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Individual, business-related, and work environment factors associated with driving tired among taxi drivers in two metropolitan U.S. cities

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Abstract

Introduction: Violence-related events and roadway incidents are the leading causes of injury among taxi drivers. Fatigue is under-recognized and prevalent in this workforce and is associated with both injury outcomes. We describe the association of individual, business-related, and work environment factors with driving tired among taxi drivers in two very different cities.

Method: We developed a comprehensive survey for licensed taxi drivers. We trained surveyors to administer the 30-min survey using systematic sampling among taxi drivers waiting for fares in two large U.S. cities: the Southwest (City 1) and the West (City 2). A driving tired scale of the Occupational Driver Behavior Questionnaire was the outcome. Multivariate logistic models described driving tired behavior in city-specific models using adjusted Odds Ratios (ORadj).

Results: City 1 and City 2 had 496 and 500 participants, respectively. Each driving tired behavior was significantly more prevalent in City 2 than City 1 ($p < .05$). There were more variables and a greater diversity of variables in the models describing drowsy driving in City 1 than City 2. In City 1, variables describing negative safety climate (ORadj = 1.15), socio-demographic groups (identifying as Asian, educational attainment), passenger-related violence (ORadj = 1.79), and company tenure (ORadj =1.15) were associated with driving tired. In City 2, high perceived safety training usefulness (ORadj = 0.48) was associated with driving tired. A risk factor for driving tired that was common to both cities was job demands (ORadj = 1.21 in City 1; 1.43 in City 2).

Conclusions: These findings represent two diverse taxi populations driving in two geographically distinct regions that differ in safety regulation. It is important that safety measures that include fatigue awareness training are reaching all drivers. Fatigue management training should be integrated into driver safety programs regardless of location.

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The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

Practical applications: Fatigue management strategies that recognize individual factors, business-related characteristics, and work environment are an important component of road safety and are particularly relevant for occupational drivers.

1. Introduction

Driving a taxi is recognized as one of the most dangerous occupations due to the high violence rates that include homicides (Chaumont Menéndez, Socias-Morales, and Daus, 2017). Roadway incidents are a close second leading cause of death (BLS, 2017). Recent public health strategies for this workforce have focused on preventing violence and promoting better overall health through healthcare access and physical activity (Gany, Bari, Gill, Loeb, and Leng, 2015; Gany, Gill, Baser, and Leng, 2014; Menéndez et al., 2013). Taxi drivers are a part of the on-demand economy where service is expected "24/7"; thus, requiring drivers to perform shiftwork, and many drivers work days and nights to earn their living. In the general population of drivers in the U.S., it is estimated that at least 21% of all fatal crashes involve driver drowsiness (Teft, 2014). A survey of 304 Singaporean taxi drivers found 33% experienced daytime sleepiness and fatigue at a level where immediately seeing a doctor is recommended, and 35% reported very poor or poor quality of sleep (Lim and Chia, 2015). In Beijing, 60% of 286 taxi drivers surveyed reported often or always experiencing fatigue while driving, compared to 38% of 274 truck drivers surveyed (Meng et al., 2015). Despite the long work hours, fatigue is an understudied risk factor for roadway incidents in this workforce whose time is spent almost exclusively on roadways (Dalziel and Job, 1997; Lim and Chia, 2015; Meng et al., 2015; Yang et al., 2014). The exposure to fatigue-related roadway incidents not only affects the drivers, but their passengers, other motorists, and pedestrians.

Taxi drivers are at risk for chronic health issues associated with sedentary behavior, inadequate and insufficient sleep, and stress – all factors associated with fatigue. Recent health promotion efforts focused on taxi drivers identified a third of drivers needed urgent care for high blood pressure or high glucose levels, and just over half did not have health insurance (Gany et al., 2015). The business-related aspects to driving a taxi, psychosocial factors (e.g., safety climate at the driver's current taxi company), sources of work stress (e.g., job demands), and passenger violence are under-represented in the literature. When measured they are predominantly conducted in other countries (Boufous and Williamson, 2009; Dalziel and Job, 1997; Facey, 2003; Firestone and Gander, 2010; Lim and Chia, 2015; Meng et al., 2015; Meng et al., 2016; Miyamoto et al., 2008; Yang et al., 2014). Approaches focusing on the complete health and wellness of the driver to improve driver safety as it relates to fatigue are needed alongside fatigue prevention strategies designed for taxi drivers and policies and procedures administered by taxi companies. Designing these approaches requires identifying and measuring work-related psychosocial factors believed to be associated with fatigue in this workforce.

Our objective was to evaluate the association of individual, business-related, and work environment factors with driving while tired among taxi drivers and, considering differences in regulation, region, and population, compare them between the two metropolitan areas surveyed.

2. Methods

2.1. Study population

City taxi drivers licensed for at least 12 months were orally administered a 30-min survey and remunerated for their time. We trained surveyors to systematically sample taxi drivers waiting for fares (a) at two international airports and a downtown location in a large metropolitan city in the Southwest U.S. (City 1), and (b) at the international airport in a large metropolitan city in the Western U.S (City 2). The airport parking lots were divided into lanes that were randomly selected by the surveyor. The surveyor then would sample every nth car. Cars with no driver or a napping driver were not approached. The response rate was reported as 100%. In both cities transportation network companies (TNCs) such as Uber and Lyft are licensed and included in the study to the extent they were represented in the taxi staging areas (not allowed in City 2) or participating drivers drove for TNCs in addition to their taxis. In City 2 TNCs were not allowed to service the airport and were not available at the staging area. The XXX Institutional Review Board approved the study protocol with all participating drivers providing informed consent.

2.2. Outcome measure

The driving tired subscale of the Occupational Driver Behavior Questionnaire (ODBQ; Newnam, Greenslade, Newton, and Watson, 2011) is the outcome measure of analysis completed for each city. The ODBQ provides an occupational context to road safety behaviors of workers who drive for a living. It is a valid tool for measuring four dimensions of work-related driver safety behaviors: speeding, rule violation, inattention, and driving while tired (Newnam et al., 2011; Newnam and Von Schuckmann, 2012). Three items describe driving while tired: (a) how often do you "drive while tired," (b) "'have difficulty driving due to tiredness or fatigue," and (c) "find yourself nodding off while driving." A 5-point Likert-type scale ranging from rarely or never (1) to very often (5) anchored the items.

2.3. Independent variables

We constructed a survey to obtain individual, business, and work environment factors centered around driving a taxi. The *individual characteristics* included age, sex, race/ethnicity, nativity, educational attainment, marital status, and religion. *Business factors* were those related to the business of driving a taxi: (a) tenure (in years) for driving a taxi, in the current city, and for the current company; (b) taxi ownership; (c) taxi license plate or medallion ownership; and (d) driving schedules. We asked about number of hours of daytime or nighttime driving in a typical day, number of hours and miles driven in a typical week, and percentage of time driving on the highway. *Work environment* factors are those the taxi drivers encounter or experience in the course of driving a taxi. We included a job demands scale (Caplan, Cobb, French, Harrison, and Pinneau, 1980) modified to include "as a taxi driver" when referencing work duties, a safety climate short scale (Hahn and Murphy, 2008), passenger violence in the past year, motor-vehicle crashes in the past year, and taxi safety measures such as security cameras and training.

2.4. Statistical analysis

Statistical analyses were conducted in 2017–2018; data were collected in 2015. We found the driving tired subscale from the ODBQ was sufficiently reliable for each city: standardized Cronbach's alpha was 0.89 for City 1 and 0.86 for City 2 (where > 0.70 is considered acceptable). The proportional odds assumption was not met for City 2, therefore based on the distribution of the subscale scores, we assigned a cut-point of >1 to allow for logistic regression modeling and comparison between cities. Variables hypothesized to be associated with the reporting of driving tired behaviors were first analyzed using bivariate logistic regression models to determine significance at $p \leq .25$. To prevent collinearity, variables found to be associated with the outcome at $p \leq .25$ were evaluated using tetrachoric (binary variables) or polychoric (non-binary categorical variables) correlations. Any variable pair with a Pearson's correlation set at $\rho \geq 0.60$ was evaluated with only one variable of the pair proceeding to model building. The variable selected to proceed was the one with the stronger association with the outcome or with greater implications for road safety promotion. A hierarchical process provided the final logistic models describing the driving tired subscale in separate models for individual, business-related, and work environment factors where the Wald test statistic was $p \leq .05$. No variables proceeded in the process unless they were associated with the outcome with a Wald test statistic of $p \leq .05$. The final separate models were then combined for further hierarchical analysis into one final model. Regression analyses were conducted separately for each city. The data were analyzed using SAS software version 9.4, 2013 (SAS Institute, Cary, NC).

3. Results

3.1. Descriptive analyses

Approximately the same number of eligible taxi drivers participated in the survey in City 2 (n = 500) as those in City 1 (n = 496; Chaumont Menéndez, in review). We present the city-specific distribution of drivers classifying their road safety behavior for each Likert value and consider a value of 2 and above as experiencing the safety behavior (Table 1). “Driving tired” was the most frequently reported behavior (51% and 64%) and “nodding off while driving” the least frequently reported (20% and 26%). In both cities, the prevalence of each tired driving-related road safety behavior was significantly different from the other two ($p < .002$). Taxi drivers surveyed in City 2 reported significantly more driving tired-related road safety behaviors compared to drivers in City 1 ($p < .05$).

3.2. Bivariate results

A series of tables present the bivariate logistic regression analyses examining various aspects to driving a taxi with driving tired: individual factors, business-related factors, and work environment factors (Tables 2–4).

Overall, City 1 had more variables associated with driving tired at 20, compared with 9 for City 2. The individual factors found to be significantly associated with driving tired for City 1 were educational attainment ($p < .001$), race and ethnicity ($p < .01$), and region of nativity ($p < .01$) (Table 2). There were no individual factors significantly associated with driving tired in City 2. In City 1, variables describing the business aspects of driving a taxi that were not significant for City 2 were driving tenure for current company ($p < .01$), plate or medallion ownership ($p < .01$), and number of hours driving at night in a typical week ($p < .01$) (Table 3). Regarding work environment, for City 1 only, the overall safety climate short scale ($p < .0001$) and the individual components feedback provided when safety practices are not followed ($p < .001$), safety as a shared activity (<0.005), and drivers feeling comfortable reporting safety problems to management ($p < .001$) (Table 4). In City 1, the additional variables of experiencing a motor-vehicle crash within the past 12 months while driving a taxi ($p = .01$) or a personal vehicle ($p < .0001$) were significantly associated with driving tired.

In bivariate logistic regression analyses examining associations with driving tired (Tables 2–4), the following variables were significantly associated with driving tired ($p < .05$) for *both* cities: the number of miles (City 1, $p < .0001$; City 2, $p < .01$) and hours (City 1, $p < .0001$; City 2, $p = .02$) driven in a typical week, safety training rated useful $p < .001$, both cities), job demands as a taxi driver (City 1; $p = .03$; City 2, $p < .0001$), and experiencing passenger violence in the past 12 months (City 1, $p < .001$; City 2, $p = .02$). Components of the safety climate short scale were significantly associated with tired driving in both cities, including company expectations of drivers to drive safely (City 1, $p < .01$; City 2, $p = .04$), company management make the health and safety of drivers a high priority (City 1, $p < .005$; City 2, $p < .01$) and drivers feel free to report safety problems to the company (City 1, $p < .001$).

3.3. Multivariable logistic models

The final models presented in Table 5 followed a modeling process that began with modeling the subgroupings of variable type – individual, business-related and work environment. The final models within each subgroup are listed with their odds ratios and 95% confidence intervals, followed by the final model combining all of the final variables across the subgroups. The final models for both cities show reporting the job is demanding and fewer number of miles driven in a typical workweek are significantly associated with driving tired. Ranking safety training as useful was associated with not driving tired in City 2. In City 1, additional variables in the final model that were not final variables for City 2 were increasing educational attainment, identifying as Asian, tenure at current company, hours driving in a typical workweek, daytime driving, negative safety climate, and experiencing passenger-related violence.

4. Discussion

In this analysis of survey data collected among approximately 1000 taxi drivers from two U.S. metropolitan areas, we determined the association of over 30 discrete variables representing socio-demographic, business-related, and work environment measures hypothesized to be associated with driving tired. The prevalence of driving tired differed significantly between most items – driving tired, difficulty driving due to tiredness or fatigue, and nodding off while driving – and differed significantly between the two geographic locations. We identified two socio-demographic variables, four business-related variables (including three work-scheduling variables), and four variables related to the work environment (two psychosocial constructs, one safety measure and one safety outcome) associated with driving tired. There were major differences between the two cities in which variables were significant, but in both cities perceived job demands and number of miles driven in a typical workweek were present in the final models for driving tired. To our knowledge this analysis makes a unique contribution to the breadth of factors examined in the context of fatigue and road safety behaviors, particularly among taxi drivers.

The variables related to work environment are arguably the most modifiable. The job demands scale, operationalized as the perceived demands from driving a taxi, was consistently significant throughout the statistical modeling process for driving tired (OR_{adj} = 1.21 for City 1 and 1.43 for City 2). Additionally, having experienced passenger violence in the past year was associated with driving tired for City 1 (OR_{adj} = 1.79). Passenger violence can be described as a chronic source of work stress in this workforce as homicides, rather than motor-vehicle crashes, remain the leading cause of fatalities among taxi drivers – a population that drives for a living. Job demands and work stress have been found to be associated with work-related motor-vehicle crashes (Robb, Sultana, Ameratunga, and Jackson, 2008; Cartwright, L, and Barron, 1996; Wills, Watson, and Biggs, 2006; Newnam and Von Schuckmann, 2012) and fatigue (MacDonald, 2003; Strahan, Watson, and Lennonb, 2008). A negative safety climate, an organizational-level psychosocial variable, was significantly associated with driving tired (OR_{adj} = 1.15 for City 1). Safety climate is an established link to fatigue-related near misses when driving, perhaps even more so than work stress (Strahan et al., 2008). The psychosocial variables present in the final models strengthen the necessity of incorporating measures of safety climate, job demands, and work stress (such as experiencing passenger violence and aggression) to better understand their role in fatigue and driving, especially among a workforce who transport people as their cargo and rely on human interaction for their livelihood. Understanding a broader range of psychosocial factors associated with driving tired among occupational drivers will help employers recognize the interrelatedness of both the safety and health of the driver and how they impact productivity and company profit in a very tight market. From a worker well-being perspective, road safety interventions in the taxi workforce would be more effective if company management considered and approached mitigating these causes and effects of fatigue as they are well established and overlooked work-related determinants for health, safety, and productivity in this industry.

The individual factors race/ethnicity and educational attainment were associated with driving tired in City 1 in opposite directions. Increasing educational attainment (OR_{adj} = 0.58) was associated with the likelihood of never or rarely driving tired. Literacy has been found to mediate the effect of educational attainment and health in a low-income population (Schillinger, Barton, Karter, Wang, and Adler, 2006); it is possible health literacy as it relates to managing fatigue and working safely is the link between educational attainment and fatigue-related road safety behaviors (Sorensen et al., 2012; Lee, Arozullah, and Choc, 2004; IOM, 2004; Paasche-Orlow and Wolf, 2007). That is, drivers with greater educational attainment could have greater health literacy and be better equipped to identify and effectively manage fatigue and driving. The other individual factor, identifying as Asian (OR_{adj} = 2.24), was associated with the likelihood of driving tired. Asian taxi drivers have previously been identified in occupational health research as a workforce that has a substantial need for healthcare access (~50% uninsured) and need for medical care (Gany et al., 2015), combined with an increased risk of cardiovascular disease risk associated with their ethnicity (Anand, Yusuf, Vuksan, et al., 2000; Holland, Wong, Lauderdale, and Palaniappan, 2011; Palaniappan, Wong, Shin, Fortmann, and Lauderdale, 2011). Indicators of poor health are associated with fatigue and fatigue-related driving. As socio-demographic factors are the least modifiable, they play an important role in identifying subpopulations of workers disproportionately at risk and in need of workplace safety policies that can effectively reach them. Future research examining fatigue and road safety behaviors such as driving tired among occupational drivers should include the constructs of health and safety literacy.

There were several business-related variables in the final model for City 1 and only one for City 2. The one variable in common was increasing number of miles driving a taxi in a typical workweek, which was consistently negatively associated with reporting any driving tired. This association coincides with a possible healthy worker effect for taxi drivers: drivers who are able to effectively manage fatigue and have the experience, training, or to drive longer distances in a typical workweek while doing so safely and without reporting a greater prevalence of driving tired. Furthermore, the variable “number of miles driven in a typical workweek” is distinct from the variable “number of hours driving in a typical workweek” since miles represents distance (progress to destination) and hours represents time spent in the taxi that could represent high traffic or waiting for a fare. Accordingly, “number of hours driving in a typical workweek” was positively associated with reporting driving tired in the final model restricted to business-related variables in City 2 (OR_{adj} = 1.53), as well as daytime driving hours (OR_{adj} = 2.30) in City 1. Increasing number of hours driving a taxi includes time spent in traffic, waiting for fares, and other scenarios that do not promote psychomotor functioning. However, the negative association of increased number of weekly hours driving a taxi in City 1 (OR_{adj} = 0.58), which is less congested, could also signify a healthy worker effect under different traffic patterns.

Training is a foundational tool relied upon by many industries to communicate topics well established as threats to worker safety. However, the effectiveness of training relies upon the contents, methods of delivery, length of training, and timing. One of the three variables associated with driving tired in the final model was taxi drivers rating their training for road safety as useful (OR_{adj} = 0.48). This finding aligns with those of a recent systematic review examining the effectiveness of a fatigue training on safety among shift workers, some of who drive for a living (Barger et al., 2018). The review found five studies reported improvements in sleep quality, and two of three studies had favorable outcomes in personnel safety and personnel performance. Although there are no data available evaluating the training given in City 2, the finding that drivers rating their safety training as useful being associated with the likelihood of never or rarely driving while tired is very encouraging as a training specializing in fatigue mitigating strategies among drivers who work various shifts would be beneficial for the industry.

The positive correlation between crashes related to driving a taxi and any motor-vehicle crash within the past 12 months with driving tired is one that reinforces the well-established association between motor-vehicle crashes and fatigue-related driving (Teft, 2014). Both of these variables were independently no longer associated with the outcome when the other variables were considered for final model selection. This finding speaks to the importance of collecting data on other constructs like physical and psychosocial work environment, business-related factors that include regulatory aspects, driving schedules and patterns, lifestyle factors like diet and exercise, and health and sleep health altogether that are generally underrepresented in the epidemiologic literature.

Overall, the variables and types of variables in the final statistical models differed between the two regions. Although both cities represented diverse taxi workforces, the final models for fatigue-related road safety behaviors in City 1 comprised several individual, business-related, and work environment variables whereas City 2 had no individual variables, one psychosocial work environment variable, one work scheduling variable, and a safety measure. The taxi industry has no national safety standards or other policies, so the city a driver works in can impact the safety and health of the driver. One major difference between the two cities is they are found in two regions – City 1 is in the Southwest, is generally less regulated and, several years prior to the survey, had reached a framework for the transportation network companies (or TNCs), such as Uber and Lyft, to legally operate in the city. City 2 is in the West and had recently allowed TNCs to operate in the city several months prior to the survey, with a group of taxi drivers telling the present study personnel anecdotally business was down 40% since the TNCs were granted permission to operate. This could explain the significance of increasing job demands in the Western city as more fares were required to earn the same amount of money just a few months earlier. Furthermore in the city in the Southwestern U.S. (City 1), which has fewer safety regulations than the city in the Western U. S. (City 2), TNCs had been a formal part of the transit market and the organizational-related psychosocial variables that reflect the company the drivers contract with may play a larger role in explaining the occurrence of fatigue-related road safety behaviors. For example, in the absence of a structured and comprehensive safety training mandated by a city, the company where the driver has a contract makes a difference as some companies espouse safety policies that others may not. This could explain why increasing yearly tenure for some companies (OR_{adj} = 1.15) and safety climate (OR_{adj} = 1.15) were consistently associated with increased prevalence of reporting driving tired in this city. In cities that are less regulated, the company a driver works for can make an even greater difference than for highly regulated cities.

This study is not without its limitations. First, we did not have a sampling frame. The list of licensed drivers in either city includes drivers who are part time, drive for as little as 1 h a week, or are currently out of the country. It was decided the best way to locate the drivers was to go to the airports where all drivers eventually end up and apply some randomization and systematic sampling there to the extent possible. Additionally, the study design was cross-sectional. It is not possible to make any causal inferences as both the outcomes and independent measures we assessed were collected at the same time. We think this limitation is outweighed by the wealth of information on multiple outcomes and multiple dimensions of risk factors we were able to collect combined with the size of the study population compared to other studies focused on taxi drivers. Another limitation is that this analysis of driving while tired was conducted as a secondary analysis, therefore we did not have further details about fatigue-related covariates (e.g., average sleep duration, prevalence of sleep disorders, total working hours including other jobs). Finally a limitation is the self-report structure of the data collection rather than direct measurement. This limitation is minimized by the appropriateness of administering the validated psychosocial scales to the drivers to obtain their perceptions of their work environment, which cannot be measured in any other way.

We administered a comprehensive survey to two separate populations of taxi drivers in two distinct geographic locations within the United States. We explored socio-demographic, business-related, and work environment dimensions to driving a taxi that, to our knowledge, have not been evaluated among taxi drivers. We identified risk factors for fatigue-related driving behaviors that should be evaluated in conjunction with naturalistic driving studies among taxi drivers, an understudied workforce who exclusively drive and transport people on-demand any time within a 24-h window. Additionally, company-sponsored road safety programs addressing fatigue and driving tired are encouraged to include strategies for mitigating job demands and job stress and improving safety climate. Occupational health and safety researchers should consider developing and evaluating taxi driver-specific fatigue interventions to reduce the overall prevalence of driving while tired, which for our study population was found to be over 50%. Taxi company management should be aware of specific groups of drivers based on socio-demographic parameters that may be experiencing greater frequency in fatigue-related driving behaviors and ensure equitable training opportunities and scheduled driving times promote safe driving. Focusing on driver safety benefits the taxi drivers, passengers, and the company at a time when for-hire transportation is increasingly competitive.

Biographies

Cammie Menéndez served as an Epidemic Intelligence Officer (Class of 2007) assigned to the Division of Safety Research at the National Institute for Occupational Safety and Health. As a research epidemiologist her focus is on describing disparities in work-related injury outcomes and evaluating interventions designed to prevent injuries among vulnerable working populations. She has been a project officer for research targeting convenience store workers and taxi drivers and has special interests in Total Worker Health™ approaches to preventing workplace violence, suicide, and motor vehicle crashes. Most recently she is developing a fatigue management training for taxi drivers.

Christina Socias-Morales served as an Epidemic Intelligence Officer at the Division of Safety Research (DSR) at the National Institute for Occupational Safety and Health within the Centers for Disease Control and Prevention from 2013–2015. As a research epidemiologist, she focuses her research on occupational injuries including fall injuries, violence, health disparities, forklift injuries, and surveillance systems such as electronic health records, surveys, and workers' compensation systems. Most recently, she is the project officer for a best practices evaluation of an intervention to reduce falls in collaboration with the US Air Force Safety Center.

Srinivas Konda has focused on data analysis for epidemiological research within the Division of Safety Research at the National Institute for Occupational Safety and Health for the past 10 years. His breadth of interest includes work-related traumatic brain injury, violence, road safety, suicides, and opioid-related injuries that spans all occupations and some focus areas such as teachers, taxi drivers, tow truck drivers, EMS workers, correctional officers and law enforcement officers.

Marilyn Ridenour is a nurse epidemiologist who began working at the Division of Safety Research at the National Institute for Occupational Safety and Health as an Epidemic Intelligence Officer in 2005. Since then she has been funded to lead research evaluating the effectiveness of workplace violence prevention programs, primarily among healthcare workers.

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Table 1

Prevalence of Likert values for fatigue-related road safety behaviors in two U.S. metropolitan areas.

Fatigue-related road safety behavior	City 1, Southwest U.S.					City 2, West U.S.				
	1	2	3	4	5	1	2	3	4	5
Driving tired	49	31	13	4	3	36	34	25	3	2
Difficulty driving due to tiredness/fatigue	71	16	10	2	1	65	16	15	2	2
Nodding off while driving	80	11	7	2	0	74	13	11	1	1

Table 2

Bivariate logistic regression analyses of individual factors with scoring >1 on driving tired subscale for each city.

Variable	***City 1, Southwest U.S.***			***City 2, West U.S.***		
	Driving tired (n = 266; 54%)	**Not driving tired (n = 229; 46%)**	**p-value**	**Driving tired (n = 321; 64%)**	**Not driving tired (n = 179; 36%)**	**p-value**
Gender			0.92			0.28
Female	25 (10%)	21 (9%)		10 (3%)	8 (5%)	
Male	232 (90%)	201 (91%)		326 (97%)	154 (95%)	
Age			0.38			0.19
20–34	76 (29%)	56 (24%)		56 (17%)	20 (12%)	
35–44	80 (31%)	75 (33%)		104 (31%)	44 (27%)	
45–54	69 (26%)	63 (28%)		118 (35%)	71 (44%)	
≥55	37 (14%)	35 (15%)		58 (17%)	27 (17%)	
Education			**<0.001**			0.26
Some high school	56 (21%)	25 (11%)		33 (10%)	17 (11%)	
High school diploma	100 (38%)	81 (35%)		116 (35%)	49 (30%)	
Trade/some college	80 (31%)	81 (35%)		127 (38%)	56 (35%)	
College or greater	25 (10%)	42 (18%)		60 (18%)	40 (25%)	
Race			**<0.01**			0.11
Asian	47 (19%)	21 (10%)		24 (10%)	18 (15%)	
All others	206 (81%)	191 (90%)		229 (91%)	101 (85%)	
Religion			0.29			0.33
Christianity/Judaism	113 (47%)	101 (52%)		144 (46%)	77 (51%)	
All others	129 (53%)	94 (48%)		166 (54%)	73 (49%)	
Region of nativity			**<0.01**			0.79
Southern Asia	30 (11%)	9 (4%)		23 (7%)	10 (6%)	
All others	236 (89%)	220 (96%)		315 (93%)	152 (94%)	
Marital status			0.48			0.81
Married or partnered	155 (58%)	134 (59%)		185 (55%)	96 (60%)	
All others	106 (40%)	88 (38%)		150 (45%)	64 (40%)	
Nativity			0.16			0.46
Born in the U.S.	159 (60%)	152 (66%)		103 (31%)	55 (34%)	

Variable	*City 1, Southwest U.S.*			*City 2, West U.S.*		
	Driving tired (n = 266; 54%)	**Not driving tired (n = 229; 46%)**	**p-value**	**Driving tired (n = 321; 64%)**	**Not driving tired (n = 179; 36%)**	**p-value**
Born outside U.S.	105 (40%)	77 (34%)		233 (69%)	107 (66%)	

Bolded type indicates p-values >.05 for bivariate analyses.

Table 3

Bivariate logistic regression analyses of business-related factors with scoring >1 on driving tired subscale for each city.

Variable	*City 1, Southwest U.S.*			*City 2, West U.S.*		
	Driving tired (n = 266; 54%)	**Not driving tired (n = 229; 46%)**	**p-value**	**Driving tired (n = 321; 64%)**	**Not driving tired (n = 179; 36%)**	**p-value**
Total years driving taxi			0.59			0.04
Mean (SD)	11.5 (8.3)	11.1 (8.8)		9.9 (6.7)	11.3 (8.4)	
Median (Range)	9.7 (0.9–49.8)	9.0 (1.0–38.2)		8.4 (1.1–42.3)	9.4 (1.1–45.6)	
Years driving taxi in city			0.65			0.14
Mean (SD)	8.7 (6.2)	8.4 (7.1)		8.8 (6.2)	9.8 (7.7)	
Median (Range)	7.0 (0.9–32.2)	6.3 (0.9–38.2)		7.0 (0.5–43.0)	7.4 (1.1–43.5)	
Years driving taxi for company			**<0.01**			0.71
Mean (SD)	6.2 (5.2)	4.9 (5.0)		6.8 (5.3)	7.0 (6.2)	
Median (Range)	4.7 (0.1–32.2)	3.3 (0–37.9)		5.4 (0.1–37.4)	5.0 (0.1–40.1)	
Plate/Medallion ownership			**<0.01**			0.92
Own	104 (39%)	58 (26%)		322 (95%)	154 (95%)	
Lease	160 (61%)	169 (74%)		16 (5%)	8 (5%)	
Cab ownership			0.92			0.17
Own	108 (41%)	94 (41%)		151 (45%)	83 (51%)	
Lease	158 (59%)	135 (59%)		187 (55%)	79 (49%)	
Daily hours driven			0.61			0.27
Mean (SD)	6.6 (3.3)	6.7 (3.1)		6.2 (3.4)	5.9 (3.2)	
Median (Range)	7.0 (0–15)	6.0 (0–20)		6.0 (0–13)	6.0 (0–12)	
Nightly hours driven			**<0.01**			0.56
Mean (SD)	3.4 (3.1)	4.2 (2.9)		3.3 (2.8)	3.1 (2.9)	
Median (Range)	4.0 (0–12)	5.0 (0–10)		4.0 (0–10)	3.0 (0–10)	
Weekly hours driven			**<0.0001**			0.02
Mean (SD)	51.5 (17.9)	61.7 (19.4)		47.0 (16.0)	44.0 (14.7)	
Median (Range)	50.0 (14–126)	65.0 (8–108)		48.0 (10–120)	40.0 (4–80)	
Weekly miles driven		**<0.0001**				b 0.01
Mean (SD)	778.9 (398.8)	1062.8 (616.4)		742.2 (324.4)	831.5 (346.7)	
Median (Range)	700 (150–2000)	1000 (100–3000)		700 (100–2000)	875 (100–2000)	

Variable	*City 1, Southwest U.S.*			*City 2, West U.S.*		
	Driving tired (n = 266; 54%)	**Not driving tired (n = 229; 46%)**	**p-value**	**Driving tired (n = 321; 64%)**	**Not driving tired (n = 179; 36%)**	**p-value**
Time driving on highway			0.90			0.59
≤50% of time	146 (58%)	125 (58%)		280 (83%)	131 (81%)	
>50% of time	105 (42%)	92 (42%)		58 (17%)	31 (19%)	

Bolded type indicates p-values <.05 for bivariate analyses.

Table 4

Bivariate logistic regression analyses of work environment factors with scoring >1 on driving tired subscale for each city.

Variable	***City 1, Southwest U.S.***			***City 2, West U.S.***		
	Driving tired (n = 266; 54%)	**Not driving tired (n = 229; 46%)**	**p-value**	**Driving tired (n = 321; 64%)**	**Not driving tired (n = 179; 36%)**	**p-value**
Safety climate		**<0.0001**				0.57
Mean (SD)	11.8 (3.0)	10.6 (2.9)		12.4 (3.5)	12.2 (3.0)	
Median (Range)	12.0 (6–24)	12.0 (5–19)		12.0 (6–24)	12.0 (6–24)	
Safety expectations			**<0.01**			**0.04**
Agree	232 (88%)	217 (96%)		225 (77%)	133 (85%)	
Disagree	33 (12%)	10 (4%)		68 (23%)	23 (15%)	
Safety feedback			**<0.001**			0.11
Agree	222 (84%)	212 (94%)		219 (75%)	127 (81%)	
Disagree	43 (16%)	14 (6%)		74 (25%)	29 (19%)	
Safety is shared			**<0.005**			0.08
Agree	217 (82%)	207 (91%)		223 (76%)	130 (83%)	
Disagree	47 (18%)	20 (9%)		70 (24%)	26 (17%)	
No safety shortcuts			**0.01**		**<0.01**	
Agree	216 (82%)	203 (90%)		216 (74%)	133 (85%)	
Disagree	48 (18%)	23 (10%)		77 (26%)	23 (15%)	
Safety a high priority			**<0.005**			**<0.01**
Agree	205 (77%)	199 (88%)		210 (72%)	130 (83%)	
Disagree	60 (23%)	28 (12%)		83 (28%)	26 (17%)	
Report safety problems			**<0.001**			0.28
Agree	237 (89%)	223 (98%)		242 (83%)	135 (87%)	
Disagree	28 (11%)	4 (2%)		51 (17%)	21 (13%)	
Safety training	usefulness		**<0.001**		**<0.001**	
Agree	102 (38%)	123 (54%)		112 (38%)	87 (56%)	
Disagree	163 (62%)	105 (46%)		180 (62%)	69 (44%)	
Job demands			**0.03**		**<0.0001**	
Mean (SD)	12.4 (3.6)	11.6 (4.0)		12.5 (3.6)	10.8 (3.1)	
Median (Range)	13.0 (4–20)	12.0 (4–20)		12.0 (4–20)	11.5 (4–19)	
Passenger violence (<12 mos)			**<0.001**			**0.02**
Experienced	121 (45%)	69 (30%)		193 (57%)	74 (46%)	
Not experienced	145 (55%)	160 (70%)		145 (43%)	88 (54%)	
Safety camera			0.70			0.45
Installed	109 (41%)	90 (39%)		331 (99%)	155 (99%)	
Not installed	157 (59%)	139 (61%)		2 (1%)	2 (1%)	
Crashes <12 months			**<0.0001**			0.25
Experienced	56 (21%)	16 (7%)		57 (17%)	21 (13%)	
Not experienced	207 (79%)	211 (93%)		279 (83%)	141 (87%)	

Variable	*City 1, Southwest U.S.*			*City 2, West U.S.*		
	Driving tired (n = 266; 54%)	**Not driving tired (n = 229; 46%)**	**p-value**	**Driving tired (n = 321; 64%)**	**Not driving tired (n = 179; 36%)**	**p-value**
Taxi crashes <12 months			**0.01**			0.40
Experienced	36 (14%)	15 (7%)		49 (15%)	19 (12%)	
Not experienced	230 (86%)	214 (93%)		289 (86%)	143 (88%)	

Bolded type indicates p-values <.05 for bivariate analyses.

Table 5

Adjusted odds ratios with 95% confidence intervals for final multivariable logistic models describing tired driving-related road safety behaviors among taxi drivers in the U.S.*

Variables	*City 1*		*City 2*	
	Final model, sub-groupings	**Final model**	**Final model, sub-groupings**	**Final model**
Individual				
Increasing educational attainment	0.62 (0.51, 0.77)	0.58 (0.44, 0.76)	–	–
Identifying as Asian	2.28 (1.29, 4.06)	2.23 (1.06, 4.69)	–	–
Business-related				
Tenure driving taxi (years)	–*	–	0.97 (0.949, 0.998)	–
Tenure at current company (per 2 years)	1.12 (1.02, 1.22)	1.15 (1.05, 1.27)	–	–
Hours driving in workweek (per 20)	0.62 (0.48, 0.80)	0.58 (0.43, 0.78)	1.53 (1.17, 2.00)	–
Miles driving in workweek (per 100)	0.91 (0.87, 0.95)	0.92 (0.87, 0.97)	0.90 (0.85, 0.96)	0.91 (0.85, 0.98)
Daytime driving (hrs)	2.66 (1.52–4.63)	2.30 (1.21, 4.38)	–	–
Work environment				
Negative safety climate	1.14 (1.07, 1.22)	1.15 (1.06, 1.25)	–	–
Job is demanding (per 2 points)	1.06 (1.01, 1.12)	1.21 (1.05, 1.39)	1.34 (1.18, 1.53)	1.43 (1.24, 1.64)
Passenger-related violence (<12 mos)	1.94 (1.31, 2.89)	1.79 (1.09, 2.92)	–	–
Ranking safety training as useful	–	–	0.42 (0.28, 0.64)	0.48 (0.31, 0.74)
Taxi crash (<12 months)	2.14 (1.11, 4.16)	–	–	–
Motor-vehicle crash (<12 months)	2.16 (1.40, 3.35)	–	–	–

*Denotes variables not selected for final model for that city.