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Cell phone use while driving laws and motor vehicle driver fatalities: differences in population sub-groups and location

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Abstract

Purpose: Research suggests that cell phone use while driving laws are associated with lower driver fatalities. This study seeks to determine whether this relationship is modified by driver age (16–24, 25–39, 40–59, 60), sex (male, female), race/ethnicity (White non-Hispanic, White Hispanic, Black non-Hispanic, Other), or rurality (rural, urban)

Methods: 2000–2014 Fatality Analysis Reporting System data were merged with state legislation. The exposure was the type of cell phone legislation in effect. The outcome was non-alcohol-related driver fatalities by state-quarter-year. Incident rate ratios (IRR) were estimated using generalized Poisson mixed regression for over-dispersed count data with robust standard errors.

Results: Amongst 190,544 drivers, sub-group differences were detected. Compared to periods without bans, universal hand-held calling bans were associated with 10% [adjusted IRR=0.90, 95% confidence interval (CI) 0.84, 0.97] lower driver fatalities overall and up to 14% lower fatalities across all age groups and sexes. When comparing state-quarter-years with bans to those without, universal texting bans were not associated with lower fatalities overall or for any demographic group.

Conclusions: The relationships between cell phone laws and driver fatalities are modified by driver demographics, particularly for universal hand-held bans. Universal hand-held bans may benefit more types of drivers compared to universal texting bans.

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Conflict of Interests

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Keywords

Automobile driving; Cell phones; Epidemiology; Death; Legislation

INTRODUCTION

Cell phones have been agathokakological for traffic safety. While these technologies can be used positively, such as to hasten emergency services post-collision, they can also be used to facilitate injury while driving. Research shows that distracted driving collisions are increasing and that cell phone use is a significant contributor of these events [1]. In 2014 alone, 3,179 people were killed and 431,000 were injured in distracted driving collisions in the United States (US) [2]. It is well-established that cell phone use can negatively impact driving ability by cognitively, manually, or visually impeding driver attention [3–8]. A 2014 national survey determined that 90% of drivers feel that cell phone use while driving is a significant threat to safety, yet a fair portion of these drivers still engage in such behaviors [9].

As of June 2017, 48 states have enacted at least one cell phone use while driving law [10]. Of these states, 14 regulate hand-held cell phone use while driving for all licensed drivers; these bans typically prohibit drivers from physically holding a mobile device and conversing, but permit hands-free technology [10]. Forty-six states have ratified texting while driving bans for all drivers, which typically bar drivers from manually answering or composing text messages [10]. However, texting bans characteristically do not prohibit hand-held cell phone conversations.

Various studies have investigated the relationship between these laws and outcomes such as observed and self-reported driver behavior and fatal collision rates [11]. To the authors' knowledge, 11 studies have investigated the relationship between cell phone use while driving laws and fatal collisions; of these studies, five have investigated universal texting bans (UTB) and ten have evaluated universal hand-held bans (UHB) [12–22]. The term 'universal' indicates that the legislation applies to all licensed drivers. One study found that UTB with primary enforcement, meaning the driver could be pulled over for that specific offense, were associated with 8% lower single-vehicle, single-occupant crashes [12]. Another study investigating primary enforced UTB determined that these bans were associated with 3% lower total fatalities [21]. Two studies concluded that UTB were not associated with significant reductions in total fatal crashes or total fatalities [13, 15]. Another study which investigated the relationship between UTB, total fatalities, and driver fatalities in specific age groups conceded that total fatalities were 5% lower in 15–21 year olds only and driver fatalities were 7% lower only among those ≥ 65 years when these bans were in effect [16]. However, the findings concerning UHB reveal that their presence were associated with up to 13% lower total fatal crashes, total fatalities, and driver fatalities [13–22]. In specific age groups, one study determined that UHB were associated with 11% lower non-alcohol-related fatal crashes among drivers < 21 years [18]. Another study concluded that among 22–64 year old, total fatal crashes were 4% lower and total fatalities were 6%

lower when UHB were effective [16]. Another study found that among 18–54 year old age groups, UHB were associated with 7–9% lower driver fatalities [19].

While these studies are informative, several gaps in the literature persist. First, several states have added this legislation within the past five years so the extant literature needs revised. With the exception of one study [17], others did not adjust for the increasing number of cell phones in the population and no studies controlled for police population; both of these factors may confound the relationship between cell phone laws and driver fatalities. Also, it is unclear whether the relationship between these laws and driver fatal collisions are modified by other demographic factors. Traffic safety research suggests that certain laws may be more effective in some populations than others. It is well-established in the literature that males tend to exhibit more risk taking behaviors, such as speeding, maintaining safe following distances, or driving too fast for conditions, compared to female drivers [23]. Drivers in rural areas are known to engage in riskier behaviors, such as speeding or seat belt non-use, compared to urban drivers [24, 25]. Age is also a well-known modifier of driver behavior and crash outcomes [23, 26, 27]. Previous traffic safety studies have also documented racial and ethnic differences in red light running, stop sign violations, driving while intoxicated, seat belt non-use and speeding [28–31]. Hence, it is possible that cell phone use while driving laws may be associated with lower driver fatalities in certain, but not all, groups.

Therefore, the purpose of this study was to investigate whether disparities in the association between driver fatalities and cell phone use while driving laws exist for those of different ages, sex, race/ethnicity, and rurality. Considering previous traffic safety research, it was hypothesized that differences would exist between these groups.

MATERIALS AND METHODS

Data Sources

The primary data source was the Fatality Analysis Reporting System (FARS). FARS is a publically available database maintained by the National Highway Traffic Safety Administration (NHTSA) and is a compilation of all fatal traffic collisions which occur on US roadways. All 50 states and the District of Columbia (DC) report collisions to the NHTSA when at least one individual involved in the crash dies within 30 days of the incident. Trained analysts abstract the data from the reported files, which detail the circumstances surrounding the crash, vehicles, and individuals involved. FARS has been described in more detail elsewhere [32, 33].

The 2000–2014 FARS data were collected and merged with states' cell phone use while driving legislation in 2017. This dataset was constructed by the authors, which was generated via internet searches [34], the Insurance Institute for Highway Safety [10], and the Governor's Highway Safety Association [35]. The laws were researched in each states' legislative archives, read and coded. Information was collected regarding effective dates, who was affected, what was permitted/prohibited, etc. Coding was completed by two individuals for accuracy.

Other data were collected. Population estimates on July 1 of each year were retrieved from the US Census Bureau [36]. The number of cell phone subscriptions by state-year were obtained from the Federal Communications Commission's Local Telephone Competition reports [37]. Information pertaining to traffic safety laws, such as speed limits, seat belt laws, alcohol laws, etc. were obtained from two sources. Dr. Scott Masten, formerly of the California Department of Transportation, provided a dataset of extant traffic laws, which were coded through 2008 [38]. The dataset was expanded by the authors through 2014 using data from the Insurance Institute of Highway Safety [39]. The quarterly unemployment rate and consumer price index were obtained from the US Bureau of Labor Statistics [40]. Annual gasoline prices were gathered from the Energy Information Administration [41]. The quarterly per capita income was garnered from the Bureau of Economic Analysis [42]. The number of full time police officers were obtained from the US Federal Bureau of Investigation [43]. The number of drivers licensed by state were obtained from the Federal Highway Administration [44].

Study Population

The study population was limited to drivers of passenger vehicles 16 years of age who were killed in a non-alcohol related collision which occurred between January 1, 2000 and December 31, 2014. Non-alcohol collisions were defined as any collision where the investigating officer reported that alcohol was not consumed by the driver.

Variables

The main exposure was the presence of a UTB and/or UHB. These laws were binary coded (present or absent) at each state-quarter-year. The primary outcome was driver fatality counts by state-quarter-year. The District of Columbia was included as a state. Drivers were categorized into four age groups: 16–24, 25–39, 40–59, and 60 years of age. Sex was categorized as male or female. Location was categorized as urban or rural, which was based on the roadway function class where the collision occurred. Race/ethnicity was combined into four groups; White non-Hispanic, White Hispanic, Black non-Hispanic, or Other. Yearly population estimates for each state were linearly interpolated into state-quarter-year. Cell phone coverage by state-year was calculated by taking the number of residents with cell phone subscriptions per 1,000 of the states' population. Yearly per capita income by state was converted to quarter-year via linear interpolation. These values were then adjusted by the 2014 consumer price index to correct for inflation. The yearly gas price by state was converted to dollars per gallon and then adjusted by the 2014 consumer price index to correct for inflation. The maximum speed limit was obtained for each state by quarter-year and was binary coded as 70 miles per hour. Administrative license suspension (i.e. the automatic suspension of a license for testing above a set blood alcohol concentration) was obtained for each state-quarter-year and binary coded as present/absent. The minimum state per se blood alcohol concentration 0.08 g/dl was binary coded as present/absent. Seatbelt laws with primary enforcement for front seat passengers were binary coded as present/absent. Graduated drivers licensing (GDL), which places additional restrictions on young or inexperienced drivers, can modify youths' driving behaviors [45]. GDL laws were binary coded by state-quarter-year as present/absent. Because the amount of police may influence traffic safety laws enforcement, the number of states' full time employed police officers per

year were included as a continuous variable. The number of licensed drivers by demographic group and state-year were obtained and linearly interpolated into state-quarter-year.

Statistical Analyses

Descriptive statistics were assessed via percentages, frequencies, and mean. Unadjusted rates of driver fatality over the 15-year period were calculated for each demographic sub-group by the type of cell phone ban in effect. Collinearity was assessed between variables using variance inflation factor. Incident rate ratios (IRR) of driver fatalities were calculated via generalized mixed Poisson regression for over-dispersed count data with robust standard errors [46]. Year (continuous) and quarter (continuous) were modeled as fixed effects, while states were modeled as random effects. Driver license estimates were used as offsets for all sub-groups except race/ethnicity. Because driver license estimates were unavailable for racial and ethnic groups, population estimates of those 16 years of age were used as the offset for race/ethnicity. Because driver fatality counts over time were not linear, two linear splines were added to the model; knots were created at 2006 and 2011. Because our primary interests were to estimate the IRR for each sub-group without making strong model assumptions, the analyses were stratified and separate models were run for each of the sub-groups. Model 1 included variables for presence of UTB (binary), presence of UHB (binary), quarter (continuous), year (continuous), and spline knots. Model 2 included variables for UTB (binary), UHB (binary), quarter (continuous), year (continuous), spline knots, log of adjusted per capita income, log of unemployment rate, log of adjusted gas price, presence of maximum speed limit 70 miles per hour (binary), presence of administrative license suspension (binary), presence of minimum blood alcohol concentration 0.08 g/dl (binary), log of cell phone coverage, presence of graduated licensing laws (binary), and log of police population. All analyses were conducted in 2017 using SAS/STAT® software, Cary, North Carolina, version 9.4 with two-sided significance level $\alpha=0.05$. Ethical approval of this study was waived as this study did not meet the definition of human subject research.

RESULTS

From 2000–2014, 190,544 drivers 16 years of age were killed in non-alcohol-related motor vehicle crashes (Table 1). The majority were aged 25–59 years (47.2%), male (64.6%), and White non-Hispanic (76.3%). Most collisions occurred in rural areas (63.3%).

The crude 15-year collision rate was highest among 16–24 year old drivers when no bans were in effect (3.1 per 100,000) (Table 2). Males had higher rates than females. Across all age groups and sex, collision rates were lowest when both legislative bans were in effect.

The 15-year collision rate was highest among White non-Hispanics when no bans were in effect (1.5 per 100,000) (Table 3). For all race/ethnicities, driver fatalities were lower when any legislative ban was effective. Driver fatalities were higher in rural areas compared to urban areas when no bans were in effect (1.1 per 100,000 vs. 0.6 per 100,000, respectively). Driver fatal collision rates were equal in rural and urban locations when both bans were effective.

After adjusting for socio-economic and traffic safety factors, the presence of UHB were associated with 10% lower driver fatal collisions overall [adjusted (a) IRR=0.90, 95 % confidence interval (CI) 0.84, 0.97] (Table 4). After adjusting for covariates, driver fatalities were up to 14% lower in all ages and sexes in state-quarter-years with UHB compared to those without; however, driver fatalities were not significantly lower for specific racial/ethnic groups or locations after adjustment. As for UTB, after adjusting for socio-economic and traffic safety factors, driver fatalities were not statistically significantly lower overall or for any demographic group in state-quarter-years when UTB were effective compared to those times without these bans.

DISCUSSION

This analysis showed that the relationship between cell phone use while driving laws and non-alcohol-related driver fatality rates can vary across population sub-groups particularly for universal hand-held bans. After adjusting for socio-economic factors and other traffic safety laws, the presence of UHB were associated with lower fatalities in general and among all age groups and sexes. The presence of UTB were not associated with lower fatalities overall or in any demographic group. These findings suggest that UHB may have benefitted more types of drivers, which may have important policy implications.

These findings share similarities and differences with other extant studies. In this analysis, UHB were associated with 10% lower driver fatalities overall. This was comparable to other studies which have shown that UHB were associated with 7–13% lower fatalities for all drivers [13, 14, 19, 21]. As for specific age groups, in this analysis driver fatalities were 14% lower for 16–39 year olds, 11% lower for 40–59 year olds, and 8% lower for drivers 60 years of age when UHB were effective compared to when they were not. Other studies have similarly reported that UHB were associated with 6–9% lower fatalities amongst 18–54 year old drivers [19], ~8% less for drivers <21 years [18], and 4% less for drivers aged 22–64 years [16]. However, the findings concerning UTB were akin to some studies and dissimilar from others. Of the five extant studies concerning UTB, two determined that these bans were not associated with lower occupant fatalities or total fatal crashes [13, 15]. A third study also found that UTB were not associated with lower total fatalities overall and for those 22 years of age and that these bans were also not associated with lower driver fatalities among 15–64 year olds [16]. However, two other studies concluded that UTB with primary enforcement, which was not the focus of the present study, were associated with 3% lower total fatalities and 8% lower single vehicle, single occupant crashes [12, 21]. Taken collectively, it appears that UHB are associated with lower fatality rates across most studies while UTB are either not associated or only associated with slightly lower fatalities across studies.

However, it is not completely clear why UHB are associated with lower fatality rates and UTB are generally not. If this relationship is causal, it is possible that UHB discourage drivers from hand-held phone use more than UTB deter texting while driving. It is possible that UHB are easier for the public to comply with or even easier for police to enforce.

Nonetheless, the findings of this analysis may have important implications for health policy. First, this analysis showed that the relationship of the bans and driver fatality were fairly consistent across driver sub-groups. While the uniformity of these relationships was initially surprising given that cell phone use behaviors are known to vary across the age span, sexes, races/ethnicities, and even location [47, 48], it may be explainable. Perhaps because cell phones are an integral component of US culture and over 95% of the population owns a cell phone [37], the homogeneity of this relationship across sub-groups should have been expected. Secondly, the majority of states (i.e. 46) have already enacted UTB and <30% have ratified UHB. Therefore, even though causality cannot be established, it is possible that states seeking to add UHB could see a reduction in overall driver fatality.

Strengths and Limitations

The strengths of this analysis were that 3,060 state-quarter-years of data were utilized and additional confounders, such as police population and the number of cell phones in the population, were controlled, which had not been done previously. However, this study has several limitations. First, driver fatality rates can be influenced by many social, economic, and legal factors. While this study did control for numerous confounders, there are many others that could not be accounted for such as advances in technology or engineering which have made roads and/or vehicles safer thereby decreasing driver fatality. However, the models did account for both state and year, which may have partially controlled for these factors. Second, this analysis focused solely on driver fatality, which is only one type of crash scenario. These findings may not be generalizable to other types of collisions such as property damage only and injurious crashes, which are more common. Third, driver license estimates were not available for race/ethnicity so driver population had to be used as the offset. Not everyone 16 years of age drives. Lastly, the study design did not permit causal relationships to be determined. Hence, only associations between driver fatalities and cell phone use while driving laws could be assessed.

Conclusions

This study sought to determine whether age, sex, race/ethnicity or rurality modified the relationship between cell phone use while laws and driver fatality rate. The findings of this analysis showed that differences between driver sub-groups do exist. The presence of UHB were associated with lower fatalities overall, for all ages, and sexes. However, the presence of UTB were not associated with significantly less driver fatalities. Although associative, these findings suggest that drivers may have benefited from the presence of UHB. States seeking to enact UHB could possibly experience fewer driver fatalities.

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LIST OF ABBREVIATIONS:

DC	District of Columbia
FARS	Fatality Analysis Reporting System
GDL	graduated drivers licensing
IRR	incident rate ratio
NHTSA	National Highway Traffic Safety Administration
UHB	universal hand-held ban
UTB	universal texting ban
US	United States

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HIGHLIGHTS:

Hand-held cell phone bans were associated with 10% lower driver fatalities overall

Hand-held cell phone bans were associated with lower fatalities by age and sex

Texting bans were not associated with lower driver fatalities

Table 1.Descriptive statistics of the study population and state data, 2000–2014 (N=190,544)^a

Characteristic	N (%)	Mean (SD)
Age (years)		
16–24	42,418 (22.3)	--
25–39	38,434 (20.2)	--
40–59	51,510 (27.0)	--
60	58,182 (30.5)	--
Missing	0	
Sex		
Male	123,149 (64.6)	--
Female	67,389 (35.4)	--
Missing	6	
Race/ethnicity		
White non-Hispanic	123,110 (76.3)	--
White Hispanic	13,534 (8.4)	--
Black non-Hispanic	18,294 (11.3)	--
Other	6,502 (4.0)	--
Missing	29,104	--
Location		--
Urban	69,659 (36.8)	--
Rural	119,889 (63.3)	--
Missing	996	--
Universal hand-held ban	--	0.10 (0.30)
Universal texting ban	--	0.26 (0.44)
Max speed limit 70 MPH	--	0.62 (0.48)
Primary seat belt law	--	0.50 (0.50)
Graduated drivers licensing	--	0.80 (0.40)
Administrative license revocation	--	0.82 (0.38)
Illegal per se 0.08 g/dl BAC	--	0.87 (0.33)
Unemployment, percent	--	5.9 (2.1)
Adjusted gas price, dollars per gallon	--	2.64 (0.65)
Adjusted per capita income, dollars	--	43,301 (7,301)
Cell phone coverage, subscriptions per 1,000	--	709 (259)
Number of full time police officers	--	19,013 (22,915)

^a: Abbreviations: BAC=blood alcohol concentration, MPH=miles per hour. The sample size was 3,060 state-quarter-years (including Washington DC). For binary variables, the mean values should be interpreted as the proportion of state-quarter-years in which the variable was present. For continuous variables, the mean values are the average over all state-quarter-years. Percentages may not equal 100% due to rounding.

Table 2.Laws, fatalities, and crude incidence rate of fatal collision by age and sex^a

Characteristic	Sub-group and ban	Fatalities (N)	Crude 15-year rate (per 100,000 driver- quarter-years)
Overall	No ban	150,123	1.6
	Hand-held ban	4,620	0.7
	Texting ban	25,534	1.2
	Both bans in effect	10,267	0.6
Age	16–24 year olds		
	No ban	34,661	3.1
	Hand-held ban	1,035	1.9
	Texting ban	4,832	2.0
	Both bans in effect	1,890	1.1
	25–39 year olds		
	No ban	30,531	1.3
	Hand-held ban	814	0.6
	Texting ban	5,178	1.1
	Both bans in effect	1,911	0.5
	40–59 year olds		
	No ban	40,855	1.3
	Hand-held ban	1,190	0.6
	Texting ban	6,705	1.0
	Both bans in effect	2,760	0.5
	60 year olds		
	No ban	44,076	2.4
	Hand-held ban	1,581	1.5
	Texting ban	8,819	1.9
	Both bans in effect	3,706	1.1
Sex	Males		
	No ban	96,787	2.3
	Hand-held ban	3,095	1.2
	Texting ban	16,347	1.8
	Both bans in effect	6,920	0.9
	Females		
	No ban	53,332	1.3
	Hand-held ban	1,525	0.6
	Texting ban	9,185	1.0
	Both bans in effect	3,347	0.5

Table 3.Laws, fatalities, and incidence rate of fatal collision by race and region^a

Characteristic	Sub-group and ban	Fatalities (N)	Crude 15-year rate (per 100,000 driver-quarter- years)
Race/ethnicity	White non-Hispanic		
	No ban	98,043	1.5
	Hand held ban only	1,256	0.3
	Texting ban only	17,115	1.1
	Both bans in effect	6,696	0.7
	White Hispanic		
	No ban	11,201	1.0
	Hand held ban only	167	0.2
	Texting ban only	796	0.6
	Both bans in effect	1,370	0.4
	Black non-Hispanic		
	No ban	14,925	1.3
	Hand held ban only	115	0.1
	Texting ban only	2,519	0.9
	Both bans in effect	735	0.4
	Other		
	No ban	5,029	0.8
	Hand held ban only	115	0.2
	Texting ban only	645	0.5
	Both bans in effect	713	0.3
Location	Urban		
	No ban	52,825	0.6
	Hand-held ban	2,428	0.5
	Texting ban	9,228	0.5
	Both bans in effect	5,178	0.4
	Rural		
	No ban	96,442	1.1
	Hand-held ban	2,186	0.4
	Texting ban	16,184	0.9
	Both bans in effect	5,077	0.4

Table 4.Results of multivariate analysis between cell phone legislation and fatal collision by sub-group^a

Characteristic	Sub-group	Model 1 IRR ^b (95% CI)	Model 2 IRR ^b (95% CI)
Overall	Hand-held ban	0.88 (0.81, 0.96)	0.90 (0.84, 0.97)
	Texting ban	1.03 (0.96, 1.10)	1.03 (0.91, 1.16)
Age	16–24 year olds		
	Hand-held ban	0.84 (0.72, 0.97)	0.86 (0.76, 0.97)
	Texting ban	0.99 (0.90, 1.09)	1.00 (0.71, 1.40)
	25–39 year olds		
	Hand-held ban	0.84 (0.79, 0.90)	0.86 (0.80, 0.93)
	Texting ban	1.05 (0.93, 1.18)	1.05 (0.77, 1.44)
	40–59 year olds		
	Hand-held ban	0.86 (0.80, 0.93)	0.89 (0.84, 0.95)
	Texting ban	1.01 (0.93, 1.10)	1.01 (0.74, 1.38)
	>60 year olds		
	Hand-held ban	0.91 (0.84, 1.00)	0.92 (0.86, 0.99)
	Texting ban	1.02 (0.97, 1.08)	1.02 (0.97, 1.07)
Sex	Males		
	Hand-held ban	0.89 (0.83, 0.96)	0.91 (0.85, 0.97)
	Texting ban	1.03 (0.95, 1.12)	1.03 (0.86, 1.24)
	Females		
	Hand-held ban	0.86 (0.78, 0.96)	0.88 (0.81, 0.97)
	Texting ban	1.02 (0.95, 1.08)	1.02 (0.83, 1.25)
Race/ethnicity	White non-Hispanic		
	Hand held ban	0.90 (0.76, 1.05)	0.93 (0.79, 1.09)
	Texting ban	1.12 (0.97, 1.30)	1.11 (0.96, 1.28)
	White Hispanic		
	Hand held ban	0.87 (0.72, 1.06)	0.83 (0.67, 1.04)
	Texting ban	0.88 (0.63, 1.24)	0.90 (0.52, 1.55)
	Black non-Hispanic		
	Hand held ban	0.86 (0.72, 1.02)	0.89 (0.75, 1.05)
	Texting ban	0.97 (0.80, 1.16)	0.94 (0.74, 1.18)
	Other		
	Hand held ban	0.88 (0.47, 1.68)	0.93 (0.75, 1.15)
	Texting ban	0.85 (0.02, 36.85)	0.85 (0.06, 12.35)
Location	Urban		

Characteristic	Sub-group	Model 1 IRR ^b (95% CI)	Model 2 IRR ^b (95% CI)
	Hand held ban	0.85 (0.67, 1.07)	0.88 (0.77, 1.00)
	Texting ban	1.01 (0.88, 1.15)	0.99 (0.92, 1.07)
	Rural		
	Hand held ban	0.89 (0.82, 0.95)	0.90 (0.45, 1.83)
	Texting ban	1.03 (0.96, 1.11)	1.04 (0.96, 1.13)

^a: Abbreviations: CI=confidence interval; IRR=incident rate ratio

^b: Model 1 contained variables for presence of universal texting ban (binary), presence of universal hand-held ban (binary), quarter (continuous), spline knots and year (continuous). Model 2 included variables for presence of universal texting ban (binary), presence of universal hand-held ban (binary), quarter (continuous), spline knots, year (continuous), log of adjusted per capita income, log of unemployment rate, log of adjusted gas price, maximum state speed limits 70 miles per hour (binary), presence of administrative license suspension (binary), presence of per se minimum blood alcohol concentration 0.08 g/dl (binary), presence of primary seat belt laws for front seat passengers (binary), log of cell phone coverage, presence of graduated drivers licensing laws (binary), and log of police population. Model 1 and Model 2 were stratified analyses. Because the focus of this analysis was the relationship between legislation and fatal collision rate, only the IRR pertaining to the bans were shown for ease of presentation.