Crash Modification Factors for Public Safety Campaigns – A Case Study: The Idaho's Shift Initiative

A Thesis

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Abstract

This study examined the potential crash reduction benefits of public safety campaigns that are aimed to positively impact the traffic safety culture for younger drivers. Crash modification factors (CMFs) for State of Idaho's SHIFT public safety initiative were developed using Idaho-specific crash data covering the period from 2014 to 2020. The CMFs developed as part of this project allow the Idaho Transportation Department (ITD) and other local, state, and federal transportation agencies to assess and quantify the potential safety benefits of public safety campaigns. Generalized linear negative binomial models were used to develop crash prediction models which were used as safety performance functions (SPF) to predict the number of crashes had the tested safety measure (Idaho's SHIFT campaign) not been implemented. Previous studies have shown that the negative binomial model appropriately accounts for the randomness and the overdispersion in the crash count data. The developed models covered total crashes as well as fatal and severe injury crashes. Specific crash types were not addressed due to the small sample size. The results of the Empirical Bayes method used in this study can be summarized as follows:

- Public safety campaigns can reduce the crash rates, and particularly amongst the youths of the age group 15-19. The analysis showed that there was a significant reduction in fatal crashes as well as total crashes for the age group 15-19 by 24.81% and 5.80% respectively.
- Similarly, the age group 20-24 and 25-44 had significant reduction in fatal crashes by 20.75% and 16.29% respectively.

- The analysis also demonstrates that safety campaigns are more successful in reducing fatal crashes as the results were significant for all the age groups considered for fatal crashes.

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Dedication

To my grandparents and my father, for their blessings from heaven.

To my mother, sister, and my brother, for always being there.

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List of Acronyms/Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ACF	Annual Calibration Factors
ACS	American Community Survey
AMF	Accident Modification Factor
ARIMA	Autoregressive Integrated Moving Average
CMF	Crash Modification Factor
CRF	Crash Reduction Factor
DUI	Driving Under Influence
EB	Empirical Bayes
FARS	Fatality Analysis Reporting System
FB	Full Bayes
FHWA	Federal Highway Administration
HSM	Highway Safety Manual
HSRC	Highway Safety Research Center
ITD	Idaho Transportation Department
LHA1	Local Health Area 1
LTSA	Land Transport Safety Authority

NCDOT	North Carolina Department of Transportation
NFRTI	Non-Fatal Traffic Injury
NHSTA	National Highway Safety Manual
NI	Nighttime Injury Crashes
NIATT	National Institute for Advance Transportation Technologies
NSVI	Nighttime Single-Vehicle Injury Crashes
SPF	Safety Performance Function
SRSP	Supplementary Road Safety Package
TAC	Transport Accident Campaign
VMT	Vehicles Miles Travelled

Chapter 1: Introduction

1.1. Background and Motivation

The analysis of crashes involving younger drivers clearly highlights several major areas of concerns: speeding, impaired and distracted driving, aggressive driving, and lower percentage of safety belt and motorcycle helmet use. Strategies to reduce motor vehicle crashes, related injuries and fatalities using engineering, emergency response, and enforcement measures have been well-researched and documented. Crash Modification Factors (CMFs), defined as the expected percentage reduction in the number of crashes that might result from implementing a given countermeasure, have been developed for a wide range of strategies and countermeasures (Crash Modification Factors Clearinghouse, 2022). Educational and general awareness programs that promote safe driving practices and the use of safety restraints along with higher visibility traffic enforcement and stronger laws to address driving under influence have all been found to have contributed to the reduction of both the number of crashes, and the resulting fatalities and injuries. These reductions in crashes could be achieved by creating a positive change in the traffic safety culture in the community. However, this is only achievable if the communities are equipped with the best available resources and techniques to effectively disseminate positive safety messages.

To positively impact the traffic safety culture for different age groups in a community, it is important to understand how the community social norms are formed and how they can possibly be impacted. There are several social science theories that tried to model and explain such behavior. One example of these theories is the theory of normative social behavior (Rimal and Real, 2005) which provides a framework for understanding cultural social norms and elements that can impact them either positively or negatively. Public campaigns that are designed to target certain groups in the community have proven to be effective tools in impacting individual levels of risk perception and sensation seeking and may impact social norms on negative behaviors such as aggressive driving, excessive speeding, and distracted driving. It is also important for transportation agencies and communities to fully understand the safety benefits of such of such public campaigns and assess their crash reduction potential. The primary objective of the study presented in this thesis is to examine the potential crash reduction benefits of public safety campaigns aimed to positively impact the traffic safety culture for different age groups with a primary focus on younger drivers using the state of Idaho's SHIFT initiative as a case study. Crash modification factors (CMFs) for Idaho's SHIFT initiative are developed using Idaho-specific crash data covering the period from 2014 to 2020.

1.2. Thesis Objectives

The objectives of this thesis are listed below:

1. Synthesize available research that has been completed on the safety effect of education and outreach public traffic safety campaigns.
2. Evaluate the potential benefits of public safety campaigns for different age groups covering both total crashes and fatal and severe injury crashes in the form of crash modification factors.

To achieve these objectives, this safety study was conducted in two main stages. The first included an in-depth literature review, and development of study methodology and analysis. In the second stage, data was collected and analyzed to develop an understanding of the safety impacts of public traffic safety campaigns and initiatives. The following tasks were part of this study:

1. Conduct a thorough review of available literature.
2. Review, collect, and document historical accident data for different counties in the state of Idaho.
3. Analyze the data using the appropriate statistical methodology.
4. Develop Crash Modification Factors for public safety campaigns based on Idaho's SHIFT initiative and the State's 2014-2020 crash experience.

1.3. Thesis Organization

This report is organized into 5 chapters. After the introduction, a summary of the literature review is presented in chapter 2. Chapter 3 documents the study methodology. The study analysis and results are presented in chapter 4. Chapter 5 includes the study conclusions and recommendations for future research.

Chapter 2: Literature Review

This chapter delves into the previous research studies, past experiences, and understandings of road safety campaigns and their effectiveness. In addition, the methodologies applied to estimate the safety effect of the campaigns are also described.

2.1. Previous Studies

The education and outreach campaigns play a vital role in increasing road safety; however, due to the complexity of the process involved, it is difficult to assess their impact as they are often studied and implemented together with enforcement and engineering. Some of the studies related to education and outreach to improve the road safety of road users are summarized below.

"Watch for Me NC" program is a comprehensive road safety campaign initiated by the North Carolina Department of Transportation (NCDOT) in 2012 by collaborating with the Highway Safety Research Center (HSRC) aimed to reduce bicycle and pedestrian injuries and fatalities in the local communities of North Carolina through the application of two Es of traffic safety: enforcement, and education. Starting with three counties of North Carolina as partner communities, this campaign focuses on an educational outreach campaign to promote pedestrian, and bicyclist safety, along with the increased high visibility enforcement of traffic laws, specifically pedestrian, bicycle, and motorist laws. Saleem et al. (2018) evaluated the effectiveness of this program by analyzing the change in crash frequencies of both bicyclists and pedestrians using the Empirical Bayesian method for Before-After data. Crash data for the years 2009-2017 were used to estimate the SPFs, and ACF, with the traffic data (VMT and vehicle distribution), and Socioeconomic data (journey to work by mode, average household income, total population (urban/rural), population distribution by age groups), as exposure data. The analysis showed that the campaign was more effective for pedestrian crashes than bicyclists. The "Watch for Me NC" campaign accounted for a 12.8% reduction in total pedestrian crashes in the treated communities, a 21.7% reduction in nighttime pedestrian crashes, and a 9.5% reduction in crashes caused due to pedestrians failing to yield. However, there weren't any significant concludable results with the impact of the program on crashes related to bicyclists.

A meta-analysis of studies varied across 14 countries showed that road safety campaigns positively impacted behavioral change. The study which involved 437 effects out of 228 studies, concluded that the road safety campaigns were associated with an approximate nine percent reduction in road incidents, a twenty-five percent increase in seatbelt use, a sixteen percent reduction in speeding, a thirty-seven-percentage increase in yielding behavior, and sixteen percent increase in risk comprehension (Phillips et al. 2009 as cited by Robertson & Pashley 2015).

A subsequent meta-analysis of 67 studies by Philips et al. (2011) to evaluate the impact of safety campaigns on crashes reported an average of nine percent reduction in crashes, which included 119 results dated 1975 to 2007. This study also suggested a positive relationship between reduction in crashes and campaigns with personal communication or roadside media as the delivery strategies. Also, short-term campaigns and those related to drinking and driving were more effective in crash reductions than other campaigns.

The study of safety effects of speed enforcement cameras in Charlotte combined with publicity through extensive media campaigns and the injury counts of different severity levels were used as the effectiveness measures. The campaign resulted in an estimated 8% to 10% decrease in fatal crashes/injuries, property damage-only crashes, and total injury crashes. Also, the post-second intervention study showed a 15% to 18% reduction in crashes. Finally, while compared, the post-intervention and before-study periods had a difference of 17% to 21% for the fatal crashes/injuries, property damage-only crashes, and total injury crashes (Moon & Hummer 2010, 38).

The pedestrian safety initiative in Montgomery County, Maryland, targeted ten high-incidence areas to coordinate engineering, education, and enforcement for a pedestrian-friendly environment. The pedestrian collision rate for 2009-2012 across the HIAs decreased by 43%, 38% throughout the county, and 79% on the Safe Routes to School (Dunckel et al. 2014, 100).

Elder et al. (2004) evaluated eight studies to study the effectiveness of mass media campaigns and found a median decrease of 13% in crashes of all severity levels and a ten-percentage decrease in the most prominent crash outcome among the studies. The studied campaigns dealt with disseminating enforcement activities, legal consequences, and the social and health impacts of alcohol-impaired driving.

Tay & Ozanne (2002) evaluated the Supplementary Road Safety Package (SRSP) by the Land Transport Safety Authority (LTSA), New Zealand, in 1995. With a budget of almost NZ$50.06 million for an advertisement campaign focused on driving under the influence and speeding, the ad campaign used extreme graphics to engage the people's core fear and vulnerabilities, highlighting the consequences of unsafe driving behavior. Although the study shows no effect on young male drivers, the estimated reductions in fatal crashes for young female drivers (age group 15-24 and 25-35) and middle-aged male drivers (35-54) were 40.21%, 70.04%, and 29.91% respectively.

A meta-analysis on the effectiveness of road safety campaigns on crashes in Sweden showed that the safety campaigns accounted for a reduction in crashes during and after the campaign was implemented by 8.9% and 14.8%, respectively. Also, single theme-based campaigns were more effective in addressing the safety problem than multi-theme-based campaigns. The mass media campaigns paired with enforcement as well as education were more effective (reduction of 13-14% of crashes) than the campaigns alone (0.9%, statistically insignificant) (Vaa et al. 2004).

A study on the demonstration programs in seven states showed that in four out of seven states, there was a significant reduction (11% to 20%) in fatal drinking-driver-related crashes. Due to the prohibition of DUI checkpoints in Michigan, saturation patrols were used, which showed a fourteen percent decrease in the ratio of the drivers driving under influence to those not under any influence involved in fatal crashes. (Fell et al., 2008).

Zampetti et al. (2013) studied the effectiveness of road safety campaigns by analyzing the change in the number of non-fatal traffic injuries (NFRTI) in Italy. The study is based on a 5-year road safety campaign in the Local Health Area 1 (LHA1) part of the Salerno province, in which 20 municipalities are included. Although not perfectly coinciding, the considered municipalities were similar in most of the aspects that could impact the factors affecting the number of crashes and their occurrences. The municipalities shared common socioeconomic and demographic characteristics as well as developmental trends; however, the road characteristics altered by environmental causes were disregarded. The campaign comprised of 5-year intensive safety education dissemination through the extensive use of mass media communication, which included general hazards of driving, the impacts of risky driving behaviors like driving under the influence, use of cellular devices, etc., in addition to pamphlets, brochures, and posters that could raise the awareness level among the public related to road safety. Of the 20 municipalities considered, 12 of them were also provided with school campaigns and conferences relating to road safety. School campaigns included lectures related to hazardous behaviors, and safe driving, road safety, and the lectures were supported by various focus groups among the students and practical driving activities provided by the Italian Automobile Association. The data collection was done between June and August of 2003 and 2008 by the information system of the LHA1 hospital. For analysis, the severity of crashes was divided into two categories: "need for hospital admission" was classified as "severe,", and "not need for hospital admission" was classified as "not severe." The number of NFRTI in the before period (June-August 2003) was found to be 907, and that for the after-period (June – August 2008) was 755. Of the 1662 records, seventy percent were male, and the average age of road users was 31.4 years. Analyzed using Fisher's exact test, the municipalities with basic campaigns (8 municipalities) had a significant difference between the after and the before NFRTIs of -0.4 (incidents per 1000), while those with intensive campaigns (12 municipalities) had a difference of -0.5. The reduction of NFRTIs in the 20 municipalities before and after, irrespective of the type of campaign used, was not significant; however, the reduction in the severe injuries before and after the campaign was statistically significant (0.2 per 1000).

Agent et al. (2002) evaluated the "You Drink and Drive. You Lose" campaign in Kentucky. The National Highway Traffic Safety Administration selected Kentucky as one of the states to conduct the impaired driving road safety campaign. Agent et al. (2002) evaluated the before and after results of the road safety campaigns using the crash data for 13 days (11 days before Labor Day, Labor Day, and the day after). The campaign involved the combination of both publicity and enforcement, and data were collected through telephone surveys and enforcement activities before and after the campaign. The data were obtained for four years period (1999 – 2002), and two different comparisons were performed, one being the number of single-vehicle crashes and the other being the number of crashes with the involvement of alcohol or drugs as a contributing factor for the crash. The survey data were obtained from the drivers who came to renew their license at the clerk's office and the high school senior students from 5 counties across the states, which included both rural and urban environments, and the publicity throughout these locations was done using paid media like television, radios, and billboards. The average of the three years (1999, 2000, 2001) was compared with the crash data of 2002, and it was found that there was a fourteen-percentage reduction in single-vehicle crashes and the cases of fatalities and injuries were less than twenty percent. The crashes, including alcohol/drugs as a contributing factor, reduced by nine percent and had a five-percent lower injury, although the difference was not statistically significant.

Whittam et al. (2006) studied the effectiveness of media campaigns in reducing traffic crashes among young drivers. The campaign was performed in two similar locations in Tennessee, and paid media advertisements, including television and radio, were used in the Tri-Cities area of Kingsport, Johnson City, and Bristol (treatment group), Tennessee, and Hamilton County was used as a comparison group. The targeted population was the young drivers, the population of 16-19 years old people in the treatment groups was 6,400, and that in the comparison group was 7795. The selection of the groups was made such that the media campaigns for the treatment groups would not impact the comparison groups. The media campaign (August 15 – December 31, 1996; no announcements during October) was based on the theme "What's the Hurry?" and aired through television, radios, and displayed using billboards. The outcomes were measured using the telephone poll of young drivers (16-19 years old), parents of teenage drivers (aged 16 to 18 years old), parents of children 14 to 15 years old, and the crash frequencies of 16 to 19 years old, when they were at fault, from 1994 to 1999 for both the treatment and comparison groups. The analysis shows an increasing trend of crashes for the treatment group during the whole study period (1994 – 1999); however, during the intervention period (August 15 – December 31, 1996), the total crash frequency for the treatment group was in decreasing trend. The crash data were fitted using the Autoregressive integrated moving average (ARIMA) model, which indicated that the treatment group had a significant reduction of 21.6% in the crash frequency during the campaign duration, whereas the comparison group had a non-significant increase in the crash frequency. Also, an analysis of the crashes resulting in serious injuries involving 16–19-year-old at-fault drivers had an insignificant reduction of 16.4%.

Mullholland, Tierney & Healy (2005) analyzed the Wipe Off 5 campaign, which dealt with the reduction of low-level (5-10 kph) speeding in Victoria, Australia. The Wipe off 5 program started in 2001 by the Transport Accident Campaign (TAC) was based on three basic strategies, to reduce the speed limits on local streets from 60 kmph to 50kmph, using mass media campaigns to reinforce the benefits of reducing the low-level speeding and using more intensive enforcement regarding the speed limits. The TAC implemented 8 phases of the campaign from august 2001 to February 2005, during which campaigns were supported by television messages, in addition to the radio and billboards displaying tailored messages.

The success indicators of this project were taken as changes in trauma rates, changes in attitudes and habits, and changes in observed speeds. The study of the crashes from 2001 to 2004 showed that both the fatalities and serious injuries decreased in both lower and higher speed zones. The death rate per 10,000 vehicles decreased from 1.33 (2001) to 0.96 (2004). In addition to that, the death toll decreased from 444 in 2001 to 343 in 2004, with the lowest toll of 330 occurring in 2003.

Jones, Rodriguez-Iglesias & Cyr (2005) evaluated Pueblo County's Smart Roads Project, a road safety campaign aimed at reducing alcohol-related crashes involving drivers aged 21 to 34 years old. The smart road program started in 2000 with initial targets as the 21-34 years old male drivers but later included both genders. The program involved three major components viz: a targeted media campaign, a workplace initiative, and community involvement encompassing a broad range of organizations. The study consisted of Pueblo County plus eight other counties consisting of the drivers involved in crashes aged 21-34 years old. The public media campaign ran from October 1999 through September 2000, and in the summer of 2001, the Smart Roads project was promoted through a public media campaign that included advertisements on television, radio, newspapers, billboards, and other collateral materials. The campaign was also supported by an educational program, "Buzzing and Tooling," among blue-collar workers regarding their drinking and driving practices which included activities emphasizing the consequences, norms, and behavioral beliefs about drinking and driving. Two comparisons were made, one between Pueblo County and all other counties in Colorado and another between the eight counties plus pueblo county and the result of the counties in Colorado. The data was collected from the Colorado department of transportation for the years 1998 and 1999 for the "before" period and 2000 and 2001 for the "after" period. The analysis was done for the nighttime injury crashes (NI) and nighttime single-vehicle injury crashes (NSVI) for both groups. The analysis of the data collected showed that there was a decrease in 40% of the NI crashes, and the percentage of NI crashes of all crashes decreased from 10.2% to 6.2 %. The percentage of NI crashes for the comparison groups, however, increased significantly from 10.5% to 10.9%. The NI crashes for Pueblo County, combined with the other eight counties, saw a decrease of 39% for the before and after-period. There was an increase of 4% in the crashes for the comparison group. Also, the percentage of NSVI crashes for the test group decreased from 8% to 6.9%, a 13.5 percent decrease, while that for the comparison group increased by 4.8 percent.

2.2. Idaho's SHIFT Campaign

In 2017, the Idaho Transportation Department's Office of Highway Safety started the SHIFT movement to reduce road crashes in Idaho. SHIFT is an "engaged-driving program" focused on preventing distracted driving by encouraging people to be more engaged in road conditions. The SHIFT program is about having the drivers talk and share about the positive safety behaviors, techniques, and strategies against distracted driving rather than using the traditional method of road safety campaigns.

The Shift campaign used audio-visual messages to convey the information, which included "Drive Well Idaho," "Driving in the Moment Free from Distractions," "In my Idaho, we drive well," and "Shift the Conversation" as the catchphrases. These contents tend to share and promote shifting the thinking, shifting the behavior, shifting the focus, and shifting the driving culture against distracted driving, along with encouraging Idahoans to discuss more the safety cultures behind the wheels. These contents try to instill the concept of discussions of engaged driving and the meaning of engaged driving itself, rather than focusing on the messages about distracted driving, unlike the preceding road safety campaigns.

Throughout the days, the Shift campaign is constantly working on its primary goal of saving lives by making the roads safer in Idaho. The dedicated website for the Shift campaign, https://shift-idaho.org, now covers the materials related to motorcycle awareness and impairment, child passenger safety, teen driver safety, seatbelt safety, impaired driving, aggressive driving, school zone safety, and winter safety, along with its initial purpose of engaged driving. These materials comprise wide collection of articles, videos, shared experiences, and outreach and educational materials, covering best roadside practices, challenges, and guidelines for safety in such conditions. In addition to this, the Shift campaign is actively engaged in social media like Facebook, Twitter, and Instagram through its official media handle, to promote engaged driving, "living in the moment when behind the wheels by shifting behaviors on Idaho's roadways" (Idaho Office of Highway Safety's Instagram handle).

Otto, Ward, and Finlay (2020, 12) report the purpose of the campaign as "to encourage conversations about engaged driving instead of focusing on conversations surrounding distracted driving". Also, on the evaluation performed by the same authors, the post-intervention community survey showed fifteen percent of males and eleven percent of females heard of the campaign three or more times; however, a large percentage of people reported that they had never heard of the campaign. However, there was an increased awareness of the campaign as per the workplace survey. Even though there were safer choices after the intervention of SHIFT among the respondents, there were not any significant changes as per the community survey as well as the workplace survey regarding actual beliefs and behaviors.

2.3. Highway Safety Manual and Crash Modification Factors

The highway safety manual (AASTHO 2010) was published to fill the prevalent gap in quantitative crash analysis and evaluations. It acts as a tool to assess future crashes and severities and develop alternatives to reduce crash frequencies. Part D of HSM deals with the application of countermeasures, estimation of their effectiveness, and quantification of their effectiveness as crash modification factors (CMF). The HSM deals with a myriad of information when it comes to the countermeasures dealing with the impacts of highway treatments and the geometric and operational characteristics of the highways.

The HSM defines CMF as "the ratio of the effectiveness of one condition in comparison to another condition." A CMF of less than 1.0 implies that the treatment is likely to reduce the crashes, and a value greater than 1.0 indicates a probable increment of crashes. CMFs can be developed not only for the measures applied on the roadways but also for any actions that can impact road safety or the contributing factors.

The study designs to estimate the CMFs can be divided into two groups: Experimental Studies and Observational Studies. Experimental Studies are those in which the study groups are identified and randomly assigned to the treatment conditions or considered a control group without applying the treatments. Observational studies, on the other hand, are those in which the study groups are identified such that the treatments of interest have already been implemented in the groups, and no further treatments are required to study the impact of the treatment. Due to the ethical issues associated with the application of treatment to only a fraction of the identified groups in the experimental studies, observational studies are preferred when designing studies related to traffic safety.

These studies can be further divided as Before-after design or Cross-sectional design. Before-after designs consist of comparisons of sites or groups of sites before and after the implementation of treatment for a certain period. These design methods can also vary from simple (naïve) before-after study, before-after study with comparison groups, before-after Empirical Bayes study, and before-after Full Bayes study. Cross-sectional designs include a comparison of performance between the sites with treatment and similar sites without treatment simultaneously.

2.3.1. The Simple (Naïve) Before and After Study

The naïve before and after study is the simplest methodology to compare the before-period crashes to the after-periods. The before-period crashes are used to predict the after-period crashes and fails to address the temporal changes that the entities go through, the regression-to-the-mean phenomenon. Literatures mention that the frequent use of naïve before-after studies is because of its simplicity in calculation as well as interpretations, easiness in data collection, statistical precision, and its usability as a starting point in before-after studies (Hauer 1997,73; Park 2015, 21).

2.3.2. The Before and After Study with Comparison Group

The Before-after study with a comparison group is used to account for the factors that affect the safety, but their influence is yet to be recognized or understood. For such factors, comparison group is set up. The comparison group consists of the entities that are under controlled environment i.e., without any treatment and identically represent the treatment groups in various aspects such as AADT, VMT, road environment, and geometric conditions. The comparison group is taken as the representation of how safety would have been had there been no treatment applied to the treatment groups. Also, the two basic assumptions of this method are that: the change in factors that affect the safety change in a similar fashion in both comparison and treatment groups, and the change in these factors has a similar impact in both comparison and treatment groups. (Hauer 1997, 116)

2.3.3. The Empirical Bayes Before and After Study

The EB method addresses the regression to the mean phenomena and the temporal changes that impact the crashes in the entities considered by predicting the crashes using SPFs, developed from the before-period crashes from the comparison sites. Due to the high overdispersion factor that comes with the crash count data, the crash data are considered to follow negative binomial distribution. This assumption is used to calibrate the SPFs, and the crashes are predicted using these functions for the after-period with the required adjustment of weight for the observed crashes in the after-period (Hauer 1997; Hauer et al. 2002, 127).

2.3.4. The Full Bayes Before and After Study

The Full Bayes method is similar to the EB method but it combines the before-period crash data at treatment sites with that of reference sites to create the prediction model. Several literatures have suggested the FB approach over the EB method lately stating that FB approach requires a smaller sample size to predict the safety effects, is more flexible with the selection of crash data distribution, more accountable to the uncertainty in the data, and provides the possibility of multi-level inferences (Lan et al. 2009; El-Basyouny & Sayed 2010).

2.3.5. The Cross-Sectional Method

The cross-sectional method is preferred when the safety impact of a specific facility is to be analyzed and the observational before-after study of the safety measure is difficult (Hauer et al. 1997, 3). The crashes of entities with and without the facility of interest are compared and CMF is calculated as the "ratio of the average crash frequency of sites with the feature to the average crash frequency of sites without the feature" (Carter et al. 2012, 13). Cross-sectional methods can be used when there are a large number of entities to be considered/available and the installation of the facility type is unknown (Donnell et al. 2020). Also, for the calibration of SPFs the count regression model is used to identify the relation between the crash and the facility (Carter et al. 2012).

Chapter 3: Study Methodology

This chapter introduces the methods employed to understand and analyze the safety effectiveness of Idaho's SHIFT program. Since the SHIFT program started in 2017, the data for the year 2017 was not used as part of this analysis, thus making the period 2014-2016 the "Before" period and 2018-2020 the "After" period with reference to the SHIFT campaign. The data collection procedures, statistical analyses employed to develop the Safety Performance Functions (SPFs), and the estimation calculation of the Safety effects of the treatment in the crashes using the Empirical Bayes method are described in this chapter.

3.1. Data Collection

With the SHIFT program being applied throughout the state of Idaho, few data parameters could be used to represent the counties as well as the age groups of interest in our analyses. Thus, the population data was used as the only factor to estimate the crashes for each county and each age group. The required data were collected from the Idaho Transportation Department (ITD) website, as well as the US Census Bureau website.

3.2. Crash Data

The Idaho Transportation Department Office of Highway Safety has made the crash data throughout the state of Idaho publicly accessible through its online crash dashboard. In addition to that, the Idaho-specific Crash Analysis Reporting System (WebCARS), available to local and state agencies to analyze the crash data, consists of a database of reportable as well as non-reportable crashes in Idaho since 1997. The reportable crashes in Idaho are the crashes involving a motor vehicle on public property with damage of more than $1500 of property damage for any one person involved in the crash or resulting in an injury to any person involved. Filled by the enforcement officer at the crash site, a vehicle collision report consists of information about the location of the crash, information on vehicle units, and users involved in the crash, the number of injuries or fatalities as a result of the crash, the contributing circumstances, and the harmful events, along with the sketch of the scene.

For the analysis purpose, the crash data of all 44 counties of Idaho, involving the age groups 15-19, 20-24, and 25-44, were retrieved. Also, the crashes of all severity were included for the analysis, and analysis for the total crashes and crashes of fatal and severe injury were used for the development of the safety factor. Since the crash report had multiple entries for the same crashes depending upon the number of units and persons involved in the crash, for any found duplicate entries found, only one crash for drivers and with a citation charge was considered. The crash data considered for each age group and year are summarized in Table 1 and Table 2 and graphically represented in Figure 1 and Figure 2.

Table 1 Annual Fatal Crashes for the Various Age Groups

Age Range	**15-19**		**20-24**		**25-44**	
Year	**Crashes Statewide**	**Maximum Crashes**	**Crashes Statewide**	**Maximum Crashes**	**Crashes Statewide**	**Maximum Crashes**
2014	259	58	297	75	654	177
2015	280	69	306	87	688	191
2016	298	79	323	79	686	183
2018	266	63	296	85	684	185
2019	242	58	252	59	619	141
2020	235	37	260	49	580	105

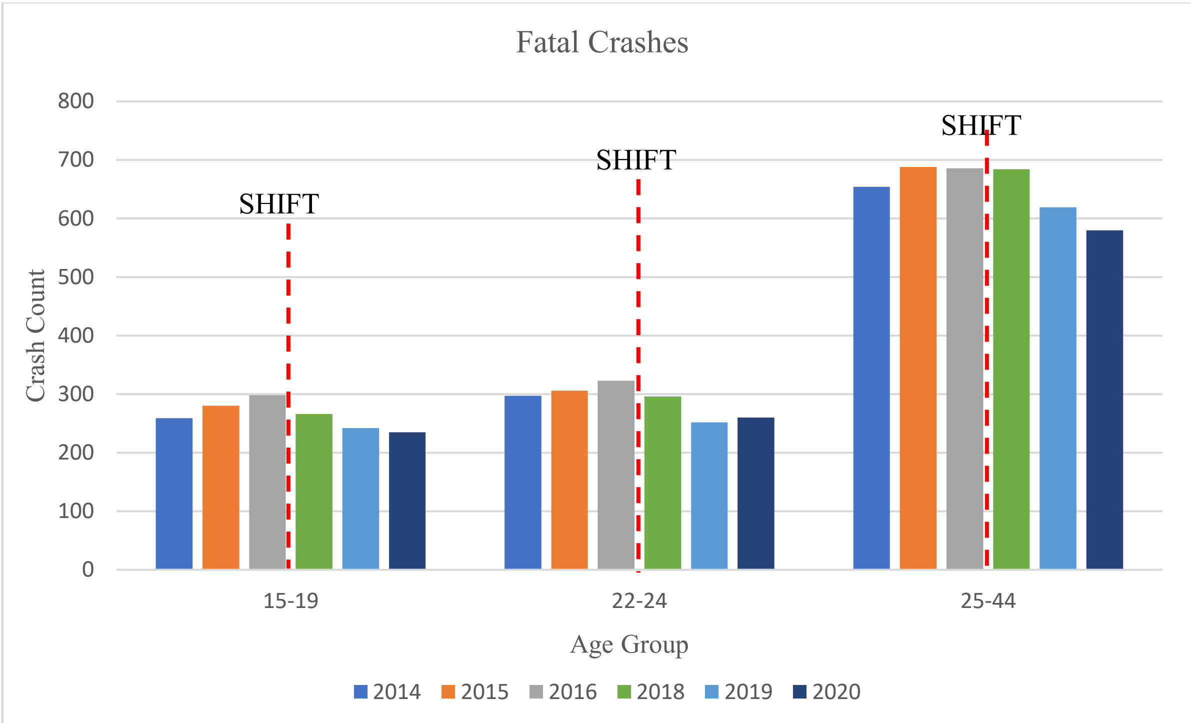

Figure 1 Annual Variation of Fatal Crashes for the Various Age Groups

Table 2 Annual Total Crashes for the Various Age Groups

Age Range	15-19		22-24		25-44	
Year	**Crashes Statewide**	**Maximum Crashes**	**Crashes Statewide**	**Maximum Crashes**	**Crashes Statewide**	**Maximum Crashes**
2014	5,354	1,565	5,312	1,590	11,077	3,508
2015	6,068	1,772	5,694	1,623	11,837	3,627
2016	6,302	1,846	5,820	1,641	11,837	3,627
2018	5,946	1,738	4,972	1,542	12,245	3,884
2019	6,674	1,893	5,990	1,717	13,689	4,030
2020	5,419	1,441	5,065	1,349	11,425	3,015

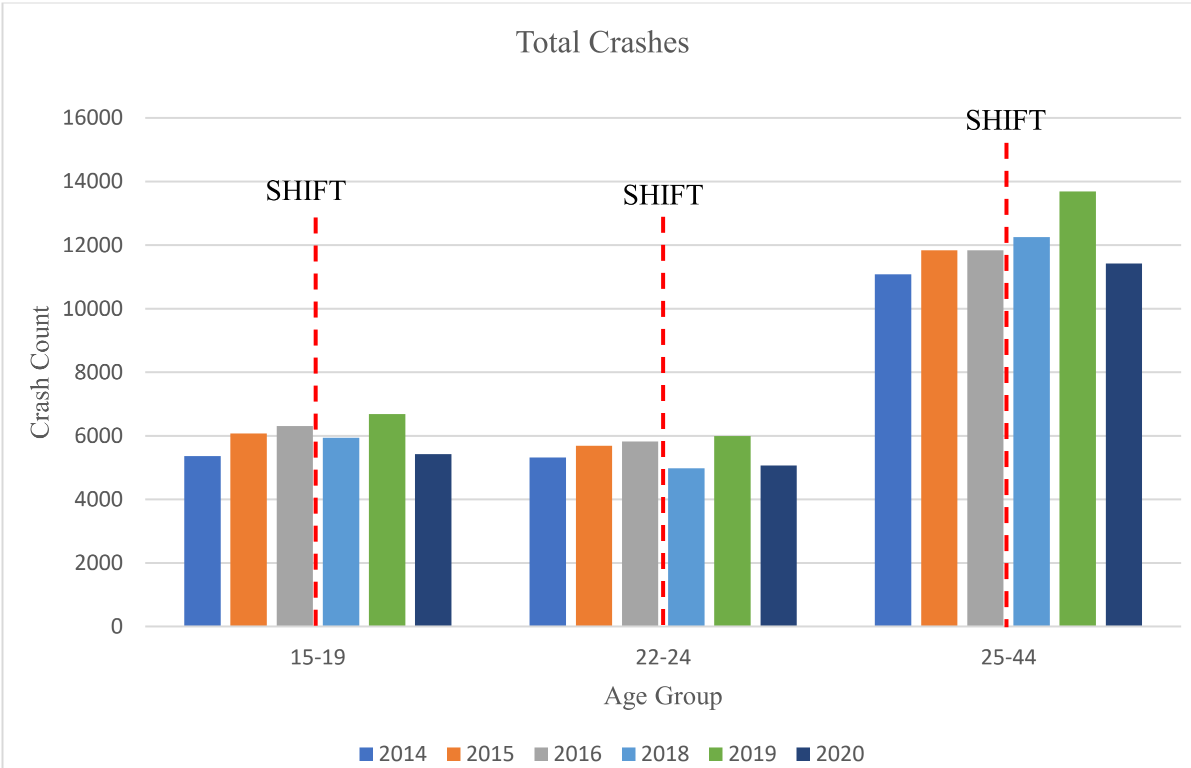

Figure 2 Annual Variation of Total Crashes for the Various Age Groups

3.3. Population Data

The population data for each age group and each year was obtained from the United States Census Bureau website. The Census Bureau publishes 1-year American Community Survey (ACS) estimates for only the areas with a population of 65,000 or more and publishes the detailed 5-year ACS data for each census tract related to Social Characteristics, Economic Characteristics, Housing Characteristics, and Demographic Characteristics of the location. The population data were obtained from the demographic characteristics of each county for the three age groups considered. One of the reasons for considering the after period till 2020 only was because of the unavailability of the demographic data for each county for the year

2021 at the time of the analysis. The summary of the population data for each age group for each year considered is presented in Table 3.

Table 3 Population Variation for the Study Period

Age Range	15-19		20-24		25-44	
Year	**Population Statewide**	**Maximum Population**	**Population Statewide**	**Maximum Population**	**Population Statewide**	**Maximum Population**
2014	113,931	27,102	111,149	26,709	407,273	117,586
2015	114,521	27,492	111,692	26,886	410,397	119,509
2016	116,334	28,285	111,710	27,058	414,712	121,450
2018	120,633	30,597	93,136	23,900	429,410	126,673
2019	121,785	31,299	114,610	27,631	439,188	129,827
2020	124,202	32,123	117,060	28,639	451,494	133,312

3.4. Safety Performance Function (SPF)

The estimation of Safety Performance Functions is one of the most important parts of the safety factor analysis using the EB Before-After method. Generally, SPFs are estimated based on the comparison groups, selected in such a way that they represent identical conditions to the treatment groups, and hence are impacted largely by the conditions that the comparison groups are exposed to. SPFs give the relationship between the crashes and the exposure parameters that govern the crashes for the considered case. The selection of appropriate exposure parameters depends upon the extent of availability of the data, as well as the correlation between the crashes and the parameters. The SPFs are then used to estimate crashes for the after-period, which is then used to determine the expected number of crashes that would have occurred in the after without the treatment by assigning the weight calculated from the EB equation.

In the case of the SHIFT campaign, the campaign was not applied to any specific counties; rather, it was a statewide program and the use of counties within Idaho as comparison groups were not possible. Also, using the counties of states other than Idaho as a comparison group was not an option because of the autonomous functioning of the states and the difference in the laws between the states inside their jurisdiction. Hence, randomly selected one-quarter of the available data from before period was used to estimate the SPFs for six different cases. Figure 3 below shows the equation used to estimate the SPFs using a negative binomial regression model.

$$N_{SPF} = \exp\left[\beta_0 + \beta_1 * \ln(\text{Population})\right]$$

Figure 3 Equation Negative Binomial Regression Model as SPFs

where,

NSPF = expected number of crashes,

β_0 = intercept of the regression line,

β_1 = regression coefficient for population, and

Population = population of the county for the given year.

The SPFs estimates of the crashes are used to calculate the Annual Calibration Factors (ACFs) to address the changes due to time trends. ACF is the ratio of the sum total of the observed crashes to the estimated total crashes using SPFs for a specific year. ACF was calculated for total crashes of the age group 15-19 only.

The estimates of the coefficients of the regression model, and ACFs are summarized in Table 4 and Table 5 respectively.

Table 4 SPFs parameter estimates

Age Groups	Crash Type	Parameter	Intercept	ln(population)
15-19	**Total Crashes**	**Estimate**	-3.481	1.068
		S. E	0.277	0.038
	Fatal and Severe	**Estimate**	-4.899	0.840
		S. E	1.141	0.154
20-24	**Total Crashes**	**Estimate**	-1.978	0.862
		S. E	0.361	0.050
	Fatal and Severe	**Estimate**	-3.124	0.655
		S. E	0.800	0.113
25-44	**Total Crashes**	**Estimate**	-2.231	0.836
		S. E	0.448	0.055
	Fatal and Severe	**Estimate**	-4.612	0.811
		S. E	0.810	0.096

Table 5 Annual Calibration Factor for Total Crashes Age Group 15-19

Year	ACF
2014	0.81
2015	0.91
2016	0.93
2018	0.84
2019	0.93
2020	0.74

3.5. Empirical Bayes Before-After Studies and estimation of Safety Effect

After developing the SPFs, these functions were used to estimate the expected number of crashes for the after-period without treatment, as well as for the before-period itself. For any given county, the difference in the crashes in the after-period without and with treatment would be the safety difference due to the campaign, as shown in figure 4 below.

$$\Delta \text{Safety} = \lambda - \pi$$

Figure 4 Safety Difference of the Campaign

where,

λ = Expected number of crashes in the after without the treatment.

π = number of observed crashes in the after-period.

The estimation of λ was done using EB estimates of the crashes for the before-period and assigning weight to account for the Regression in the mean effects. The expected number of crashes (m) for the before period is obtained as a function of the sum of annual SPF estimates for the before period (P), the count of crashes (x) in the before period, and the EB weight calculated from the equation in the figure 5.

$$m = w * P + (1-w) * (x)$$

Figure 5 Equation Expected Number of Crashes for Before Period

Also, the EB weight (w) can be calculated from the equation from the figure 6 as a function of the overdispersion parameter (k) from the negative binomial regression model used to estimate the SPFs.

$$w = \frac{1}{1+k*P}$$

Figure 6 Equation Empirical Bayes Weight

The expected number of crashes in the after without the treatment in the after period (λ) can be estimated as follows:

$$\lambda = m * \left(\frac{A}{P}\right)$$

Figure 7 Equation Estimated Number of Crashes in the After Period

where,

A = sum of annual SPF estimates for the after-period

The estimated values of λ, its variance, along with π and its variance were used to estimate the safety effect (θ) and its standard error, SE(θ), as follows:

$$\text{Safety Effect } (\theta) = \frac{\pi_{sum}/\lambda_{sum}}{1 + \left(\frac{var(\lambda_{sum})}{\lambda_{sum}^{2}}\right)}$$

Figure 8 Equation Safety Effect

$$Standard\ Error\ of\ \theta = \sqrt{\theta^2 \left(\frac{\frac{var(\pi_{sum})}{\pi_{sum}^{2}} + \frac{var(\lambda_{sum})}{\lambda_{sum}^{2}}}{\left(1 + \frac{var(\lambda_{sum})}{\lambda_{sum}^{2}}\right)^2}\right)}$$

Figure 9 Equation Standard Error of the Safety Effect

The safety effect and the standard error calculated in figure 8 and figure 9 are used to determine the percentage change in crashes with its statistical significance.

Percent change in crashes = 100 * (1- θ)

Figure 10 Percentage Change in Crashes

$$\text{Standard error} = 100^* \, SE(\theta)$$

Figure 11 Equation Standard Error of the Percentage Change in Crashes

$$\text{Statistical Significance} = \frac{\text{Percent change in crashes}}{\text{Standard error}}$$

Figure 12 Equation Statistical Significance of the Percentage Change in Crashes

The percentage change in crashes is statistically significant at the 95% confidence level if the ratio of percent change and its standard error is greater than 1.96.

Chapter 4: Analysis and Results

As described in the Chapter 3, negative binomial distribution was used to calibrate the SPFs based on the previous studies performed in this field. The SPFs were estimated for each age groups for both “fatal and severe” crashes as well as total crashes.

4.1. Estimated Fatal and Severe Injury Crashes Safety Effects

The estimated safety effects of the SHIFT campaign on fatal and severe injury crashes are summarized in Table 6. The changes in crashes which were found significant based on the ratio of percentage change in crashes and its standard error, at the significance level of 0.05 are presented in bold. Also, the expected crashes had the SHIFT program not been employed, the actual crashes recorded after the implementation of SHIFT program, the percentage change in crashes and the safety effect for each age group along with the standard error are tabulated in Table 6.

Table 6 Safety Effect, Standard Error, and Percentage Change in Fatal Crashes - SHIFT Campaign for Various Age Groups

Age Group	EB Expected Crashes in the After Period	Number of Crashes Observed in the After Period	Safety Effect	Standard Error of Safety Effect	Percentage Change in Crashes
15-19	988.14	743	**0.752**	0.015	**-24.81%**
20-24	1019.53	808	**0.792**	0.016	**-20.75%**
25-44	2249.43	1883	**0.837**	0.017	**-16.29%**

From the results obtained we can conclude that the SHIFT program has played a positive role in decreasing the fatal and the severe injury crashes for all the age groups. The maximum reduction was 24.81% for the age group 15-19. The age group 20-24 saw a reduction of 20.75% in the after period (2018-2020), while the age group 25-44 experienced a decrease of 16.29%.

4.2. Estimated Total Crashes Safety Effects

The estimated safety effects of the SHIFT campaign on total crashes are summarized in Table 7. The changes in crashes which were found significant based on the ratio of percentage change in crashes and its standard error, at the significance level of 0.05 are presented in bold. Also, the expected crashes had the SHIFT program not been employed, the actual crashes recorded after the application of SHIFT program, the percentage change in crashes and the safety effect for each age group along with the standard error is tabulated in Table 7.

Table 7 Safety Effect, Standard Error, and Percentage Change in Total Crashes - SHIFT Campaign for Various Age Groups

Age Group	EB Expected Crashes in the After Period	Number of Crashes Observed in the After Period	Safety Effect	Standard Error of Safety Effect	Percentage Change in Crashes
15-19	19149.4	18039	**0.942**	0.022	**-5.80%**
20-24	16459.11	16027	0.973	0.022	-2.63%
25-44	36770.93	37359	1.016	0.024	1.60%

From Table 7, the SHIFT campaign has had mixed results for total crashes across the various age-groups considered. The age group 15-19 had a significant decrease of 5.80% in the total crashes in after-period. The impact of the campaign on the other age-groups however was not as significant as the age group 20-24 experienced a non-significant reduction of 2.63% whereas the age-group 25-44 had a non-significant increase in the total crashes of 1.6%.

From the results we can deduce that the SHIFT campaign had mixed outcome for the total crashes, but the reduction was significant for the fatal and severe injury crashes. In light of these findings and the methods used to complete this thesis, the next chapter offers the conclusion and suggestions for future research to evaluate the safety effects of educational campaigns and the SHIFT campaign in particular.

4.3. Results from University of Idaho and Idaho Transportation Department Distracted Driving Public Safety Campaign

On the sponsorship of ITD, the National Institute for Advanced transportation Technology (NIATT) conducted a distracted driving survey campaign and competition among the high school students throughout the state of Idaho. The survey campaign involved nine schools and 165 students in the preliminary phase to understand the opinions of the high school students (only the age group 15-19 is considered) towards distracted driving and it comprised twenty-two questions most of which involved the answers in seven-point Likert scale, except for the few demographic questions. The survey was followed by a competition and two post-competition surveys, one after 2 weeks of the competition and the other 5 months after the competition. The post-competition surveys only included the students that took part in the competition with 22 and 19 participants involved. The competition involved students creating public service announcements to inform other people on distracted driving, using their understanding and research. The PSAs ranged from short videos on distracted driving to social media posts which included memes, and text messages. NIATT also provided the resources needed for the students to self-learn about distracted driving through the competition website and it included experiences and learning from past campaigns, the statistics on distracted driving, and examples of the contents that students could submit. In addition to the use of social media, the high school teachers were also involved to convey the information. The competition had a cash prize for first, second and third-placed student(s) along with a scholarship offer for the first-placed student(s) from the University of Idaho, College of Engineering. The competition received thirty-nine submissions from thirteen schools in Idaho. Larrea and Abdel-Rahim (2017) analyzed the effectiveness of the campaign and competition, which showed that the competition had a positive impact on the students that took part in the competition. The survey response received after 5 months of the competition demonstrated that the students involved had a negative attitude towards distracted driving (texting and emailing while driving). These results also suggest that educational campaigns like these involving PSAs and students help to alter the understandings and change the norms related to distracted driving and thus the driving behavior, helping in improving traffic safety.

The 2018-2020 crash data was used to identify the number of total crashes the campaign participants were involved in during these three years. These values were compared with the expected number of crashes estimated using the calculated safety effect of the SHIFT campaign, the results can be summarized as follows in Table 8:

Table 8 Crash Analysis of the NIATT Survey Campaign

Year	Participants Involvement in Total Crashes	Expected Crashes using SPF and Annual Calibration Factor (15-19)	Percent Change Compared to Predicted Crashes
2018	5	6.05	-17.35%
2019	4	6.71	-40.38%
2020	6	5.33	+12.57%

The expected number of crashes was calculated using the SPFs for the age group 15-19 and the Annual Calibration Factor for the corresponding year. The observed crashes among the students involved in the survey campaign showed some variation with the expected crashes from the SPFs. The first and second years after the survey and competition saw a decrease of crashes by 17.35%, and 40% respectively. However, there was an increase in crashes in the third year after the survey. The variation in the expected and the observed crashes can be explained by two main reasons: i) the lesser population size considered in each year with respect to the county-level population size used to create the SPF, and ii) this particular group of students being a special sample population, i.e., they are exposed to both the SHIFT campaign, and the survey campaign as well, and on top of that these programs having as almost identical goal, to change the driving behavior to promote the traffic safety.

Chapter 5: Conclusions and Recommendations

5.1. Conclusions

This study examined the potential crash reduction benefits of public safety campaigns that are aimed to positively impact the traffic safety culture for younger drivers. Crash modification factors (CMFs) for State of Idaho's SHIFT public safety initiative were developed using Idaho-specific crash data covering the period from 2014 to 2020. The CMFs developed as part of this project allow the Idaho Transportation Department (ITD) and other local, state, and federal transportation agencies to assess and quantify the potential safety benefits of public safety campaigns. Generalized linear negative binomial models were used to develop crash prediction models which were used as safety performance functions (SPF) to predict the number of crashes had the tested safety measure (Idaho's SHIFT campaign) not been implemented. Previous studies have shown that the negative binomial model appropriately accounts for the randomness and the over-dispersion in the crash count data. The developed models covered total crashes as well as fatal and severe injury crashes. Specific crash types were not addressed due to the small sample size. The results of the Empirical Bayes method used in this study can be summarized as follows:

- Public safety campaigns can reduce crash rates, particularly amongst the youths of the age group 15-19. The analysis showed that there was a significant reduction in fatal crashes as well as total crashes for the age group 15-19 by 24.81% and 5.80% respectively.
- Similarly, the age group 20-24 and 25-44 had significant reduction in fatal crashes by 20.75% and 16.29% respectively.

- The analysis also shows that the safety campaigns are more successful in reducing the fatal crashes as the results were significant for all the age groups considered for fatal crashes.

The data from ITD and NIATT survey campaign were also used for the after period to analyze the effectiveness of the survey campaign as well as to validate the SPF estimates. The results showed an initial decrease of 17.35%, and 40% in the first two years after the campaign in total crashes and an increase of 12.57% in the third year.

5.2. Study Limitations

The evaluation of the crashes was performed to compute the CMFs for the public safety campaigns, however, there might have been various underlying factors that could have influenced this study and hence the results. First, this study generalizes that the change in the number of crashes throughout the study period is the result of the implementation of the SHIFT campaign. The variation of crashes during any period could also be affected by several confounding factors which could have also influenced the outcome of this study. Also, the influence of the factors like self-learning in the community, alterations in the choices (e.g., destinations, modes, routes, etc.) of the travelers along a trip, infrastructural advancement that took place during the study period, pandemic incidents during the study period, and even the variation in the price and availability of resources that impact the use of the traffic facilities (e.g., Gas prices), on crash occurrence cannot be negated.

5.3. Recommendations for Future Works

Since there are only a handful of research works that address the effectiveness of safety campaigns and outreach activities, future studies should be concerned with the maximization of the safety effectiveness of such campaigns along with the use of various statistical models to estimate the SPFs that could perfectly represent the relationship between crashes and the control parameters. Also provided that sufficient datasets are available, the impact of safety campaigns on specific crash types like crashes involving aggressive driving, impaired driving, or weather conditions could be studied to understand the existing problems in traffic safety and use the understandings in the development of future safety campaigns.

The use of zero inflated negative binomial distribution could be done to address the excessive zero crash counts, which is an issue that could arises when considering age groups with very few populations as well as the fatal crashes. In addition to that, the use of the FB method could be done instead of the EB method to predict the safety effect as the FB method is compatible even with low number of sample data to start with, and accounts for more uncertainty as suggested by various literatures on the development of CMFs.

Chapter 6: References

Agent, Kenneth R., Eric R. Green, and Ronald E. Langley. "Evaluation of Kentucky's You Drink and Drive. You Lose"." (2002).

Carter, Daniel, Raghavan Srinivasan, Frank Gross, and Forrest Council. "Recommended protocols for developing crash modification factors." *Final Report NCHRP* 2027, no. 314 (2012).

Crash Modification Factors Clearinghouse. 2022. Accessed: November 4, 2022. https://www.cmfclearinghouse.org/

Donnell, Eric T., Ephraim Hanks, Richard J. Porter, Lawrence Cook, Raghavan Srinivasan, Fan Li, Maggie Nguyen, and Kimberly A. Eccles. *The Development of Crash Modification Factors: Highway Safety Statistical Paper Synthesis*. No. FHWA-HRT-20-069. United States. Federal Highway Administration. Office of Safety Research and Development, 2020.

Dunckel, Jeff, William Haynes, Joana Conklin, Susan Sharp, and Alexandra Cohen. "Pedestrian safety initiative in Montgomery County, Maryland: Data-driven approach to coordinating engineering, education, and enforcement." *Transportation Research Record* 2464, no. 1 (2014): 100-108.

El-Basyouny, Karim, and Tarek Sayed. "Full Bayes approach to before-and-after safety evaluation with matched comparisons: case study of stop-sign in-fill program." *Transportation research record* 2148, no. 1 (2010): 1-8.

Elder, Randy W., Ruth A. Shults, David A. Sleet, James L. Nichols, Robert S. Thompson, Warda Rajab, and Task Force on Community Preventive Services. "Effectiveness of mass media campaigns for reducing drinking and driving and alcohol-involved crashes: a systematic review." *American journal of preventive medicine* 27, no. 1 (2004): 57-65.

Fell, James C., A. Scott Tippetts, and Marvin Levy. "Evaluation of seven publicized enforcement demonstration programs to reduce impaired driving: Georgia, Louisiana, Pennsylvania, Tennessee, Texas, Indiana, and Michigan." In *Annals of Advances in Automotive Medicine/Annual Scientific Conference*, vol. 52, p. 23. Association for the Advancement of Automotive Medicine, 2008.

Idaho Office of Highway Safety Instagram Handle. 2022.Accessed: October 5, 2022. https://www.instagram.com/highwaysafety_id/.

Jones R, Rodriguez-Iglesias C, Cyr E. Evaluation of Pueblo County. Springfield: Colorado's Smart Roads Project; 2005

Lan, Bo, Bhagwant Persaud, Craig Lyon, and Ravi Bhim. "Validation of a full Bayes methodology for observational before–after road safety studies and application to evaluation of rural signal conversions." *Accident Analysis & Prevention* 41, no. 3 (2009): 574-580.

Larrea, Meagan, and Ahmed Abdel-Rahim. *Educating Idaho Teenage Drivers of the Dangers of Distracted Driving*. No. FHWA-ID-17-251. Idaho. Transportation Department, 2017.

Moon, Jae-Pil, and Joseph E. Hummer. "Speed Enforcement Cameras in Charlotte, North Carolina: Estimation of Longer-Term Safety Effects." Transportation research record 2182, no. 1 (2010): 31-39.

Mulholland, E., P. Tierney, and D. Healy. "Wipe Off 5–a Victorian social marketing campaign." In *Australasian Road Safety Research Policing Education Conference, 2005, Wellington, New Zealand*. 2005.

Otto, Jay, Nicholas J. Ward, and Kari Finley. *Evaluation of Interventions to Reduce Distracted Driving in Idaho*. No. FHWA-ID-20-259. Idaho. Transportation Department, 2020.

Phillips, Ross Owen, Pål Ulleberg, and Truls Vaa. "Meta-analysis of the effect of road safety campaigns on accidents." *Accident Analysis & Prevention* 43, no. 3 (2011): 1204-1218.

Rimal, Rajiv N., and Kevin Real. "How behaviors are influenced by perceived norms: A test of the theory of normative social behavior." *Communication research* 32, no. 3 (2005): 389-414.

Robertson, Robyn D., and Charlotte Pashley. *Road safety campaigns*. desLibris, 2015.

Saleem, Taha, Bo Lan, Raghavan Srinivasan, Laura Sandt, Kristin Blank, and Sam Alden Blank. "Crash Based Evaluation of the Watch for Me NC Program." *Retrieved from Watch for Me NC website: www. watchformenc. org/wp-content/uploads/2019/02/2018-38-Final-Report-NCDOT-WFMEVAL. pdf* (2018).

SHIFT Idaho.2022. Accessed: October 5, 2022. https://shift-idaho.org/

Tay, Richard S., and Lucie Ozanne. "Who are we scaring with high fear road safety advertising campaigns?." (2002).

Vaa, Truls, Terje Assum, Pål Ulleberg, and Knut Veisten. *Effects of Information Campaigns on Behaviour and Road Accidents-Conditions, Evaluation and Cost-Effectiveness*. No. TOI727/2004. 2004.

Watch for Me NC.2022. Accessed: 10/14/2022. https://www.watchformenc.org/

Whittam, Kimberly P., William O. Dwyer, Patricia W. Simpson, and Frank C. Leeming. "Effectiveness of a Media Campaign to Reduce: Traffic Crashes Involving Young Drivers 1." *Journal of Applied Social Psychology* 36, no. 3 (2006): 614-628.

Zampetti, R., G. Messina, C. Quercioli, F. Vencia, L. Genco, L. Di Bartolomeo, and N. Nante. "Non-fatal road traffic injuries: can road safety campaigns prevent hazardous behavior? An Italian experience." *Traffic injury prevention* 14, no. 3 (2013): 261-266.