traffic fatalities from 1982-2005 can be attributed to alcohol policies; a small percentage can be attributed to reductions in alcohol consumption; and a substantial proportion can be attributed to shifts in the demographic composition. In terms of demographics, there has been an increase in the proportion of female and older drivers who are at lower crash risk than younger men (Voas & Fell, 2011). Since the mid- to late 1990s progress in the reduction of alcohol-related traffic fatalities has stabilized and drinking and driving remains a substantial problem (Williams, 2006). Further progress in preventing alcohol traffic fatalities may require a better understanding of the factors that lead some people to drink and drive.

While drinking and driving could be viewed as an obviously poor choice, there are nuances to how people make decisions. A variety of risks and benefits, in addition to biases, can influence these types of decisions. For some people, benefits associated with drinking alcohol outside the home may far outweigh any perceived risk of drinking and driving. While those with lower educational attainment and minorities are more likely to drink and drive and to be arrested for drinking and driving (Dunaway, Will & Sabo, 2011; Gruenewald, Mitchell & Treno, 1996), many differences in this type of alcohol problem can be attributed to differences in alcohol consumption patterns and drinking location preferences (Bergen, Shults, Beck, & Qayad, 2012; Birdsall, Reed, Huq, Wheeler & Rush, 2012; Chia et al., 2011; Dunaway, Will & Sabo, 2011; Gruenewald, Mitchell & Treno, 1996; Grunewald, Johnson & Treno, 2002).

Relevant to risk perceptions, decision theory suggests that the perceived probability of an outcome will have a direct impact on one's decisions (Turrisi & Jaccard, 1992). The decision to drink and drive may be influenced by the perceived probabilities of the range of possible adverse consequences of such behavior. Differences in risk perception may explain some of the differences in drinking and driving behavior by age and sex. For example, younger drivers and males tend to have lower and less realistic risk perceptions compared to other groups (DeJoy, 1989; Finn & Bragg, 1986; Guppy, 1993).

In general, people adapt their behaviors according to perceived risk (Beck, Yan, Wang, Kerns, & Burch, 2009; Janz, Champion, & Strecher, 2002). Risk perception of being in a crash due to drinking and driving has been associated with various measures of drinking and driving (Bertelli & Richardson, 2008; McCarthy, Lynch, & Pederson, 2007; Turrisi & Jaccard, 1992). Lower risk perceptions for drinking and driving have been associated with poorer driving records in adults and increased self-reported behavior among college students (McCarthy, Lynch, & Pederson, 2007; Turrisi & Jaccard, 1992). This was further illustrated in a national survey, where again, lower risk perception for drinking and driving were associated with a higher propensity for engaging in drinking and driving (Bertelli & Richardson, 2008).

While perceptions of risk for drinking and driving are associated with various measures of drinking and driving behavior (Bertelli & Richardson, 2008; Dionne, Fluet, & Desjardins, 2007; Guppy, 1993; McCarthy, Lynch, & Pederson, 2007; Turrisi & Jaccard, 1992), little is known about how objective environmental-level crash risk measures and individual-level perceived risks are correlated. Some have suggested that traffic injuries may be more salient than enforcement efforts for altering risk perceptions. In bivariable county-level analyses in Maryland (Beck, Yan, Wang, Kerns, & Burch, 2009), impaired driving injury crash rates were positively correlated with concerns about drinking and driving as a traffic safety issue. In addition, higher alcohol-impaired fatality rates were positively associated with beliefs about levels of enforcement, which may deter behavior. Driving under the influence (DUI) citation rates were not associated with concerns about drinking and driving as a traffic safety issue or beliefs about levels of enforcement (Beck, Yan, Wang, Kerns, & Burch, 2009).

This paper aimed to understand how to intervene to reduce drinking and driving by examining how risk perceptions may be shaped by objective environmental-level measures of crash risk and by relaxing the linear assumption. A person's knowledge of their environment is affected by both the external reality and their perceptions of that environment. Understanding how people respond to cues in their environment can inform tailored educational efforts. However, very few studies have examined the relationship between an objective environmental-level crash measure and corresponding risk perceptions. We extend previous findings by analyzing the relationship between residential city-level alcohol traffic crashes and individual-level risk perceptions while controlling for factors that may bias risk perceptions. We further add to the literature by examining how alcohol traffic crashes and related risk perception influence self-reported drinking and driving behavior.

## Material and methods

The current study is nested within a broader project, the California Roadside Survey, which consisted of a roadside survey in 9 communities throughout California. The overall objective of the primary project was to estimate the prevalence of substance use and driving among California weekend nighttime drivers. This study took place June-August 2012.

### 2.1. Study procedures

Nine jurisdictions within the northern (Eureka, Redding, and San Rafael), central (Modesto, Fresno), and southern (Ontario, Gardena, Anaheim, Chula Vista) regions of California were selected in collaboration with the California Office of Traffic Safety (OTS) (Lacey, Kelley-Baker, Romano, Brainard, & Ramirez, 2012). Data were collected from a random sample of approximately 1,375 weekend nighttime drivers. Data collection occurred on Friday and Saturday nights from 10 pm to midnight and from Saturday and Sunday morning 1 am to 3 am. For 8 jurisdictions, data collection occurred over one weekend. In Modesto the data collection occurred over 2 weekends. Vehicles were randomly selected from the flow of traffic at select locations near well-lit parking lots by a uniformed police officer who went through human subjects training. Driver participation was voluntary and anonymous, and this was indicated with road signs at the parking lot entrance. Police officers were present to assist with traffic control but were not part of the research effort. Respondents were surveyed by trained data collectors and police officers were requested to not speak to any drivers concerning the study. If police officers were questioned, they said, “Please pull in to learn more.” Drivers who were willing to participate pulled into the survey area where they were directed by a research team member using a directional traffic wand. After the driver stopped safely in the “interview bay” (designated with orange cones), an interviewer greeted the driver using a consent script.

The survey operations were approved by an Institutional for Review Board (IRB) which allowed drivers (under 18) to conduct the survey and provide a BAC and oral fluid because they were of driving age. The IRB required the utilization of an Impaired-Driving Protocol when necessary. As part of this protocol, data collectors were trained to detect impaired/intoxicated drivers. This has been standard procedure for all of the Pacific Institute for Research and Evaluation's (PIRE's) field research since 1996 (Lacey et al., 2011). The protocol has a dual purpose: (a) to protect the rights of participants; and (b) to protect the public from impaired driving. The Impaired-Driving Protocol involves convincing impaired drivers that they should not be driving and uses study resources to ensure that they can get home safely (Lacey, Kelley-Baker, Romano, Brainard, & Ramirez, 2012).

Drivers who agreed to participate were given a $20 cash incentive and an Information Sheet at the end that contained information about the study, stated the rights of participants, and provided contact information for the Principal Investigators and for the Chair of PIRE's Institution Review Board. Drivers who declined participation were given a piece of candy along with Information Sheet that described the research and provided contact information. Both Information Sheets included language that warned participants of the risks associated with driving after any drug usage or alcohol consumption (Johnson, Kelley-Baker, Voas & Lacey, 2012; Lacey et al., 2009).

### 2.2. Survey

Trained and experienced survey teams obtained anonymous data on alcohol and drug use with the following survey instruments: verbal interview questions, preliminary breath-testers (PBTs), self-administered paper-and-pencil surveys, and oral fluid test kits. The oral fluid tests were not used in the present analyses. A breath sample was collected using the Mark V Alcoviser™ collection unit. The PBTs stored the results internally without displaying the results. The PBT result and survey forms were linked with an assigned case number. No names were collected and the results of the breathilizer test and oral fluids were not known or displayed during the survey procedures. It was communicated to participants during the study procedures that this was a voluntary and anonymous study and that the information they provided would not be shared with enforcement (Lacey, Kelley-Baker, Romano, Brainard & Ramirez, 2012; Lacey et al., 2009).

### 2.3. Study population

To be included in the study, drivers had to be at least 16 years of age, able to speak English or Spanish, not in emotional or physical distress that would prevent them from giving informed consent, not driving a commercial vehicle, and understand that they were being asked to voluntarily participate in a research study. The 1,375 weekend nighttime drivers that consented to participate in the roadside survey represented 81% of the eligible population were invited to participate.

There were no significant differences by age, sex, and race for the drivers who refused compared to those who agreed to participate in the survey (Lacey, Kelley-Baker, Romano, Brainard & Ramirez, 2012). Participants were fairly similar to the California driving (age 16+) and adult age (18+) populations (Census vs. survey: 40% vs. 39% female, 60% vs. 55% White, 6% vs. 9% Black, 14% vs. 11% Asian or Pacific Islander). A higher percent of participants were younger and Hispanic or Latino (Census vs. survey: 26% vs 44% age 21-34 and 33% vs. 45% Hispanic or Latino) (U.S. Census Bureau, 2010). The differences by age may be due to the study day and time and differences ethnicity may be due to the survey locations.

In this sample of weekend, nighttime drivers, 1,287 answered the perceived risk associated with alcohol-impairing driving question. Of these, 89% (n=1,147) provided residential ZIP Codes in California and complete information (e.g. age, sex, race) and constitutes the analysis cohort for this paper.

### 2.4. Variables

**Acceptance of drinking and driving—**The primary outcome measure was measured at the individual-level (level 1). Participants were asked: “How likely do you think it is that alcohol could impair a person's ability to drive safely?” Participants had the option of responding: very likely, likely, somewhat likely, and not at all likely. Answers were coded on a 4-point Likert scale where a higher score indicated higher agreement with this statement. A majority (81%) thought it was very likely that alcohol impairs driving ability. As the distribution was not symmetric, this variable was then dichotomized and coded as 1 for less likely or lower agreement with the statement above (11% responded likely, 4%

responded somewhat likely, and 4% responded not at all likely) and 0 for very likely. It was hypothesized that those who did not strongly endorse this as a safety concern were conceptually different from the other group. In a previous national study, minor and no perceptions of risk for drinking and driving have been collapsed (Moulton, Peterson, Haddix & Drew, 2010).

**Drinking and driving—**Another key outcome was past-year drinking and driving which was measured at the individual-level (level 1). Participants were asked: "In the past 12 months, did you ever drive after drinking enough that you might be considered to be legally under the influence of alcohol?"

**Crash exposure—**The level-2 exposure variable was operationalized as the number of injury and fatal crashes that involved a driver who had been drinking alcohol divided by the number of overall crashes for that city. Road quality and other environmental safety features may confound the relationship between drinking and driving and traffic crashes, so, the exposure measure was normalized by considering all injury and fatal traffic crashes in the denominator. This was determined using the California Statewide Integrated Traffic Record System (SWITRS). SWITRS is an electronic database of police-reported traffic collisions maintained by the California Highway Patrol (CHP). CHP and all local law enforcement agencies in the state are required by law to submit data on all police-reported collisions. Property-damage-only crashes were excluded as these are less serious, frequently underreported, and would not gain the same attention as an injury crash. SWITRS data for the 5-year period prior to the survey (2007-2011) were included. The crash locations were geocoded and then joined to Census 2010 Designated Places using ArcGIS 10 (ESRI, Redlands, CA).

To determine the residential city for each respondent, the residential ZIP Codes provided were merged to Census ZIP Code Tabulated Areas (ZCTAs) and then ZCTAs were related to Census Place data (i.e. cities and towns). If more than one Place was associated with a ZCTA, the Place with the most area overlap with the ZCTA of interest was assigned. These data were then merged to SWITRS data by city and county.

The exposure variable is right skewed. The mean percent is 11.9 with a standard deviation of 7.5. The median is 10.0 (min= 0, Q1= 8.3, Q3=13.9, max=50.0). This variable was analyzed as a continuous variable with a quadratic term to relax the linear assumption.

**Potential confounders—**Analyses adjusted for demographic characteristics and alcohol- and driving- related variables. Age was collected as a continuous variable. Female sex was used as the reference group. Hispanic or Latino ethnicity was coded as 1 vs. 0 (non-Hispanic or Latino). Three dummy variables were used for race categories with White race as the reference group. Education was collected with the following categories: less than high school, trade school certificate, high school graduate, some college, bachelor's degree, and graduate degree. Education was collapsed as bachelor's degree and beyond vs. less than bachelor's degree.

A 15-item Alcohol Use Disorder (AUD) survey was administered. The survey is derived from the Alcohol Use Disorder and Associated Disabilities Interview Schedule (AUDADIS) and the Alcohol Use Disorders Identification Test consumption subscale (AUDIT-C) and has been validated for use in roadside surveys (Furr-Holden et al., 2009). The following alcohol use patterns were explored separately: binge drinking frequency and alcohol use disorder status. For binge drinking frequency, respondents were asked "In the past year, how often did you have six (five for a woman) or more drinks on one occasion?" Dummy variables were created for categories: less than monthly and monthly or more often (monthly, weekly, and daily/almost daily) with never as the reference group. Alcohol use disorder was indicated with two dummy variables for abuse and dependence with none as the reference group. Dummy variables for missing data were created for each alcohol measure and included in the analyses. Blood alcohol content (BAC) was also collected at the time of survey and was explored as a continuous variable and categorized as a blood alcohol content >=0.05 vs. <0.05. Although a blood alcohol content of 0.05 is not the legal limit, it is considered to be high enough to alter judgment and reaction times. At that blood alcohol level there is reduced coordination and ability to track moving objects (Centers for Disease Control and Prevention, 2011). Dummy variable for missing data was also included in the analyses.

Driving categories were based on average annual miles driven and were collected as: below average, average (15,000 miles or 24,140 kilometers per year), or above average. A dummy variable was created for above average vs. average and below.

### 2.5. Analysis

To explore whether city-level proportion of alcohol-involved crashes were related to individual-level perceptions while controlling for individual-level characteristics that may bias risk perceptions, population average logistic models were implemented. As respondents were nested within cities, there was the concern of underestimating the standard errors. Population average models are frequently implemented for nested data within groups. In this case, the groups are cities. For population average models, dependence among respondents from the same city is treated as a nuisance and robust standard errors are produced. Probabilities are averaged and the effects are interpreted across groups. Fewer assumptions are made with population average modeling (Hubbard et al., 2010). In addition, the research question aims to understand the effects across cities.

Building up to the final model, we evaluate the contribution of confounders with the bivariable logistic regression, a multivariable logistic regression model with participant characteristics only, and the final multivariable logistic regression model (participant and city-level characteristics). To test whether effects of objective measures of alcohol-involved crashes on drinking and driving behavior were mediated by perceptions of ability to drive after drinking, indirect effects were computed using the product of the coefficients approach and the standard errors were produced using bootstrapping methods (Enders, 2011; Kenny, 2008; Kenny, 2009). All analyses were conducted using Stata version 12 (Stata Corp, College Station, TX). No missing data were imputed. However, missing data were accounted for in analysis of alcohol-related variables with the use of dummy variables.

Among the analysis cohort for this paper, participants were missing BAC, binge drinking status, alcohol use disorder status, and self-reported past year drinking and driving 1.3%, 3.4%, 6.5% and 0.3% respectively.

## Results

### 3.1. Descriptive

The analysis cohort of 1,147 participants resided in 170 California cities. The number of participants per city ranged from 1 to 182 with an average of 6.7 participants per city.

Frequency distributions for categorical variables and means and standard deviations for continuous variables are shown in Table 1, overall and stratified by low (lower quartile), moderate, and high (upper quartile) proportion of alcohol-involved crashes in a city. In this sample, the average age was 33, 40% were female, 44% were Hispanic, a majority of participants were White (57%), nearly a quarter had at least a college degree (23%), a third of respondents reported driving more than average, 65% did not binge drink in the past year, 17% were alcohol dependent, and 4% reported drinking and driving in the past year.

### 3.2. Bivariable

Bivariable results for the population average models are shown in Table 2. The population average models indicate, that across cities, female sex was associated with an decreased odds compared to males; Blacks and Asians had an increased odds compared to Whites; and those with a blood alcohol content of 0.05 or higher had an increased odds compared to those with <0.05 in the acceptance of drinking and driving. In addition, city-level alcohol-involved traffic crashes were related to acceptance of drinking and driving and this relationship was non-linear.

### 3.3. Multivariable

Models 1 and 2 are shown in Table 3. Model 1 includes participant characteristics and model 2, the final model, includes participant and the city-level characteristics. Controlling for other participant characteristics did not reduce the male-female differences in the acceptance of drinking and driving (comparing table 2 and model 1, table 3). And adding the city-level characteristic did not substantially impact the results of the participant characteristics. Across cities, females had an estimated decreased odds of 34% compared to males; Hispanics had an estimated 1.7 times the odds compared to non-Hispanics; Blacks and Asians had more than twice the odds of Whites; and those with a BAC of 0.05 or higher had an estimated 3.3 times the odds of those with <0.05 in the acceptance of drinking and driving, controlling for the other covariates in the model (models 1 and 2, table 3). Age, education, and drinking patterns were not significantly associated with acceptance of drinking and driving in any of the models. Across cities and controlling for respondent characteristics, there was significant relationship between the proportion of alcohol traffic crashes and the acceptance of drinking and driving. This relationship was non-linear. The results of a Wald test supported the inclusion of both the proportion of alcohol-involved crashes and the quadratic term ($x^2$=8.39, $p$<0.05). The predicted probabilities from model 2 of Table 3 are presented in Figure 1. Estimates indicated that as the proportion of alcohol-involved crashes increase the probability of acceptance of drinking and driving increases and then declines. Respondents in cities with <=5% or >=25% alcohol-involved crashes represent the bottom 1% and top 1%, respectively. Post hoc analyses revealed that these cities have low population density (not shown).

To examine whether the effects of objective measures of alcohol-involved crashes on drinking and driving behavior were mediated by acceptance of drinking and driving, analyses were conducted for the 1144 who reported drinking and driving experience for the past year and for a subset that were most likely to drink outside the home (n=158). For the full set (n=1144), the proportion of the total mediated effect was 0.03. Based on the bootstrap results, the indirect and direct effects were not significant. For those most likely to drink outside their home, the proportion of the total effect mediated was 0.15. Based on the bootstrap results, the indirect and direct effects were not significant. However, acceptance of drinking and driving was directly related to drinking and driving behavior (Table 4). The results of the bivariable and multivariable analyses indicated, that across cities, more frequent binge drinking and acceptance of drinking and driving were significantly associated with the odds of reporting drinking and driving behavior in the past year. Controlling for respondent characteristics and the proportion of alcohol-involved crashes, those who accepted drinking and driving had an elevated odds of reporting this behavior compared to those who did not accept drinking and driving. In this smaller sample, multivariable models did not converge with race and binge frequency, as there were race groups that did not binge drink, so these variables were omitted from table 4.

## Discussion

In a sample of weekend nighttime drivers in California, nineteen percent were somewhat accepting of drinking and driving, four percent reported drinking and driving in the past year, two percent had a BAC of 0.05 g/dL or higher at the time of survey, and the average city proportion of drinking and driving traffic injury crashes was ten percent. In this exploratory study, a non-linear relationship between drinking and driving crash exposure and acceptance of drinking and driving was found. It was hypothesized that the effects of objective measures of alcohol-involved crashes on drinking and driving behavior would be mediated by acceptance of drinking and driving. This was not found. However, acceptance of drinking and driving was positively related to self-reported behavior among those most likely to drink outside the home.

Given the evidence on alcohol and driving, it is somewhat surprising that nineteen percent of this sample in 2012 did not strongly endorse the fact that alcohol impairs driving ability. Interestingly, a 2008 National Highway Traffic Safety Administration (NHTSA) study found similar results. In a national survey of the driving age population, nineteen percent reported that drinking and driving was not a major threat to their personal safety (Moulton, Peterson, Haddix & Drew, 2010). However, these results may vary by geographic location. In a random telephone survey conducted in Maryland in 2004-2007, nine percent of participants did not perceive drunk driving to be a critical traffic concern (Beck, Yan, Wang, Kerns, & Burch, 2009). This may be because they consider drinking and driving to be very rare or because they think the risks are overstated. Further research into this issue is warranted.

It was hypothesized that city-level drinking and driving traffic crash exposure may inform individual-level perception of alcohol impairing driving ability. A previous study found that Maryland county-level impaired driving injury crash rates were positively correlated with agreement that drunk driving is a traffic safety concern (Beck, Yan, Wang, Kerns, & Burch, 2009). In another study conducted in Maryland, pedestrian crash rates were positively associated with perceptions of pedestrian crash risk (Cho, Rodriguez, & Khattak, 2009). At high proportions of alcohol-involved crashes, there is low acceptance of drinking and driving. Perhaps this reflects that this environmental exposure informs drinking and driving risk perceptions.

Interestingly, at lower proportions of alcohol-involved crashes, lower acceptance of drinking and driving was observed. This may mean that respondents who do not accept drinking and driving reside in cities with like-minded residents, therefore, drinking and driving is uncommon. Therefore, the directionality for cities with low and high alcohol-involved crashes may differ. However, this should be interpreted with caution as the directionality was not assessed in this cross-sectional study. However, this finding is consistent with theory from the Social Norms Approach where one's behavior can be influenced by the perceived or actual norms of one's social group (Berkowitz, 2004). Other studies have found an association between neighborhood norms and alcohol behaviors. A study conducted in New York City found that permissive neighborhood drunkenness norms were associated with more binge drinking (Ahern, Galea, Hubbard, Midanik & Syme, 2008).

Four percent of respondents reported driving after drinking too much in the past year. In a study conducted in Maryland, eleven percent participants admitted to driving after several drinks (Beck, Yan, Wang, Kerns, & Burch, 2009). Other survey results ranged from two percent to twenty percent depending on study population and the way the drinking and driving question was asked (Bergen, Shults, Beck, & Qayad, 2012; Compton, & Berning, 2009; Moulton, Peterson, Haddix & Drew, 2008). Further, acceptance of drinking and driving was associated with a blood alcohol content of 0.05 or higher at the time of survey. It may be that prior perceptions influenced drinking and driving behavior. It may also be that under the influence of alcohol, risk perceptions are altered. In a small laboratory experiment conducted with men, under the influence of alcohol and with certain conditions (e.g. if the scenario was the travel distance was short), viewpoints about drinking and driving behavior changed (MacDonald, Zanna, & Fong, 1995).

In general, with greater perceptions of risk, one is more likely to alter behavior accordingly (Janz, Champion, & Strecher, 2002). Acceptance of drinking and driving was positively associated with self-reported drinking and driving among those most likely to drink outside their home.

### 4.1. Implications

While perceptions of risk for drinking and driving have been found to be associated with behavior (Bertelli & Richardson, 2008; Dionne, Fluet, & Desjardins, 2007; Guppy, 1993;

McCarthy, Lynch, & Pederson, 2007; Turrisi & Jaccard, 1992), few studies have evaluated how objective and subjective traffic crash measures are correlated. Understanding how people respond to cues in their environment can inform tailored educational efforts and may identify people who are at greater risk for risky driving.

Some have suggested that traffic injuries may be more salient than enforcement for modifying risk perceptions (Beck, Yan, Wang, Kerns, & Burch, 2009). Mass media has been used to implement fear-based strategies in road safety campaigns. These consist of showing the public adverse outcomes (e.g. crash injuries and deaths) associated with various driver behaviors (e.g. speeding, drinking and driving). Some early studies of fear-based tactics found that higher levels of fear arousal to be more persuasive while other studies found that decreasing levels of fear arousal to be more persuasive. One explanation for these inconsistencies is that people reject messages when the optimal amount of fear is exceeded. In a review of this literature, researchers found relevance or perceived vulnerability and efficacy to be consistent elements of successful approaches (Lewis, Watson, Tay & White, 2007). The challenge in public health is to develop messages that provide signals that can be identified as meaningful, relevant, and coherent. Social media may be one approach to communicate meaningful risk information due to the personal nature and the potential for rapid and extensive transmission of information (Reyna, 2011). Receiving messaging from one's own network may be regarded as more relevant than general mass media campaigns.

It has also been suggested that perceptual information on traffic safety can also be used to indicate geographic locations that may be overlooked (Schneider, Ryznar, & Khattak, 2004). In this case, perceptual information may indicate places where the norms are more permissive and drinking and driving is more common. The Social Norms Approach has been used to develop individual-level interventions where normative feedback about alcohol behavior is presented (Berkowitz, 2004). Normative feedback could be presented to high risk communities. Perceptual information may also indicate people who may be at greater risk for a traffic crash. In a longitudinal study of novice drivers, lower perceptions of safety were associated with an increased crash risk two years later (Ivers et al., 2009). Regularly assessing risk perceptions can assist in benchmarking traffic safety efforts and in understanding how new cohorts of drivers respond to these efforts.

In this sample of weekend nighttime drivers, the relationship between acceptance of drinking and driving and drinking and driving behavior was only observed among those most likely to drink outside their home. Another study conducted in California found that drinking and driving was more likely among frequent drinkers who prefer to drink outside the home (Grunewald, Johnson & Treno, 2002). It may be more efficient to focus on particular subpopulations. However, this raises important public health questions about whether to focus on high risk populations or a larger proportion of the population at lower risk that may give rise to drinking and driving cases (Rose, 1985).

### 4.2. Limitations

There are limitations to this research. First, this was not a representative sample of the California adult population. Among weekend, nighttime drivers at specific locations in California risk perceptions did not vary much by age. This may differ from the larger

California adult population. In general, younger drivers are less likely to perceive traffic risk (DeJoy, 1989). However, given the objective of the overall project, this study design was efficient and focused on weekend nighttime drivers. This is arguably an important segment of the population as drinking and driving is more common on weekend nights.

Second, this study was cross-sectional and the temporal ordering of risk perceptions and behaviors cannot be determined. The city-level exposure was for a period of time prior to the survey. However, there may be residential instability (e.g. moving) among this study population that cannot be accounted for in this study. In addition, it should be noted that one's personal geography may be more expansive or more nuanced than one's residential city. And,there are other exposures that can influence one's acceptance of drinking and driving that were not assessed here. For example, educational efforts and personal experiences with drinking and driving traffic crashes were not collected as part of this study.

Finally, social desirability and the study context may bias responses to perceptions about drinking and driving and self-reported drinking and driving behavior. In terms of acceptance of drinking and driving, our results were similar to national reports (Moulton, Peterson, Haddix & Drew, 2010).

### 4.3. Future research

In this study, at lower proportions of alcohol-involved crashes, low acceptance of drinking and driving was observed. The perceptions of participants in this study, in part, reflect the attitudes of their social environments. In addition, some racial and ethnic groups appear to doubt that alcohol can impair safe driving. Future research could focus on how attitudes, perceptions, and beliefs about drinking and driving are transferred among social networks and communities.

## Conclusion

To these authors' knowledge, this is one of the few studies to evaluate the relationship between objective and subjective crash risk for drinking and driving. Traffic crashes are typically studied to address safety issues and perceived traffic safety is sometimes studied to understand barriers to active modes of transportation (Cho, Rodriguez, & Khattak, 2009). It has also been suggested that perceptual information on traffic safety can also be used to identify “problems waiting to happen” (Schneider, Ryznar, & Khattak, 2004). In a sample of weekend night time drivers in California, risk perceptions were similar to a previous national study of the driving age population (Moulton, Peterson, Haddix & Drew, 2010). At higher proportions of alcohol-involved crashes in one's residential city, there was low acceptance of drinking and driving. In addition, those who accepted drinking and driving and were more likely to drink outside their home were more likely to report drinking and driving in the past year. Enforcement and sobriety checkpoints require extensive resources. Efforts to reduce drinking and driving could be supplemented with lower cost approaches to communicating risk. Regularly assessing risk perceptions can assist in benchmarking efforts and in identifying vulnerable populations.

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### Highlights

- We conducted a cross-sectional survey of weekend, nighttime drivers in California.
- We explored perceived drinking and driving risk and city alcohol-involved crashes.
- At low proportions of crashes, lower acceptance of drinking and driving was observed.
- At high proportions of crashes, lower acceptance of drinking and driving was observed.
- Risk perceptions influence behavior for those most likely to drink outside the home.

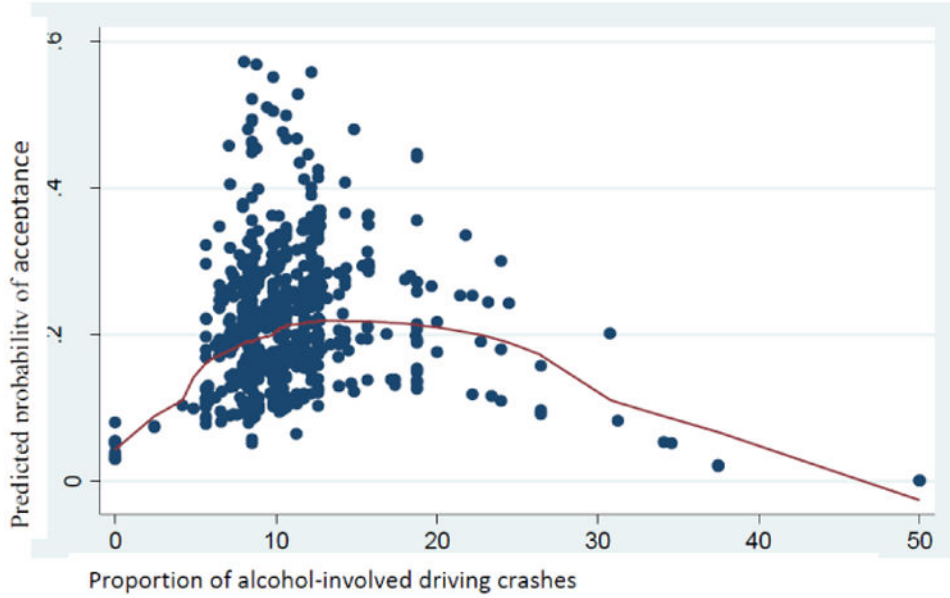


**Figure 1.**
Predicted probabilities of acceptance of drinking and driving by the proportion of drinking and driving traffic crashes in city, SWITRS 2007-2011 and the California Roadside Survey 2012 (n=1147)

**Table 1**

**Respondent characteristics by proportion of alcohol-involved crashes in residential city, SWITRS 2007-2011 and California Roadside Survey 2012 (n=1147)**

| | Low (N=238) | | Mid (N=617) | | High (N=292) | | Total (N=1147) | | *P* |
|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | |
| Age | 35.0 | 13.8 | 32.8 | 13.3 | 33.3 | 15.1 | 33.1 | 13.5 | 0.17 |
| | N | % | N | % | N | % | N | % | |
| Sex: Female vs. Male | 78 | 32.77 | 261 | 42.30 | 118 | 40.41 | 457 | 39.84 | 0.09 |
| Ethnicity: Hispanic vs. Non-Hispanic | 87 | 36.55 | 272 | 44.08 | 145 | 49.66 | 504 | 43.94 | <0.001 |
| Race | | | | | | | | | <0.001 |
| White | 123 | 51.68 | 372 | 60.29 | 156 | 53.42 | 651 | 56.76 | |
| Black | 32 | 13.45 | 37 | 6.00 | 26 | 8.90 | 95 | 8.28 | |
| Asian | 37 | 15.55 | 59 | 9.56 | 31 | 10.62 | 127 | 11.07 | |
| Other | 46 | 19.33 | 149 | 24.15 | 79 | 27.05 | 274 | 23.89 | |
| Education | | | | | | | | | 0.21 |
| Less than HS | 14 | 5.88 | 42 | 6.81 | 22 | 7.53 | 78 | 6.80 | |
| Trade School Certificate | 7 | 2.94 | 21 | 3.40 | 10 | 3.42 | 38 | 3.31 | |
| High School Graduate | 43 | 18.07 | 123 | 19.94 | 64 | 21.92 | 230 | 20.05 | |
| Some College/Associate | 104 | 43.70 | 303 | 49.11 | 126 | 43.15 | 533 | 46.47 | |
| Bachelor's Degree | 33 | 13.87 | 86 | 13.94 | 35 | 11.99 | 154 | 13.43 | |
| Graduate Degree | 37 | 15.55 | 42 | 6.81 | 35 | 11.99 | 114 | 9.94 | |
| Annual driving | | | | | | | | | <0.05 |
| More than average | 69 | 28.99 | 194 | 31.44 | 112 | 38.36 | 375 | 32.69 | |
| Average (24140 km) | 86 | 36.13 | 211 | 34.20 | 110 | 37.67 | 407 | 35.48 | |
| Less than average | 78 | 32.77 | 201 | 32.58 | 67 | 22.95 | 346 | 30.17 | |
| Alcohol use disorder | | | | | | | | | 0.86 |
| None | 175 | 73.53 | 462 | 74.88 | 214 | 73.29 | 851 | 74.19 | |
| AUD | 6 | 2.52 | 15 | 2.43 | 5 | 1.71 | 26 | 2.27 | |
| Dependent | 43 | 18.07 | 98 | 15.88 | 55 | 18.84 | 196 | 17.09 | |
| Binge frequency | | | | | | | | | 0.71 |
| Never | 163 | 68.49 | 409 | 66.29 | 173 | 59.25 | 745 | 64.95 | |

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| | Low (N=238) | | Mid (N=617) | | High (N=292) | | Total (N=1147) | | *P* |
|---|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | |
| <Monthly | 44 | 18.49 | 124 | 20.10 | 69 | 23.63 | 237 | 20.66 | |
| Monthly | 14 | 5.88 | 48 | 7.78 | 31 | 10.62 | 93 | 8.11 | |
| Weekly | 6 | 2.52 | 16 | 2.59 | 8 | 2.74 | 30 | 2.62 | |
| Daily/almost daily | 0 | 0 | 2 | 0.32 | 1 | 0.34 | 3 | 0.26 | |
| Drank too much to drive in past 12 mo | 10 | 6.21 | 30 | 3.35 | 9 | 9.89 | 49 | 4.27 | <0.05 |
| BAC at survey >=0.05 | 4 | 2.48 | 19 | 2.12 | 3 | 3.30 | 26 | 2.27 | 0.76 |

Note: Percentages do not sum to 100 due to missing

## Table 2

**Bivariable modeling of the odds of acceptance of drinking and driving, California Roadside Survey 2012 (n=1147)**

| | Population average model | | | |
|---|---|---|---|---|
| | **OR** | **95% CI** | | ***P*** |
| **Individual-level** | | | | |
| Age | 0.99 | 0.99 | 1.00 | 0.32 |
| Sex: Male vs. Female | 1.35 | 1.13 | 1.51 | <0.01 |
| Ethnicity: Hispanic vs. Non-Hispanic | 1.24 | 0.87 | 1.76 | 0.24 |
| Race | | | | |
| White | ref | | | |
| Black | 2.31 | 1.42 | 3.75 | <0.01 |
| Asian | 2.00 | 1.29 | 3.10 | <0.01 |
| Other | 1.29 | 0.95 | 1.74 | 0.10 |
| Education: College +vs. <college | 1.10 | 0.73 | 1.65 | 0.64 |
| Heavy driving status | | | | |
| Average or below average | ref | | | |
| Above average | 0.83 | 0.58 | 1.20 | 0.32 |
| Unknown | 1.42 | 0.60 | 3.33 | 0.42 |
| Binge frequency | | | | |
| Never | ref | | | |
| <Monthly | 1.28 | 0.84 | 1.94 | 0.25 |
| Monthly or more | 1.36 | 0.92 | 2.03 | 0.13 |
| Unknown | 2.98 | 1.48 | 6.02 | <0.01 |
| Alcohol use disorder status | | | | |
| None | ref | | | |
| Dependence | 0.57 | 0.22 | 1.48 | 0.25 |
| Disorder | 1.21 | 0.86 | 1.69 | 0.27 |
| Unknown | 1.64 | 0.99 | 2.72 | 0.06 |
| Blood alcohol content at survey | | | | |
| <0.05 | ref | | | |
| >=05 | 3.19 | 1.28 | 7.91 | <0.05 |
| Unknown | 1.08 | 0.24 | 4.91 | 0.92 |
| **City-level** | | | | |
| Proportion of traffic crashes that are alcohol-involved | 1.22 | 1.08 | 1.37 | <0.01 |
| Quadratic term | 0.994 | 0.990 | 0.998 | <0.01 |

**Table 3**

**Multivariable modeling of the odds of acceptance of drinking and driving, California Roadside Survey 2012 (n=1147)**

| | Model 1 | | | | Model 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | **OR** | **95% CI** | | ***P*** | **OR** | **95% CI** | | ***P*** |
| **Individual-level** | | | | | | | | |
| Age | 1.00 | 0.99 | 1.01 | 0.42 | 1.00 | 0.99 | 1.01 | 0.71 |
| Sex: Male vs. Female | 1.34 | 1.14 | 1.50 | <0.01 | 1.34 | 1.14 | 1.49 | <0.01 |
| Ethnicity: Hispanic vs. Non-Hispanic | 1.74 | 1.21 | 2.50 | <0.01 | 1.72 | 1.25 | 2.36 | <0.01 |
| Race | | | | | | | | |
| White | ref | | | | ref | | | |
| Black | 2.81 | 1.71 | 4.61 | <0.001 | 2.65 | 1.65 | 4.26 | <0.001 |
| Asian | 2.40 | 1.49 | 3.85 | <0.001 | 2.30 | 1.47 | 3.59 | <0.001 |
| Other | 0.97 | 0.70 | 1.33 | 0.84 | 0.91 | 0.68 | 1.22 | 0.53 |
| Education: College +vs. <college | 1.05 | 0.69 | 1.58 | 0.83 | 1.03 | 0.69 | 1.53 | 0.89 |
| Alcohol use disorder status | | | | | | | | |
| None | ref | | | | ref | | | |
| Dependence | 0.52 | 0.19 | 1.40 | 0.20 | 0.55 | 0.22 | 1.40 | 0.21 |
| Disorder | 1.15 | 0.83 | 1.60 | 0.40 | 1.12 | 0.82 | 1.55 | 0.82 |
| Unknown | 1.45 | 0.83 | 2.54 | 0.19 | 1.44 | 0.84 | 2.47 | 0.84 |
| Blood alcohol content at survey | | | | | | | | |
| <0.05 | ref | | | | ref | | | |
| >=.05 | 3.26 | 1.29 | 8.24 | <0.05 | 3.28 | 1.30 | 8.26 | <0.05 |
| Unknown | 0.93 | 0.21 | 4.16 | 0.93 | 0.89 | 0.21 | 3.81 | 0.87 |
| **City-level***  | | | | | | | | |
| Proportion of injury traffic crashes that are alcohol-involved | | | | | 1.18 | 1.04 | 1.34 | <0.01 |
| Quadratic term | | | | | 0.995 | 0.991 | 0.999 | <0.05 |

*The *p*-value for the proportion of injury traffic crashes that are alcohol-involved and the quadratic term tested together was <0.05 and was obtained from the Wald's test.

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**Table 4**

**Modeling the odds of past year drinking and driving, California Roadside Survey 2012 (n=158)**

| | Bivariable population average | | | | Multivariable population average | | | |
|---|---|---|---|---|---|---|---|---|
| | **OR** | **95% CI** | | ***P*** | **OR** | **95% CI** | | ***P*** |
| **Individual-level** | | | | | | | | |
| Age | 0.98 | 0.93 | 1.03 | 0.42 | 1.02 | 0.95 | 1.09 | 0.60 |
| Sex: Male vs. Female | 1.90 | 1.23 | 1.99 | <0.05 | 1.87 | 0.93 | 1.98 | 0.06 |
| Ethnicity: Hispanic vs. Non-Hispanic | 0.85 | 0.27 | 2.67 | 0.27 | 0.80 | 0.25 | 2.52 | 0.70 |
| Race | | | | | | | | |
| White | ref | | | | | | | |
| Black | 0.0004 | 0.0001 | 0.0016 | <0.001 | | | | |
| Asian | 0.39 | 0.05 | 3.45 | 0.40 | | | | |
| Other | 0.29 | 0.07 | 1.27 | 0.10 | | | | |
| Education: College +vs. <college | 1.06 | 0.37 | 2.99 | 0.92 | 0.77 | 0.26 | 2.29 | 0.64 |
| Heavy driving status | | | | | | | | |
| Average or below average | ref | | | | | | | |
| Above average | 1.23 | 0.49 | 3.11 | 0.66 | | | | |
| Unknown | N/A | | | | | | | |
| Binge frequency | | | | | | | | |
| Never | ref | | | | ref | | | |
| <Monthly | 3.06 | 0.42 | 22.16 | 0.27 | 3.70 | 0.39 | 35.36 | 0.26 |
| Monthly or more | 21.83 | 4.03 | 118.22 | <0.001 | 22.29 | 3.29 | 151.04 | <0.01 |
| Unknown | 6.11 | 0.58 | 64.20 | 0.13 | 5.38 | 0.48 | 59.61 | 0.17 |
| Acceptance vs. no acceptance | 5.38 | 1.85 | 15.63 | <0.01 | 3.46 | 1.12 | 10.71 | <0.05 |
| **City-level** | | | | | | | | |
| Proportion of traffic crashes that are alcohol-involved | 0.99 | 0.49 | 1.97 | 0.97 | 0.74 | 0.39 | 1.42 | 0.37 |
| Quadratic term | 1.01 | 0.98 | 1.03 | 0.67 | 1.01 | 0.99 | 1.04 | 0.27 |