ABSTRACT

This study focuses on understanding the effectiveness of Indiana's legislation on distracted driving by comparing crashes before and after implementation of cell phone use law. 13069 fatal and non-fatal crashes due to cell phone use from 2007 to 2017 is used to test this. Data reveals that Indiana legislation on cellphone usage is only partially successful. For young drivers (15-24 years), 5% reduction in crashes is observed. However, there is no significant change in overall accidents. This study also scrutinized the influence of factors such as temporal, weather, road type, crash type, speed limit, etc. on cell phone use law.

Keywords: road crashes, cellphone usage, legislation effectiveness, highway safety

INTRODUCTION

Cell phones are deep-rooted into the lives of humans more than ever. The seamless connectivity to a cellphone is leading to distracted driving behind the wheel [2]. National Safety Council reported that 27% of all car crashes are associated with cellphone usage while driving. Despite the detrimental effects, it is alarming to know that 56% of drivers answer calls while driving [2]. In 2017, distractive driving claimed 3166 lives (9% of total crash fatalities), and cellphone usage is one of the prime reasons for these distractive fatalities [5].

While cell phone conversations during driving increase the probability of being in a crash by a factor of four, texting increases the chances by a factor of 23 [6]. Research studies examined the antecedents and precedents of crashes due to distracted driving through simulation studies [10] [21], surveys [23], and empirical studies [8] [11]. These studies evaluated various characteristics associated with the cell phone crashes like the driver, environment, vehicle, territory, road, social, legislation, etc.

Laws imposed by the national and governmental bodies on cell phone use while driving are expected to play a critical role in limiting crashes due to distracted driving. Several states in the United States issued policies limiting cellphone use when driving. These laws either ban cell phone usage partially or entirely with New York being the first state to ban handheld phone conversations for all drivers in the year 2001 [5]. Currently, 20 states in the US have banned handheld phone conversations for all drivers, whereas 48 states banned texting for all drivers. Among drivers of different age groups, it is observed that young
drivers have a higher inclination to engage in risky driving [11]. Hence, 33 states have endorsed cell phone bans targeting youth.

Prior studies indicate that the cell phone ban laws and campaigns are only partially successful in swaying the driver’s behavior [13] [16] [23]. The reason could be that legislation on distracted driving is focused too much on the role of a driver, ignoring the other elements in the road transport system [24]. According to [11], [19], studies on fatal crashes at a national level provide an overall understanding of the legislative laws. However, this study differs from that proposition. National-level studies on accidents fail to capture the effectiveness of state law as each state have different regulations. Moreover, each state, county, and the city have its unique road transport systems. Analysis at each territory level by considering the attributes specific to each state can provide better insights about the impact of cell phone law [14].

Yearly crash reports provided by federal institutes like National Highway Traffic Safety Administration (NHTSA) primarily focus on fatal accidents. Prior studies also focused more on fatal accidents due to cell phone usage while driving. Studies on deadly accidents are necessary; yet, review on non-fatal accidents is also equally important. All crashes (fatal and non-fatal) have significant economic and social impacts. The published research aimed more at understanding the effectiveness of cellphones law; however, fewer studies recommended the amendments needed to be a more productive law.

This study is focused on filling some of the existing research gaps discussed above. Following are the objectives framed for this study:

- Examine the effectiveness of legislation on cell-phone usage while driving over a period. In this study, law for the state of Indiana is chosen.
- Study the various crash-related attributes like driver characteristics (age, gender), environmental (weather, type of road), temporal aspect (month, day of the week, and time), and type of collisions.
- Examine the differences between the crash characteristics before and after legislation.
- Provide recommendations for amending the current law by highlighting the areas where legislation have positive results and where it can be improved further.

Our study benefits the traffic safety policymakers and the state government bodies to get a deeper understanding of the paybacks of the distracted driving law and suggest remedial actions to amend the policies. The remainder of the paper describes the data and methodology used for the study, data insights, and recommendations.

**Analysis on Effectiveness of Cell Phone Legislation During Driving in Indiana**

For this study, the Indiana state is selected as the state maintains a detailed crash database. Indiana Department of Labor defines distracted driving as "any non-driving activity a motorist engages in that has the potential to distract him or her from the primary task of driving". In Indiana, cell phone use while driving is restricted since July 1, 2011. According to the legislation, it is against the law to type, transmit, and, read email or text messages on a communication device while driving. However, the texting and email ban does not apply to motorists who use hands-free or voice-operated technologies. Also, it is illegal to use a cellphone while driving for drivers who are below the age of 21 with the only exception for making 9-1-1 calls. Data for this study is acquired from Automated Reporting Information Exchange System (ARIES), maintained by the Indiana State Police. ARIES contains data about various aspects of vehicle traffic
collisions that occurred statewide in Indiana. Each record in the ARIES data set is about a crash that occurred involving a driver who got injured. This study is performed on the crash data between 2007-2017. There is a massive data on crash incidents from 2007-2017. Out of the huge data, 13069 crash cases are extracted and the primary reason for crash in all these cases is cellphone usage during driving. This study employed data visualization techniques along with statistical tests to understand the effectiveness of legislation. Data visualization helps in understanding the role of various attributes of cellphone crashes as well as in perceiving the effectiveness of the law. This study performed analysis to understand the presence of significant differences in the crash characteristics before and after the enforcement of code to determine the efficiency of legislation in Indiana.

**METHODOLOGY**

This study performed data visualization on driver characteristics (age, gender), environmental (weather, type of road), temporal aspect (month, day of the week, and time), type of collision, and driving speed. All these characteristics are grouped into before (2007-2011) and after (2012-2017) legislation. Visual analysis is used to understand the differences in the characteristics before and after legislation.

Statistical analysis is conducted by testing the null hypothesis that the Indiana state-wide ban on texting as well as the ban on young drivers has no impact on the number of crashes before and after legislation. Two tailed and one tailed, Welch two sample T-test was performed on the data to test the effectiveness of legislation. The alternate hypotheses for the t-test is the occurrence of less crashes after legislation compared to the prelaw period. The data was also tested for the assumptions of: 1) normality with Shapiro–Wilk test, and 2) homogeneity of variance with F-test. Upon verifying the results, appropriate t-test (depending on equal or unequal variance) is applied to determine if the expected values of the number of crashes show a statistically significant change after the law was enacted.

**RESULTS AND DISCUSSIONS**

This section reports the results of the differences in the impact of critical attributes of crashes before and after enforcement of legislation in Indiana.

**Overall Trend of Crashes due to Cellphone**

Among the 13,069 crashes caused due to cell phone distraction between 2007 to 2017, 4,977(38 %) crashes occurred before and 8,092(62 %) occurred after imposing legislation on distracted driving in Indiana. A detailed analysis of the year wise statistics of cellphone crashes as a percentage of all types of crashes is displayed in Figure1. It is evident that there is a slightly decreasing trend in the percentage of cell phone crashes before legislation from 2007 to 2011. Surprisingly, the graph indicates a reversal of the trend after 2011 posing questions on efficiency of the legislation.

Using a Welch 2 sample T-test, this study tested if the expected value of number of crashes after legislation are less compared to the crashes before legislation. Shapiro-Wilk test confirmed the normality of the data and F-test indicated heteroscedasticity (F = 0.10053, p-value = 0.04492). Hence a one tailed T-test with unequal variances was conducted. The T-test indicated a non-significant result (T = -3.7266, p-value = 0.9953) indicating that the number of crashes has not reduced after legislation. Similar studies conducted on California [9] and New York [14] observed reduction in crashes after legislation. It is obvious that the influence of legislation differs from state to state. Relying only on the national statistics dissolves the influence of law at the state level.
Effect of Legislation on Driver Characteristics

Previous research studies reinforce that younger drivers engage more frequently in secondary tasks that increase the risk of collisions [1] [11] [20] [21]. Drivers with diverse attributes perceive different types of road conditions in a different way [21].

Age

Figure 2 presents the data on age distribution, gender, and gender-wise age distribution before and after legislation. According to Figure 2a, 15-24 years age-group are involved in more crashes than other groups. Although the percentage of crashes recorded for 15 to 24 is highest compared to all others, a reduction in the percentage (35.8 to 31.0) of crashes after legislation can be observed. This is a positive outcome as Indiana legislation aims at young drivers (below 21 years). Conversely, the number of crashes increased for all the other age groups. This finding suggests the amendment of law such that it influences all the age groups.
Gender

Prior studies [7] [10] indicated a non-significant effect of gender on distracted driving behavior. From Figure 2b, it is evident that the legislation is having an encouraging impact on female drivers as the percentage dropped from 45.3 to 43.7 pre and post the law. It indicates that female drivers in Indiana are more cautious. Prat, Planes, Gras, & Sullman [18] also stated that female drivers tend to be a little bit more careful with less response time for braking compared to male drivers. It is evident from Figure 2b that male drivers have more likelihood of getting involved in crashes than female drivers. Figure 2c and 2d present the distribution of crashes for female and male drivers respectively.

Effectiveness of Legislation on Temporal Attributes

According to Chen, Chen, and Ma [3], temporal factors on crashes have been least researched. Kim et al. (2013) [8] noted that the temporal and weather characteristics such as time, weather, and lighting correlate with crashes. This study investigated three temporal factors: hourly (Figure 3a and 3b), the day of the week (Figure 3c), and monthly (Figure 4).

The occurrence of crashes can differ based on the time-variant factors such as peak traffic time or busy days of the week. Figure 3 (a) shows the influence of temporal distribution on crashes. Overall a very high percentage of cell phone-based crashes are recorded in the PM timings compared to the AM timings. Observation of the detailed graph 3 (b) shows that 3:00 pm to 6:00 pm is the time that is highly susceptible to the occurrence of crashes. This timeframe is the rush hour time where traffic is at its peak. During this timeframe, people return to their homes and have a high tendency to use cell phones to communicate with
the near and dear. It can also be observed that there is a very less percentage of crashes in the late night and early morning hours between 12:00 am to 6:00 am. Visual observation of temporal distribution did not show any difference before and after legislation. The number of crashes in the peak traffic hours increased after law.

![Distribution of Crashes Based on Temporal Attributes (Prior and After Legislation)](image)

Among the five days in a week, Friday turned out to be the day with a higher percentage of cell phone crashes. Least portion of cell phone crashes occurred on Sunday. Commuter employees, students in the nearby cities of Indiana, travel most on Friday. Friday being the beginning of the weekend tend to have more crashes.

It is a common perception that chances of distracted driving crash increases in dangerous weather conditions due to poor visibilities. Figure 3d shows that a higher number of accidents happened in the daytime when the weather is clear. It can be argued that there are several clear weather days than the bad climate in a year. In Indiana, the winters are long (Mid-November to Mid-April) with more snowy and slippery conditions. However, the data revealed that nearly 90% of accidents happen when the road condition is dry.

Figure 4 explains the distribution of crashes based on year and month. The heat map tells that most cell phone-related crashes occurred in the Fall season during September, October, and November. Also, the percentage of accidents recorded in early summer is quite high. Surprisingly less rate of crashes is recorded during the peak winter month (January, February, and March) and months during rains (July and August). During these months roads conditions are comparatively hazardous for driving in Indiana. The temporal studies indicate that the enforcement of legislation is required during the peak hours of traffic (3PM-6PM).
Instead of manual ticketing, automated traffic enforcement is recommended. Similarly, more awareness
reminders should be implemented during the early summer and fall (May and October) where drivers are
relaxed after a long winter and rainy conditions.

Effectiveness of Legislation on Type of Road, Speed Limit and Type of Collision

Figure 5a shows that two-lane roads experienced a high percentage of crashes compared to multilane
divided and undivided highways. In the multilane roads, the rate of accidents reduced after enforcement
of legislation. Most crashes occurred in lower speed limits between 30 to 35 mph, as shown in Figure 5(b).
There is not much change in the percentage of crashes before and after legislation based on the speed
limit. Rear-end collisions dominated the overall accidents that occurred due to cell phones, followed by
road runoff and head-on collisions (Figure 5c). When drivers are on using cell phones while driving, they
need to multitask and must coordinate several activities at the same time. In this situation, observing read
dend vehicles becomes a daunting task leading to an increase in rear-end collisions. The precondition
of the car before the crash is driving straight (58%) and slowing or stopped traffic (27%).
The following are the insights and recommendations upon researching on the crashes from 2007-2017 caused primarily by cellphone usage.

- The legislation on cellphone usage by the state of Indiana is partially successful. There is an increase in percentage and number of crashes in Indiana due to cellphone usage. However, on the bright side, the rate of accidents by the young drivers (15-24 years) reduced by ~5%. Since the law is primarily targeted on the young drivers (below 21 years) prohibiting the use of a cellphone, a 5% decrease is a positive outcome.

- Possibly it is the time to amend the legislation and prevent handheld usage of a cell while driving irrespective of age. Other research findings further strengthen this recommendation for amendment. A survey conducted by Rudisill et al. [19] found that universal handheld device ban fared better compared to the comprehensive texting ban. The fatalities reduced by 10% compared to the times without a handheld ban. Lim and Chi [11] examined the effectiveness of cell phone law on drivers using crash data of 48 states in the united states. The authors found the effect of a handheld cell phone ban for all drivers was highly significant in reducing crashes in comparison with the laws targeted at young drivers.

- The analysis of driver characteristics revealed that the legislation has a strong influence on female drivers. A drop in female drivers involved in a crash due to cell phones is observed. There is an increasing number of accidents by age group 25-34 years drivers.

- The temporal assessment disclosed that 3:00 pm to 6:00 pm is the time frame during which a high percentage of accidents are happening. Weekdays witnessed a more significant number of crashes
than weekends, especially Friday’s. The heatmap created (Figure 4) shows that months May, September, and October witnessed the highest number of accidents.

- More crashes are recorded (~90%) when the driving conditions are favorable. Drivers are more cautious during adverse driving conditions and have a relaxed approach in favorable circumstances. Thus, more crashes happened in the early summer and fall months of Indiana.
- Most accidents happened on two-lane two-way roads where the posted speed is between 30-55 MPH. The condition of driving before crashes are also examined. The bulk of vehicles state before the accident is slow-moving traffic and driving in straight lines. Hence a higher number of accidents are the rear end and ran off the road. This type of accidents happens at the signalized intersections or during traffic delays, which makes drivers take eyes off the streets.
- Strict enforcement of law during Fridays between 3:00 pm to 6:00 pm may reduce the accidents. Also, creating more awareness techniques at the signalized intersections could lessen the accidents.
- Finally, till date, emphasis on cell phone usage is only on texting and talking. However, the current generation drivers are more enthusiastic in using cell phones for accessing, taking photos, live streaming, etc., while behind the wheel. Hence, there is a necessity to amend the legislation by including video streaming and photo capturing.

LIMITATIONS

The study has the following limitations. Firstly, the percentage of crashes due to cell phones among all crash cases are less than 1%. A possible reason for this is that cell phone crashes are often underreported. In the ARIES database, crashes due to distraction are different from cellphone usage cases. According to NHTSA data from 2007-2018, nearly 10% of distraction fatal crashes are due to a cell phone. Authors believe that there may be cases in the distraction category, which are due to cell phone usage. A narrative of the incident is required to categorize the cause in the distraction cases. Applying text analytics techniques on the distraction crash reports and extract the cell phone related cases. This study also attempted to perform predictive analytics; however, the size and quality of the data does not support to produce a good fit. This study is limited to examining the before and after legislation studies. A future study is warranted to include the influence of concurrent changes in other state policies and traffic educational efforts on the effectiveness of legislation.

REFERENCES


