Accident Analysis and Prevention 125 (2019) 106–115

Contents lists available at ScienceDirect

Accident Analysis and Prevention

journal homepage: www.elsevier.com/locate/aap

Self-reported handheld device use while driving

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ARTICLE INFO

Keywords:
Handheld device use
Distracted driving
Accident analysis
Prevention

ABSTRACT

In spite of research and awareness of the hazards associated with handheld mobile device use while driving, many motorists continue to engage in this risky behavior. The mobile device use while driving has a detrimental effect on the operation of the vehicle. It contributes significantly to distraction which is a leading cause of accidents. Especially, the use of text messaging and the dialing of a 10-digit number while driving can be attributable to crash risks. Phone use bans have a positive role in reducing mobile phone use for texting while operating vehicles. There are limited studies on whether drivers admit to the use of handheld devices while driving. The aim of this study was to identify the experiences, practices, and attitudes of handheld device use while driving. A total of 337 respondents nationwide replied to the survey on the attitudes and self-reported behaviors of handheld device use while driving. In the survey, the characteristics of handheld device users, use of handheld devices, and the differences in self-reported behaviors across states with and without device use restrictions were compared. The perceptions and experiences of device users are also examined. Based on the background of device users and their attitudes, a multivariate logistic regression is used to identify the characteristics of those who use handheld devices while driving. The model is relevant to this research because it allows the consideration and comparison of many variables to identify the attitudes of people towards distracted driving. The affirmative self-reporting of 59 percent of the respondents is a surprising result given that there are state bans on texting and the use of handheld mobile phones while driving. Older drivers are least likely to engage in these behaviors, compared to younger drivers and adult drivers. Based on the findings, targeted educational and enforcement campaigns to reduce device use during driving are suggested. Additional promising areas for further inquiry and research are also proposed.

1. Introduction

There has been much research pointing to the impacts of mobile phone use and distraction on driving performance (Oviedo-Trespalacios et al., 2016) using a diverse array of methods including crash analysis (Svenson and Patten, 2005; McCartt et al., 2006), with instrumented vehicles (Caird et al., 2014a, b) naturalistic observations (Caird et al., 2014a; Ferdinand and Menachemi, 2014), and driving simulators (Törnros and Bolling, 2005; Ranney, 2008; Collet et al., 2010; Caird et al., 2014a). Based on a review of the published literature, there is evidence of the detrimental effects of mobile phone use while driving (Lipovac et al., 2017) with text messaging associated with the highest levels of distraction, followed by ten-digit dialing (Ranney et al., 2011). Research has shown that crash risk can be attributable to drivers talking on cell phones while driving (McEvoy et al., 2005; Márquez et al., 2015; Sun and Jia, 2016). There are deficiencies on reporting on the use of mobile phones that result in road traffic accidents around the world even though there are legislative bans on mobile phone use while driving in those nations (Ige et al., 2016).

While handheld cell phone use has declined over the past decade (2006–2015), visible manipulation of handheld devices has continued to increase according to the National Occupant Protection Use Survey (NOPUS), which shows device use is highest among young drivers, aged 16–24, and among female drivers over male drivers (Pickrell et al., 2016). Research in 2012 found that 11% of drivers reported always answering their phones while driving, and 17% report almost always answering while driving with more than half (58%) continuing to drive while completing their conversations (Tison et al., 2011; Schroeder et al., 2013). Between 2005 and 2008, there was a 28% rise in the fatalities from distracted driving and one of the major reason was the rise in texting (Wilson and Stimpson, 2010). In a recent three month analysis of 3 million drivers taking 570 million trips, amounting to 5.6 billion miles, Zendrive Research found that drivers use their phones 88 out of 100 trips (Zendrive Research, 2017). As to factors which lower

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https://doi.org/10.1016/j.aap.2019.01.032
Received 12 January 2018; Received in revised form 14 December 2018; Accepted 27 January 2019
Available online 07 February 2019
0001-4575/

handheld device use while driving, Rudisill and Zhu (2015) found that texting among U.S. high school aged drivers to be lower in states with both universal texting bans and young driver all cell phone bans (Rudisill and Zhu, 2015).

The perception of the driver has been significant determinants of mobile phone use while driving. Regardless of the legal ban on the use of mobile phones while driving, subjective values and norms play a key role among drivers who decide whether to use the mobile phone while driving (Rozario et al., 2010). Having a positive attitude on using a mobile phone and greater perception of the normative pressures of using a mobile phone while driving increases the likelihood of using a mobile phone while driving (Walsh et al., 2008). People with higher approval from others on the use of mobile phone while driving tend to increase their mobile phone use among themselves while they are driving (Walsh et al., 2008). But the drivers who perceive themselves as a skillful driver tend to use mobile phones while driving whereas law-abiding and safety oriented drivers use their phones less frequently while operating their vehicles (Pöysti et al., 2005). The illegal use of mobile phones while driving is also influenced by the social pressure to use the phone while driving. Drivers are more likely to respond to the mobile phone call than initiating the call. This indicates that there is higher social pressure to use the phone while driving (Waddell and Wiener, 2014). Beyond this, people initiate the phone call while driving if they perceive the importance of the call regardless of danger and the illegality of mobile phone use (Nelson et al., 2009).

Given the research and widespread knowledge of the dangers associated with distracted driving, this study explores the experiences, practices and attitudes of drivers towards handheld device use while operating a motorized vehicle. It strives to answer following questions: What are the characteristics of self-reported device use drivers? Do factors such as accident experience or attitudes influence the likelihood of being a device using driver? What is the likely impact of device use on accidents, based on both observational and self-reported data? Do motorists admit to handheld device use while driving? Based on these four questions, this study also recommends what can be done to target and discourage distracted driving?

2. Methods

2.1. Data sources

Several different datasets are combined to analyze distracted driving. First, a nationwide attitudinal survey on self-reported distracted driving conducted in July of 2017 is analyzed. Second, combining annual observation studies conducted in Hawaii and VMT data, the extent of distracted driving is estimated.

The attitudinal survey and protocol, reviewed by the University of Hawaii's Institutional Review Board (IRB) were accessible by a link using the Qualtrics web-based survey distribution system. The link was emailed to over 5,000 email addresses for individuals interested in transportation topics, traffic safety, public policy, risk management, and education. It was distributed via social media platforms (Facebook, Twitter, Linked-in, Instagram, etc.) to reach a diverse national audience. The researchers used a combination of public, professional, and personal networks and encouraged others to distribute the link widely. The researchers came from diverse backgrounds which helped to widen the distribution of the electronic survey. The survey ran for approximately 15 days.

In addition to the self-reported survey data, the University of Hawaii has been collecting observational data on cell phone use while driving since 2003, as part of the annual traffic safety studies conducted for the Hawaii Department of Transportation. These studies include observations on belt use, child safety seat use, riding in the back of pickup trucks, and other aspects of motorist behavior. The procedure involves sending teams of trained observers to observe and record the behavior of approximately 30,000 motorists at 152 locations throughout the state. Since 2003, the observation sites were revisited in terms of their weights and spatial location and it was approved by NHTSA. An iteration of an NHTSA-approved method for sampling was implemented in June 2011. The NHTSA method uses proportional sampling based on the weighting of road length and traffic volumes. A total of 152 observation sites across the State were selected. Seat belt and cell phone use rates were determined using the station selection probability values. The NHTSA method ensured adequate observations to enable statewide, county, and district level estimates as well as a mix of roadway types, volumes, and locations. For the imputation of potential distracted driving with handheld device analysis, Vehicle Mile of Travel (VMT) data was retrieved from the Department of Business, Economic Development & Tourism 2015 State of Hawaii Data Book.

2.2. Instruments

Five types of questions were asked in the survey. The first set relates to the backgrounds (age, gender, education, vehicle type, etc.). The second type of question focused on handheld device use while driving (phone, GPS, gaming console, tablet, hands-free speakers, etc.). The third group of questions was related to perceptions regarding the safety of drivers using handheld devices, the likelihood of being cited for device use as well as whether or not enforcement should be increased. The fourth set of questions focused on whether or not the driver has been in an accident or received a citation for handheld device use. Finally, by asking for the residence of motorists, the respondents were classified according to whether or not they lived in states with strong or weak handheld device use laws.

The characteristics of the respondents are contained in Table 1, (Characteristics of Survey Respondents). The location of respondent addresses is presented in Fig. 2.

Table 1
Characteristics of Survey Respondents.

Description	N	Mean	Min	Max
Age				
Male	177	49.99	19	78
Female	144	45.51	19	80
Total*	321	48.11	19	80

	Frequency	Percent	Cumulative Frequency	Cumulative Percent
Ethnicity				
Asian	52	15.9	52	15.9
African American	10	3.06	62	18.96
Caucasian	203	62.08	265	81.04
Latino or Hispanic	18	5.5	283	86.54
Native American	3	0.92	286	87.46
Pacific Islander	25	7.65	311	95.11
Other	16	4.89	327	100
Education				
Less than high school	1	0.31	1	0.31
High school graduate (include equivalency)	10	3.06	11	3.37
Some college, no degree	50	15.29	61	18.66
Associate's degree	35	10.7	96	29.36
Bachelor's degree	96	29.36	192	58.72
Graduate degree	135	41.28	327	100
Most Frequently used Vehicle				
Car	169	51.68	169	51.68
Truck	52	15.90	221	67.58
Van	14	4.28	235	71.87
SUV	82	25.08	317	96.94
Motorcycle	3	0.92	320	97.86
Other	7	2.14	327	100

* Total N = 337, does not total because of missing values.

The ages range between 19–80 years. The overall mean age is 48 years, with males older (mean = 50 years) than females (mean = 45.5 years). In terms of ethnicity, Caucasians dominate, comprising 62% of the sample, followed by Asians (16%), Pacific Islanders (7.7%), Hispanic (5.5%), Other (4.9%), African American (3.1%), and Native American (0.9%). The sample is biased towards highly educated respondents with 135 (41.3%) holding a graduate degree, 96 (29.4%) with a bachelor's degree; with over 25% having an Associate's degree or some college education. Ten of the respondents are high school graduates and one has less than high school education. As to be expected, the most frequently used vehicle is a car (51.7%) followed by SUVs (25.1%), trucks (15.9%), and vans (4.3%). Only 3 (0.92%) of the respondents rode motorcycles with 7 (2.14%). The demographic characteristics are not completely representative of the demographic profile of the respective communities of respondents. But the sample covers the perception and experiences of relatively highly educated and the mature section of the population.

The sample collected in this study was compared to the 2009 National Household Travel Survey (NHTS) data (Federal Highway Administration, 2009). While the mean respondent age was found to be similar (Sample = 48.11 years, NHTS = 49.42 years), the sample completed in this study contains more males (Sample = 55.14%, NHTS = 46.34%), is more educated (Bachelor's or Graduate Degree (Sample = 70.64%, NHTS = 36.33%), uses cars less (Sample = 51.68%, NHTS = 66.9%) and uses SUVs and trucks more (Sample = 40.98%, NHTS = 22.49%) than the national sample.

Fig. 1 shows the Observed Cell Phone Use While Driving, Hawaii, 2003–2017. The observed use of cell phones over the period from 2003 to 2017 has fluctuated, from a high of 4.69% in 2006 to the lowest observed levels of 1.68% and 1.56% in 2011 and 2017, respectively. This allows the study team to triangulate the validity of the survey data. The self-reported survey has shown much higher percentage than the observational data.

In order to impute the extent of handheld device use while driving, information from the attitudinal and observational studies as well as annual vehicle miles traveled (VMT). Potential trips where handheld devices were used can be derived from the annual VMT and the self-reported handheld device use rate and the average trip length. The observed cellphone use rate can then be applied to impute the number of distracted driving trips.

2.3. Statistical analysis

In addition to univariate and bivariate statistical tests, multivariate logistic regression analysis is used to estimate the likelihood of factors associated with self-reported device use while driving. This type of analysis builds on the authors' long and extensive experience with logistic regression and categorical data analysis (Kim et al., 1995; Kim and Yamashita, 2001; Kim et al., 2010). The advantage of such a multivariate technique is that it enables the consideration and comparison of many variables so that the relevant factors or attitudes can be identified for the purposes of developing focused strategies for addressing the problem of distracted driving.

Both descriptive and inferential statistical approaches were used. The demographic characteristics are summarized followed by the descriptions on the self-reported handheld device use. A logistical regression model is used to relate the likelihood of self-reported device use while driving to various characteristics of the respondents. Self-reported device use/not use is a binary dependent variables. The logistic regression is an appropriate regression analysis as it can be used to explain the relationship between one dependent binary variable and one or more independent variables. The logistic regression model uses

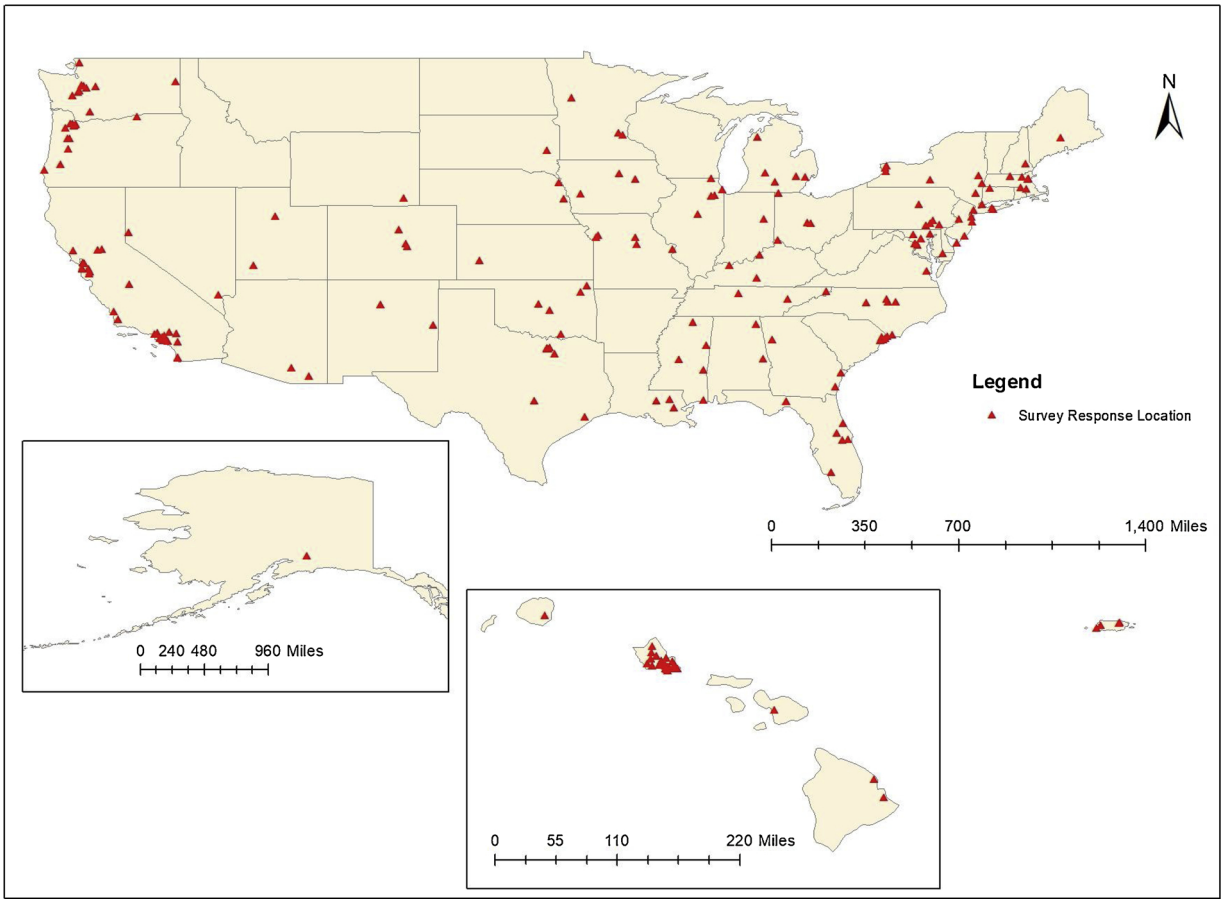

Fig. 1. Location of Survey Respondents.

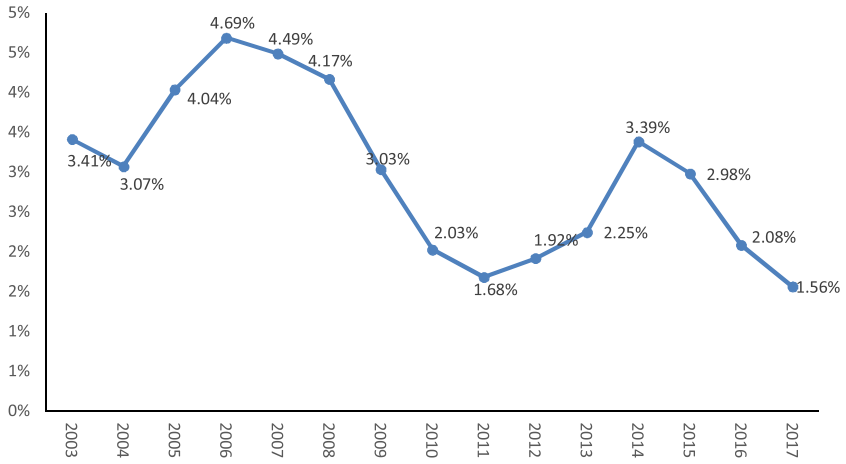

Fig. 2. Observed Cell Phone Use While Driving, Hawaii.2003–2017.

the logarithm of the odds as a linear function of the explanatory variables (Allison, 2012). For k explanatory variables and $i = 1\ldots$ n individuals the logistic model is:

$$\log\left[\frac{p_i}{1-p_i}\right] = \alpha + \beta_1 x_{i1} + \beta_2 x_{i2} + \ldots + \beta_k x_{ik} \quad (1)$$

Where p_i is the probability that $y_i = 1$, α is the intercept and β_k the coefficient for the explanatory variables. The result of the logistic regression is described using odds ratios, a commonly used measure of the relationship between two dichotomous variables. The odds ratio is defined as the ratio of the expected number of times that an event will occur to the expected number of times that it will not occur. Model fit statistics are used to assess the strength of the model. Likelihood Ratio tests the null hypothesis that all the explanatory variables have coefficients of 0. For a model to be valid, the hypothesis need to be rejected ($P < .05$). Higher values of -2 Log L (-2LL) mean a worse fit of data and usually used to compare models. Since models with more covariates tend to fit better by chance alone, fit statistics such as Akaike's Information Criterion (AIC) and Schwarz Criterion (SC) which penalized models with more covariates are used. Additional, goodness-of-fit statistics include Max-rescaled R-Square which mimics the traditional R-Square statistics of regression analysis and Hosmer-Lemeshow (HL) goodness-of-fit (GOF) test for logistic regression. In the HL test, a high p-value (non-significant) indicates that the fitted model cannot be rejected (Allison, 2012).

The final analysis includes the imputation of the magnitude of distracted driving with handheld device use in Hawaii based on the survey result, annual seat belt survey observation and the annual travel data.

3. Results

In this section, the key aspects of the attitudinal survey are summarized in terms of 1) characteristics of respondents; 2) self-reported use of handheld devices while driving; 3) device use while driving by age and gender; 4) how handheld devices are used while driving; 5) state distracted driver laws and handheld device use; 6) perceptions and experiences associated with distracted driving; and 7) logistic regression model results explaining device use while driving.

3.1. Self-reported handheld device use

Table 2, self-reported use of handheld device use, shows that 196 (58.9%) of respondents use a handheld phone while driving; 93 (27.9%) use a speaker or other hands free device while driving, and 13 (3.9%) use another handheld device (GPS, gaming console, tablet, etc.) while driving. A total of 31 (9.3%) respondents don't use a phone or other handheld device or even a hands-free device when driving.

Table 3 shows differences in device use while driving by age and gender. Among youth, those 25 years or less, 57% admit to handheld phone use while driving, similar to the 60% level among adults (aged 26–65 years old) higher than seniors (38%). Interestingly, both young drivers (36%), as well as seniors (33%), are more likely to use a speaker or hands-free communications device than adult drivers (28%). As mentioned earlier, only 9% of the total group does not use any device while driving but the proportion of elder drivers (25%) is much higher than either young or adult drivers (7% and 8%).

Among the 206 respondents who admit to handheld device use while driving, the description as to how the devices are used is contained in Table 4, Use of handheld devices while driving. This table reveals that receiving phone calls (85%) is the most common behavior followed by making calls (75%), navigation (75%), texting (55%), listening to music (43%), checking email (30%), reading web-based content (13%), watching videos (6%) or gaming activities while driving (3%). According to published research texting, dialing telephone numbers, reading web-based content, and checking emails are among the most dangerous and distractive activities while driving (Ranney, 2008; Ranney et al., 2011; Gliklich et al., 2016).

3.2. State distracted driving laws and handheld device use

In this section, state distracted driving laws are summarized (Table 4) and then, based on self-reported behaviors from the survey, handheld device use among drivers is compared for states with and without handheld or text messing bans (Table 5).

According to the Insurance Institute for Highway Safety's Highway Loss Data Institute, there are 19 states, D.C., and territories including Guam, Puerto Rico, and the Virgin Islands, which have complete bans on handheld device use while driving. Four states (Arkansas, Louisiana, New Mexico, and Oklahoma have partial or limited bans, while 32 states allow talking on handheld mobile phones. Forty-seven states as well as the District of Columbia, Puerto Rico, Guam and the Virgin Islands ban texting while driving. Two states (Arizona and Missouri) have limited bans on text messaging and one (Montana) allows texting while driving (Insurance Institute for Highway Safety, 2017).

The National Occupant Protection Use Survey (NOPUS) administers the only nationwide probability-based observed data on driver electronic device use in the United States and does not produce State-by-State driver electronic device information (Pickrell et al., 2016). The Fatality Analysis Reporting System (FARS) is a nationwide census providing yearly data regarding fatal injuries suffered in motor vehicle traffic crashes. Among other data, FARS, 2018 contains pre-crash driver distraction information. The 2016 FARS database shows that the top three highest states with fatal accidents caused driver distracted by

Table 2
Self-reported use of Handheld Devices.

Description	Frequency	Percent	Cumulative Frequency	Cumulative Percent
All Respondents				
Yes, I use a handheld phone while driving	196	58.86	196	58.86
Yes, I use other portable devices (such as handheld navigator, gaming console, tablet etc.) while driving	13	3.9	209	62.76
No, I use a speaker or other hands-free communication device while driving	93	27.93	302	90.69
No, I don't use a mobile phone, handheld portable device or other hands-free communication devices while driving	31	9.31	333	100

Table 3
Handheld Devices use by Age and Gender.

	N (%)			
Description	Youth	Adult	Senior	Total
Age				
Yes, I use a handheld phone while driving	8 (57)	171 (60)	9 (38)	188 (59)
Yes, I use other portable devices (such as handheld navigator, gaming console, tablet etc.) while driving	–	11 (4)	1 (4)	12 (4)
No, I use a speaker or other hands-free communication device while driving	5 (36)	78 (28)	8 (33)	91 (28)
No, I don't use a mobile phone, handheld portable device or other hands-free communication devices while driving	1 (7)	23 (8)	6 (25)	30 (9)
Total	14 (100)	283 (100)	24 (100)	321 (100)

	N (%)		
	Male	Female	Total
Gender			
Yes, I use a handheld phone while driving	106 (59)	82 (57)	188(58)
Yes, I use other portable devices (such as handheld navigator, gaming console, tablet etc.) while driving	7 (4)	6 (4)	13(4)
No, I use a speaker or other hands-free communication device while driving	52 (29)	41 (28)	93(29)
No, I don't use a mobile phone, handheld portable device or other hands-free communication devices while driving	15 (8)	16 (11)	31(9)
Total	180 (100)	145 (100)	325(100)

cellphone-related distractions are Tennessee (81), Texas (74), and Florida (39). Similarly, the top three highest states in 2015 were Texas (83), Tennessee (71), and California (35).

In Table 5, "Handheld Device Use by Distracted Driving Laws," shows that 88 drivers (51.5%) of those in states with handheld device use bans admit to handheld phone use while driving. Surprisingly 152 drivers admit to handheld phone use in those states with bans on text messaging. The largest frequencies of both speaker or hands-free communications device use while driving as well as no device use whatsoever occurs in states with text messaging bans (N = 86) or bans on handheld phone use (N = 58).

3.3. Perceptions and experiences related to distracted driving

Table 6, Perceptions and Experiences, captures the perceptions and experiences related to distracted driving. A majority of respondents (50.9%) feel unsafe or very unsafe (18.6%) if they are with a driver who is using a handheld phone or other portable device while driving. Also, a majority (59.5%) think that it is either somewhat or very unlikely that a motorist will be stopped and issued a traffic citation for handheld device use while driving. Approximately 32% of respondents, however, feel that it is either very likely or somewhat likely that device using drivers will be cited by the police. A clear majority (77%) believe that police should increase enforcement of bans on a handheld phone or device use while driving. Approximately 15% of respondents have been involved in an accident over the past three years. Only 5.2% have received a citation for handheld device use while driving.

Compared to national surveys conducted in 2011 and 2013, 34.5% (2011) and 41.8% (2013) of the passengers felt very unsafe while a driver talked on a handheld cell phone while driving (Tison et al., 2011; Schroeder et al., 2013). While 26.2% (2011) and 24.3% (2013) of the passengers felt somewhat unsafe while riding a car when a driver talked on a handheld cell phone while driving (Tison et al., 2011; Schroeder et al., 2013).

Most drivers (68%) reported that driving becomes more dangerous when they take their eyes off the road for 2 s or more (NHTSA, 2011). One-third of young drivers 18–24 identified durations longer than 2 s (NHTSA, 2011).

3.4. Logistic regression model results

The final set of findings are contained in Table 7, Handheld Device

Table 4
Summary of Distracted Driving Laws by State.

Description	Complete	Limited	None
Hand-held Ban	California, Connecticut, Delaware, D.C., Guam, Hawaii, Illinois, Maryland, Nevada, New Hampshire, New Jersey, New York, Oregon, Puerto Rico, Vermont, Virgin Island, Washington, West Virginia	Arkansas, Louisiana, New Mexico, Oklahoma,	Alabama, Alaska, Arizona, Colorado, Florida, Georgia, Idaho, Indiana, Iowa, Kansas, Kentucky, Maine, Massachusetts, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, North Carolina, North Dakota, Ohio, Pennsylvania, Rhode Island, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wisconsin, Wyoming
Text Messaging Ban	47 States (except Arizona, Missouri, and Montana) and D.C., PR, Guam, Virgin Islands	Arizona, Missouri	Montana

Table 5
Handheld device use by State Distracted Driving Laws.

	Hand-held Ban N (%)			Text messaging Ban N (%)		
Description	No	Yes	Total	No	Yes	Total
Yes, I use a handheld phone while driving	70 (63.64)	88 (51.46)	158	6 (85.71)	152 (55.47)	158
Yes, I use other portable devices (such as handheld navigator, gaming console, tablet etc.) while driving	3 (2.73)	7 (4.09)	10	0 (0)	10 (3.65)	10
No, I use a speaker or other hands-free communication device while driving	29 (26.36)	58 (33.92)	87	1 (14.29)	86 (31.39)	87
No, I don't use a mobile phone, handheld portable device or other hands-free communication devices while driving	8 (7.27)	18 (10.53)	26	0 (0)	26 (9.49)	26
Total	110(100)	171(100)	281	7(100)	274(100)	281

Table 6
Perceptions and Experiences.

Question	Frequency	Percent
How safe do you feel if you are riding with a driver who is using a handheld phone or other portable device while driving?		
Very Safe	4	1.22
Safe	20	6.1
Neutral/No impact	76	23.17
Unsafe	167	50.91
Very unsafe	61	18.6
How likely do you think a person will be stopped by the police and receive a traffic citation using a handheld phone or other portable device while driving?		
Very likely	27	8.23
Somewhat likely	78	23.78
Neutral/No impact	28	8.54
Somewhat unlikely	110	33.54
Very unlikely	85	25.91
Do you think the police should increase enforcement of laws prohibiting handheld phone or other portable device use while driving?		
Yes	252	77.06
No	75	22.94
As a driver of a vehicle, have you been in a motor vehicle accident within the last three years?		
Yes	49	14.94
No	279	85.06
Have you ever received a citation for using a handheld phone or other portable device while driving?		
Yes	17	5.18
No	311	94.82

Use Models, and Table 8, Characteristics of respondents who believe their driving abilities are not affected by the device and use and who believe police should not increase enforcement of handheld device bans.

Table 7 provides the result of the logistic regression. The dependent binary (yes/no) variable is the self-admitted cellphone or handheld device use. The explanatory variables included individual characteristics such as age, gender, vehicle type, perceptions about safety and regulatory environment such as jurisdiction with hand-held device ban, feeling safe riding with driver using cell phone, belief that police citation is unlikely when using cell phone while driving, belief that there should not be increased enforcement of hand-held ban law, and belief that driving ability is not affected by cell phone use while driving. Past experiences such as involvement in an accident in the last three years and past citation incidences for cell phone use while driving were also included as explanatory variables.

The first five columns show the initial model result, which reveals that many of the variables such as gender, vehicle type, feeling safer when the driver is using a handheld device, believing police citations are unlikely, or accident involvement, are not significant in explaining the likelihood of self-reported device use while driving. The strongest, significant effects include believing that driving abilities are not affected by handheld use (OR = 13.94), does not believe that police should enforce handheld device laws (OR = 2.0), being a younger driver (OR = 6.6) or adult driver (OR = 3.8) compared to being a senior driver (omitted variable). Also statistically significant is the negative relationship between self-reported device use while driving and living in a jurisdiction with bans on texting or handheld cell phone use.

Table 7
Handheld Device Use Models.

Independent Variable	Initial Model				Final Model			
	Coeff	Std error	Pr > ChiSq	Odds Ratio	Coeff	Std error	Pr > ChiSq	Odds Ratio
Youth (up to 25 years)#	1.88	0.85	0.03	6.56	1.85	0.83	0.025	6.35
Adult (26 to 65 years)#	1.35	0.55	0.01	3.84	1.36	0.54	0.011	3.89
Male	0.14	0.28	0.61	1.15				
SUV and Truck Drivers	−0.05	0.28	0.87	0.95				
Lives in the jurisdiction with hand-held device ban	−0.66	0.29	0.02	0.52	−0.67	0.28	0.016	0.514
Feels safe riding with driver using cell phone	0.22	0.34	0.53	1.25				
Thinks police citation unlikely when using a cell phone while driving	0.35	0.3	0.25	1.42				
Does not think there should be increased enforcement of hand-held ban law	0.7	0.36	0.05	2.02	0.71	0.33	0.033	2.028
Has been involved in an accident in the last three years	−0.12	0.38	0.75	0.89				
Has received a citation for cell phone use while driving	1.55	0.89	0.08	4.71				
Thinks driving ability not affected by cell phone use while driving	2.63	0.78	0.0007	13.94	2.68	0.77	0.001	14.63
Number of cases	277					277		
Intercept	−1.21	0.6	0.04		−0.84	0.54	2.46	
Likelihood Ratio Chi-Square	47.8	df = 11	Pr > ChiSq < .0001		47.79	df = 11	Pr > ChiSq < .0001	
−2 log likelihood	326.76				332.07			
SC	394.25				365.81			
Max-rescaled R-Square	0.21				0.192			
Hosmer and Lemeshow (HL) GOF	9.85	df = 8	Pr > ChiSq < .28		0.39	df = 5	Pr > ChiSq < .99	

Table 8
Characteristics of respondents who believe their driving abilities are not affected by handheld device use and who believe police should not increase enforcement of handheld device ban laws.

	Respondents believing their driving abilities are not affected by handheld device use[a]		Respondents believing police should not increase enforcement of handheld device ban laws[b]	
Description	Frequency	Percent	Frequency	Percent
Age Group				
Youth	1	2.44	3	4.17
Adult	36	87.80	65	90.28
Senior	4	9.76	4	5.56
Gender				
Male	28	66.67	38	52.78
Female	14	33.33	34	47.22
Education				
Less than high school				
High school graduate (include equivalency)	2	4.55	2	2.71
Some college, no degree	11	25	11	14.86
Associate's degree	3	6.82	8	10.81
Bachelor's degree	15	34.09	21	28.38
Graduate degree	13	29.55	32	43.24
Most Frequently used Vehicle				
Car	21	47.73	39	52.7
Truck	7	15.91	12	16.22
Van	3	6.82	2	2.7
SUV	12	27.27	20	27.03
Motorcycle				
Other	1	2.27	1	1.35
State Hand-held Ban Status				
No	14	40	25	37.31
Yes	21	60	42	62.69
State Text Messaging Ban Status				
No	2	5.71	2	2.99
Yes	33	94.29	65	97.01

[a] Total number (N) of cases = 46, n may not add to total because of missing value.
[b] Total number (N) of cases = 75, n may not add to total because of missing value.

The results of the final model, which removes the non-significant variables in the first model, are presented in the last four columns of Table 7. The model analysis indicates that efforts should be targeted to younger drivers, adults, as well as promoting handheld device bans in states without them. In terms of attitudinal factors, believing that driving ability is not affected by cell phone use or that police should not increase enforcement of distracted driving laws are the most important attitudes associated with self-reported device use driving. Several model fit statistics are used to assess the strength of the model. The Likelihood Ratio shows that both models are valid models. The Schwarz Criterion (SC), which adjust the value based on the number of covariates are used, shows that second model is better even when the -2LL values indicate otherwise. The Hosmer-Lemeshow goodness-of-fit test for logistic regression is also used to test the model fit. For the model to be accepted, the p-values should be non-significant (Allison, 2012). Both models have non-significant Hosmer-Lemeshow goodness of fit (GOF) and hence the models are reasonable. Furthermore, the calculated Max-rescaled R-Square values are around 0.20 suggesting that the models are weak but fair representation of the observations.

Table 8 shows the demographic characteristics of those respondents that believed that their driving abilities are not affected by the use of handheld devices while driving and those respondents who believe that police should not step up the enforcement of the use of handheld devices of drivers. What stands out from these results are that 60% and 62.69% of those drivers from states with a handheld use ban for drivers still feel that their driving ability is not affected by the use of such a handheld device and that police should not step up the enforcement of the use of handheld ban laws, respectively. The corresponding percentages for the States with text messaging ban were 94.3 and 97, respectively.

Table 9
Imputation of Potential Distracted Driving with Handheld Device Use.

Year	Observed % Cell Phone Use[a]	Self-Reported Use % for Hawaii[b]	VMT (Million)[c]	Potential HHD Use Trips (Million)	Number of Distracted Driving Trips (Millions)
2003	3.41	60	9325	1463	49.9
2004	3.07	60	9735	1527	46.9
2005	4.04	60	10129	1589	64.2
2006	4.69	60	10196	1600	75.0
2007	4.49	60	10260	1610	72.3
2008	4.17	60	10189	1599	66.7
2009	3.03	60	10095	1584	48.0
2010	2.03	60	10111	1586	32.2
2011	1.68	60	10654	1672	28.1
2012	1.92	60	11518	1807	34.7
2013	2.25	60	12078	1895	42.6
2014	3.39	60	10173	1596	54.1
2015	2.98	60	11130	1746	52.0
2016	2.08	60	–	–	–
2017	1.56	60	–	–	–

[a] Annual Hawaii Seat Belt Use Survey.
[b] The July 2017 survey self-reported use value obtained used for all years.
[c] 2015 State of Hawaii Data Book, Department of Business, Economic Development & Tourism, State of Hawaii (DBEDT, 2015).

The survey results can be used to extract user behavior to further understand and model the potential for traffic accidents. Those who have admitted using cell phones while driving do not necessarily use handheld devices during all the trips they make. The observed cell phone use rate, on the other hand, records the frequency of cell phone uses. Using the two rates allows imputation of the number of trips (potential distracted driving condition) where the handheld device was used. Table 9 provides the imputation for distracted driving trips for Hawaii based on the results of this survey, the annual observation of cell phone use and the yearly VMT. The observed cell phone use from the Annual Hawaii Seat Belt observation ranged from 1.56% to 4.69% (Column 2). For Hawaii respondents (N = 85), the self-reported handheld device use was 60% (Column 3), which is used for all years. Column 4 provides the annual VMT for the State of Hawaii. Column 5, provides the potential number of handheld device use and is based on the annual VMT, the self-reported handheld device use, and the average trip distance from the 2013 Oahu Household Travel Survey. The final column provides the number of distracted driving trips which is determined from Column 4 and Column 2, the observed cell phone use rate. For example, VMT for Hawaii was 11,130 million miles in 2015. Using the self-reported handheld device use (60%) and the average trip length of 3.82 miles, the number of trips which would potentially involve the use of handheld devices is calculated as 1746 million. Given that the observed cell phone use rate for that year was 2.98%, the imputed number of handheld device distracted driving trips is calculated as 52 million.

4. Discussion

In this study, a nationwide survey of self-reported driver behaviors is examined and analyzed using both descriptive statistics as well as logistic regression. Furthermore, for a sub-sample, the imputed risk levels for Hawaii based on both observational and self-reported handheld cell phone use while driving are also estimated. Several different questions emerge from this research. First, how accurate are self-reported data? Second, how valid is the sample of respondents? Third, what are the implications of the findings for reducing distracted

driving? The following sections discuss these questions with evidence of analysis of results presented above.

4.1. The characteristics of the respondents who use of handheld device while driving

The 58.86% of respondents of the survey replied affirmative to the quesiton whether they use the handheld device while operating an motor vehicle. Interestingly, highest percentage of use is among the adults with 60% and second highest is among youth with 57%. The males are higher in percentage at 59% comare to female at 57%. Among these uses, 85% is done for receiving the phone calls followed by making a call and nevigation. There is some difference in the handheld device use among drivers based on their enthicities. Among the three highest responding ethnic groups (Asian, Caucasian and Pacific Islanders), the Pacific Islanders have highest rate of using handheld device while driving at 70.83%. The second highest is among the Caucasian at 60.20% and Asian is at 50%. The response rates among these three groups were not same. The Caucasian had 62.08% of total response of 327 whereas the Pacific Islanders had only 7.65% of total responses. In terms of education level, there is not strong difference. The respondents with bachelor degree or with some college degree had the highest use rate at 60% of handheld device use while driving. The high school graduates or respondents with bachelor degree had 50% handheld device use rate while driving. The demographic characteristics of respondents are presented above in the Table 1 (Characteristics of Survey Respondents).

4.2. Admission of respondents of using the handheld device while driving

The 63% of the 321 respondents said that they use handheld device of some type while driving vehicle. But this percentage may be lower than the actual use because respondents tend to reply negative to such question if the response entails a reporting of a traffic law violation which may be considered dangerous or socially unacceptable. Earlier research by the authors focused on the so-called “lie factor” in traffic safety (Kim, 1999). Police reported accident data show much lower levels of distracted driving because motorists are unwilling to admit to law enforcement that they were in violation of traffic laws. Research by the authors also examined the differences between observed and self-reported behaviors related to child safety seat use (Kim, 1991) whereby the observed use rate of child safety seats was much lower than self-reported rates. Another study conducted in the state of Utah shows that drivers favor the legislation to limit the use of mobile phone while driving but they like to use the mobile phone while driving because they believe that cell phone use by others while driving is dangerous (Sanbonmatsu et al., 2016). These are examples of the “consistency controversy” where there is a difference between attitudes and actual behaviors. People tend to underreport socially unacceptable or risky behaviors such as driving without seat belts, drunk driving or using handheld devices while driving. The fact that so many people admitted to these behaviors suggest that these estimates are likely to be underestimated, suggesting that the problem is worse than reported in this study. The affirmative self reporting of 63% about use of hand held device while driving is less than the actual percentage of such incidents.

Despite the skewed representation of older, more males and more educated in the sample, this study has 63% respondents replying affirmative on the use of hand held device while driving. It is underrepresentation of the overall trend because the respondents of the study are less likely to use handheld device while driving. But there may be bias in the results. The bias would likely reduce self-reported handheld device use. Research has shown that device use is more heavily concentrated among younger (Troglauer et al., 2006) and female populations. More educated groups might be less willing to admit behaviors contributing to distracted driving. Notably, drivers of trucks and commercial vehicles have much lower rates of admitted distracted driving. Overall, with a larger concentration of males, older adults, and educated individuals, the effect would be lower self-reported rates of handheld device use while driving.

4.3. Factors influencing the handheld device using behaviors

The age and gender influence on the handheld device using behavior among drivers. The adult and youth drivers use handheld device more than elderly. Similarly, the female drivers use less handheld device than male drivers.

The legal ban has impact on the handheld device use while driving. The majority of the respondents from the States with legal ban of handheld device or text messaging use responded that they do not use handheld device while driving. It is 63.64% for handheld device use and 85.71% for the text messaging. The absolutely no use of the handheld device is higher among the respondents from handheld ban states at 10.53% compared to 9.49% from states with text messaging ban.

Surprisingly, more than 77% of respondents supported increased enforcement of laws prohibiting handheld device use while driving. Enforcement may be challenging because of the difficulties of detection. It is recommended as effective means to reduce the fatalities caused by distracted driving through the use of the handled devices while driving (Wilson and Stimpson, 2010). A review of police training to spot and record device use while driving is also needed. The survey found that most motorists do not believe that they will be caught and cited for using a handheld device while driving. In addition, to enhancing enforcement, increased penalties and greater publicity surrounding enforcement campaigns related to distracted driving are also needed. Enforcement has been shown to increase seat belt use (Kim and Yamashita, 2003) and similar efforts for distracted driving may also reduce the incidence of handheld device use while driving.

4.4. Impacts of handheld device use on accidents

The findings of this research reinforces the role of handheld device use on the traffic accidents (Lipovac et al., 2017) eventhough the respondents may not use the handheld device in every trip they make. The empirical findings on nexus between authomobile accidents and the handheld phone use show that the handheld phone use (texting, dialing or receiving) leads to the accident. One of the questions asked in the survey was whether the respondent has been in the accident within last 3 years. The affirmative responses to this question were compared to the question that ask whether the respondents have used the handheld device while driving. Among the total 323 respondents, only 14.86% has been in motor vehicle accident in last three years. Among 48 respondents who have been in motor accidents, 62.50% replied affirmative on the use the handheld device use while driving a vehicle. Among the users of handheld device while driving and who have been in accident within last three years, the 60% responded that they use the handheld phone or portable device for texting. The 73.33% of them responded that they use those devices to receive the phone call during their driving. Compare the group who were in accident within last three years, the percentage of handheld device use while driving who have not been in accident within last three years is less. Among 275 respondents who were not in accident within last three years, the 57.45% replied affirmative on use of such device while driving. Among them, 54.43% respondents replied that they use the mobile phone or other handheld device to text while operating the vehicle. The difference is not large between two groups but the use percentage of respondents who have been in accident is larger.

4.5. Strategies to reduce distracted driving

The findings have implications for driver education, enforcement of existing laws and possible expansion of bans on device use while

driving, enhanced technologies and better vehicle design, and additional research. There is a need for more education of drivers as to the hazards of handheld device use while driving. While respondents recognize the hazard, especially when asked: "how safe do you feel if you are riding with a driver who is using a handheld phone or other portable device when driving?" A majority, approximately 69%, felt either unsafe or very unsafe, suggesting that there are strategic opportunities to increase awareness of the hazard by considering the behaviors of others. In a similar research conducted among cell phone use among teens by Pew Center, the 40% teens felt that they have been a car in which driver has used the cell phone that put them in the danger (Madden and Lenhart, 2009). It is clear that there is greater awareness among professional drivers and those with commercial drivers' licenses. The training and education with regard to the hazards of distracted driving need to be further extended to research more drivers, especially younger drivers and those who believe that driving abilities are not affected by handheld device use. The research in this paper can be used to both target potential distracted drivers but also to customize training and educational programs to curb these behaviors.

Improved vehicle design, including heads up or larger in-vehicle display, better integration between handheld devices and vehicle information systems can also reduce the risks of crashes occurring due to distracted driving. The introduction of Bluetooth or other automobile technologies in vehicles can help to reduce handheld phone use while driving (Wilson and Stimpson, 2010). The fact that so many drivers admit to device use while driving suggests that there are opportunities to improve and expand interfaces and technologies to make device use while driving safer. Combined with collision avoidance systems or other technologies for preventing crashes, device use driving could be better engineered (Cicchino 2017).

5. Limitations of the study

This study likely underestimates the extent of the problem. Future research will work towards identifying and analyzing the behaviors of hard-to-reach motorists who may not necessarily respond to the web-based survey. This research is based on the self-reported data on handheld device use while driving. It is an illegal activity in many States including Hawaii. That creates biases among respondents. They might not provide accurate habitual information rather they might have tried to be "legal" in some responses. The future research should address these biases using other triangulation methods in the study. Yet even with the study's limitations, the fact that nearly 60% of the respondents admit to using a handheld phone while driving and that 55% of those admitting to handheld device use text while driving, suggests that the prevalence of these behaviors is great. A special group to focus attention on are those drivers who believe that their driving abilities are not affected by handheld device use.

Further research needs to be conducted as to the nature and extent of distracted driving and comparing those states or communities with higher levels of device use and accident outcomes. There is a need for more comparative research considering states with strong versus weak laws related to texting and mobile device use. There are some strategic research opportunities. While Hawaii conjures images of swaying palms and white sandy beaches, it is also an ideal setting for researching and testing behaviors related to mobile phone use while driving because of its isolation and centralization of government (with only four counties), enabling both the investigation of behaviors over time as well as focusing on differences between drivers or the effects of policy changes. Combined education, enforcement, and engineering approaches are needed. Research which allows for the evaluation of multiple strategies is also needed.

While more education, enforcement, and engineering are needed, there is also need for more research related not just to nature and extent of distracted driving but also how drivers perceive risks as well as what penalties or incentives would encourage behavioral change. The problem of distracted driving involves many different stakeholders. It's not just the drivers and their vehicles, but also the technology companies building handheld devices or developing applications for mobile devices. In addition to law enforcement and traffic safety professionals, there is need to embrace others involved with risk management such as the insurance industry.

Although the findings of the research show that the personal perceptions and social characteristics of individuals have influential role on handheld device use while driving, their generalization cannot be made for whole United States. The first reason is the representation of population. The respondents were mainly elderly, educated, and male. The second reason is the sample size. It is relatively small to represent more than 325 million population and some States did not have any respondents.

Finally, like other campaigns promoting seat belt use or reducing impaired driving, the psychology of the distracted driver needs to be better understood. Perhaps over time, the self-reported and observed behaviors will change as more motorists not only better understand the risks of distracted driving, but also realize that they too must not engage in these behaviors.

6. Conclusion

Distracted driving due to a handheld device used by motorists remains a serious problem. In addition to investigating the demographic and perceptions factors associated with the handheld device use while driving, the study estimated the number of distracted driving trips in Hawaii using survey data, annual VMT, average trip distance, and annual cell phone use rate from Hawaii Department of Transportation observation studies.

Because self-reporting questionnaires have some disadvantages due to the way respondents behave, particularly not wanting to respond truthfully to committing an unlawful act. This study showed the benefits of using other datasets (i.e., observational surveys and VMT) to improve and validate the results of the self-reporting questionnaire.

Even though the majority of States ban texting while driving, more than half of the respondents agreed that they text while operating their vehicle. Interestingly, there is a special group of drivers who claim that their driving ability is not affected by using a handheld device while driving. Further investigation on this can provide interesting insights. Introduction of more stringent laws and fines can have an impact on handheld device using behavior. It is less prevalent in States with laws that prohibit the use of handheld devices while driving. Over time, more and more people will continue to acquire and use mobile handheld devices for communications, navigation, entertainment, and information gathering.

Acknowledgements

The authors would like to thank Ms. Lily Bui for assisting in the review and editing of this manuscript. Ms. Bui is currently a pH.D. student at MIT's School of Architecture and Planning and is an intern at the University of Hawaii's National Disaster Preparedness Training Center.

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