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Understanding the Complex Impacts of Seatbelt Use on Crash Outcomes

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Abstract: Despite the importance of seatbelt use in the reduction of injuries and fatalities, the majority of past studies failed to account for the complex nature of seatbelts on the safety of roadways. The complexity of seatbelt use is especially related to a possible association between seatbelt use and other factors at the time of crashes. Ignoring those interaction terms might result in unrealistic or biased point estimates regarding the underlying impact of seatbelt use on roadway safety. For instance, is the impact of seatbelt use on the severity of crashes stable or varies based on other factors such as gender? Or does the impact of seatbelt use changes based on whether a driver is under the influence of alcohol or not? The mixed logit model was used to model the severity of crashes. In this study we focused on interaction terms between seatbelt use and all other plausible predictors of crashes. The results highlighted that there are important and significant interaction terms between seatbelt status and other predictors such as drivers under the influence (DUI), drivers with invalid driver's licenses, lack of attention in crashes, having a citation record, ejected drivers, and other environmental and roadway characteristics. For instance, it was found that the impact of seatbelt use on the severity of crashes varies based on the actions that drivers took before crashes, such as improper lane changes or following too close. On the other hand, seatbelt use is more effective in crash severity reduction for ejected drivers and less effective for drivers under the influence of alcohol or unattended drivers. The results provide important information to gain a better understanding regarding the effectiveness of seatbelt use.

Keywords: seatbelt; policy recommendations; interaction terms; traffic safety; crash severity

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1. Introduction

Motor vehicle crashes (MVC) are a leading cause of injury and fatalities around the world. Traffic crashes result in thousands of deaths, billions of dollars in economic costs, and millions of injuries annually. For instance, the social costs of road crashes account for 1% of Gross Domestic Product (GDP) in low-income countries to about 2–3% in high income countries [1].

About 50% of passenger occupants killed in crashes in the U.S. were unrestrained passengers or drivers [2]. On the other hand, the rate of seatbelt use in the U.S. stands at the level of 90%, so, the remaining 10% account for almost half of all road deaths [3]. It should be noted that the rate of seatbelt use in the case study of Wyoming is significantly lower, with 79%, than the average of the US which stands at about 89% [3].

It is reasonable to assume that wearing a seatbelt is one of the most effective ways of saving lives in crashes. States have made extensive efforts to increase seatbelt usage and to prevent fatalities and severe crashes due to a lack of seatbelt use.

The objective of this research is to better understand the complex impacts of seatbelt use on the crash outcome, while talking into consideration all plausible pairwise interaction terms. There is no study that comprehensively examines the interactive impacts of seatbelts on the severity of crashes. This study is conducted to answer the main question of: is the impact of seatbelt use on the severity of crashes multiplicative and, if yes, what are other factors interacting with seatbelt use while impacting the severity of crashes?

2. Literature Review

Almost all studies that evaluated the severity of crashes ignored the complex impact of seatbelt use on the severity of crashes and only considered its additive effect. However, there is consistency between all those studies, highlighting that seatbelt use reduces the severity of crashes [4].

Limited studies also considered the choice of seatbelt use without considering their involvement in crashes. For instance, the choices of seatbelt use by observing various drivers and passengers were considered [5]. Various factors were considered that could account for unobserved characteristics of drivers. For instance, vehicle types, time of day, weather conditions, day of the week, and residency were some of the factors that were found to impact the choice of buckling up.

Numerous studies have been conducted on evaluation of the effectiveness of seatbelt use. Those studies could be divided into two main categories of those which ignored the interactive effect of seatbelt use, and also the few studies that considered the interaction of seatbelt use with a limited number of predictors. This subsection also follows that structure by presenting some studies that considered the non-interactive relationship of seatbelt use and then its interactive relationship.

Few studies consider interactions between limited predictors and seatbelt use. For instance, the interaction between seatbelt use and various age groups on the severity of crashes was considered [6]. The results highlighted a significant interaction between seatbelt use and age groups. A matched-pair cohort method was used in another study for estimating the effectiveness of seatbelt use [7]. Interaction terms between seatbelt use and age groups and between seatbelt and seatbelt position were found to be statistically significant.

Seatbelt use among drunk drivers in different legislative settings was evaluated in the other study [8]. The results showed that interactive impacts of stricter drunk driving laws and seatbelt laws are more effective than laws passed in isolation. In another study, the interaction between seatbelt use and obesity and their impact on the severity of crashes was evaluated [8]. The results highlighted no significant interaction between those factors. It should be noted that the aforementioned study divided data into different subsets and comparison was made only based on a simple summary of statistics.

In another study, mortality reduction with air bag deployment and seatbelt use was evaluated for head-on passenger car collisions [9]. Differences in categorical variables between fatal and nonfatal observations were tested against chi-square distribution. The results established an interaction term between seatbelt use and air bag deployment.

Based on the above discussion, there is some evidence that seatbelt use interacts with various factors. However, it could also be observed that while the majority of past studies ignored the interactive effects of seatbelt use, there is a great likelihood that the performance of seatbelt use varies based on different settings and to improve the effectiveness of seatbelt use, it is important to gain a better understanding of its complex interaction terms with other factors. So, this study was considered while considering all pairwise interactive terms between different factors. The severity of crashes was used as a response to highlight the interactive impacts of various predictors.

3. Method

The random parameter binary logit model assumes that the random coefficients vary randomly across individual crash severity based on some continuous distribution. Here, the interests of the random parameters model are the first moment of the distribution (the means of the parameters), and the second moment of distribution, or standard deviation for capturing the unobserved factors.

This study evaluated the variation across observations for a binary response of severe crashes versus property damage only (PDO) as a reference. The Logit model is a traditional method, which has been mostly used to model the severity of crashes. However, one of the main shortcomings of the standard logit model is its inability to capture the possible unobserved heterogeneity across individual observations. To explain the mixed model, first, the formulation of the standard logit model will be presented, followed by its modification to the mixed model estimation.

The mixed model is the generalization of the standard logit model that allows the parameter to vary across each individual. The standard logit model could be written as:

$$y_i = \beta x_i^{\intercal} + \varepsilon_i \tag{1}$$

where y_i is the log odds or probability for crash, i, x_i is observed characteristics of crash, i, ε_i is the i.i.d error term, and β is the fixed coefficient. The mixed logit could be extended from the standard logit model by letting β_i vary across crash observation i based on continuous density of $f\ (\beta_i|\theta)$, where θ is some parametric distribution. So now the probability of distribution parameter θ based on all possible values of β is written as:

$$P_i(\theta) = \int_{\beta_i} P(y_i|x_i, \beta_i) f(\beta_i) d\beta_i \tag{2}$$

As β_i is unobserved and varies across individual crashes, the probability density function (PDF), or f is used to define that. As Equation (2) does not have a closed form, an approximation of $P_i(\theta)$, or $\hat{P}_i(\theta)$, is used as

$$\hat{P}_i(\theta) = \frac{1}{R} \sum\nolimits_{r=1}^{R} \hat{P}_i(y_i|x_i, \beta_{ir}) \tag{3}$$

where R is the number of draws and $\hat{P}_i(y_i|x_i, \beta_{ir})$ is the simulated probability for individual i evaluated at rth draw. Now the parameters will be estimated by maximizing the sum of $\hat{P}$ for all individuals' crashes.

4. Data

The data used for conducting analysis in this study came from the crash dataset between 2015–2019. This dataset includes crashes that occurred on Wyoming highway and interstate system. After removing observations with missing values, there were 39,934 crashes during the period. Regarding some of the included variables in Table 1, a few points are worth mentioning. For our data, the age group of 42 years old divides the data into two equal datasets. However, due to the significance of the age group of 51 years old, when considering the interaction terms, this age group was considered instead (ID = 10).

A small proportion of drivers (mean = 0.02) involved in crashes had revoked, suspended, or expired drivers' licenses (ID = 16). Here, those drivers who had only a single ticket on their record were not considered as a cutting point (ID = 17), as that category was found not to be important while considering its interaction with seatbelt status. So, instead, we changed the category to those drivers with no ticket or a single ticket in their citation records. Recall that the main objective of the analysis is to identify which predictors have important interaction terms with seatbelt use.

The considered proximity of drivers (ID = 18) refers to whether drivers involved in crashes live in the proximity of crashes (the same town), or if they are travelers from other towns/states. This is expected to be especially important in interacting with seatbelt status as drivers' attitudes might change based on whether they are traveling inside or outside town. The average annual daily traffic (AADT) is the only continuous variable considered in the analysis, and other predictors are all self-explanatory.

Finally, it should be iterated that considering various cutting points for the variables citation and age group is justified as the main objective was to consider those predictors that significantly interact with the seatbelt status of drivers. The impact of seatbelt use on the severity of crashes is subjected to a complex dimension. Various factors could contribute to the dimension complexity, which could be categorized under crash, environmental/roadway, drivers' demographic, drivers' actions, and drivers' conditions (see Table 1).

Table 1. Descriptive summary of important predictors.

ID	Variables	Mean	Variance	Min	Max
1	Binary response, the severity of crash, injury/severe crashes versus PDO *	0.205	0.162	0	1
2	Seatbelt status, belted as 1, (versus others *)	0.87	0.114	0	1
	Crash characteristics				
3	Manner of collision, Single vehicle crash (versus others *)	0.40	0.240	0	1
4	Ejection status, ejected (versus others *)	0.360	0.338	0	1
5	Vehicle maneuver, straight ahead (versus others *)	0.69	0.212	0	1
	Environmental/roadway characteristics				
6	Type of highway, interstate (versus highway *)	0.33	0.221	0	1
7	Lighting condition, dark (versus light *)	0.46	0.248	0	1
8	Road condition, icy (versus others *)	0.24	0.183	0	1
	Drivers' demographic characteristics				
9	Gender, female (versus male *)	0.32	0.216	0	1
10	Age category, <=50 * (versus others)	0.31	0.214	0	1
	Drivers' actions				
11	Driver action, too fast for conditions, (versus others *)	0.12	0.108	0	1
12	Driver action, Follow too close, (versus others *)	0.04	0.04	0	1
13	Driver action, failure to keep proper lane, (versus others *)	0.07	0.069	0	1
14	Driver action, improper lane change, (versus others *)	0.02	0.020	0	1
	Drivers' characteristics/conditions				
15	Alcohol condition, under the influence of alcohol (versus others *)	0.044	0.042	0	1
16	Driver license validity, not valid (versus valid *)	0.02	0.02	0	1
17	Drivers' citation record, no or a single ticket *, (versus others)	0.38	0.235	0	1
18	Proximity of driver residency, driver was involved in crash is from the same town (versus others *)	0.18	0.145	0	1
19	Driver condition, inattention as true (versus others *)	0.02	0.016	0	1
20	Residency, non-Wyoming residence (versus Wyoming residence *)	0.39	0.237	0	1
	Random parameters				
21	AADT/1000	4.36	19.900	<100	32.9
22	Emotional condition of driver, conditions such as depressed or sad versus others *	0.007	0.007	0	1
23	Type of vehicle, passenger versus others *	0.22	0.170	0	1

* Reference category.

5. Results

For analyzing the crash data, the mixed logit model was employed to consider the important interaction terms between seatbelt use and various important predictors, while accounting for the unobserved heterogeneity across crash observations. A significant improvement, a decrease of 55 points in the log likelihood (LL), was observed, moving from the standard logit (LL = $-15{,}833$, #par = 36), to the mixed logit model (LL = $-15{,}777$, #par = 42), at the cost of 6 extra parameters.

The results in Table 2 follow the ordering of variables in Table 1, and similarly, the variables were categorized into their related groups. It is clear, while interpreting the interaction terms, that the main effects and the interaction terms should be considered. Moreover, due to considering all binary predictors for interaction terms, there will be 4 scenarios. For example, the scenario of belted condition when the other predictors vary will be outlined.

Table 2. Results of the mixed model, considering all interaction terms of seatbelt use.

Category	Predictors	Estimate	SE	*p*-Value
---	Seatbelt status	−0.07	0.05	0.10
Crash characteristics	Manner of collision (Single vehicle crash)	2.00	0.078	<0.005
	Manner of collision × Seatbelt status	−1.95	0.089	<0.005
	Ejection status	1.13	0.083	<0.005
	Ejection status × Seatbelt status	−4.94	0.159	<0.005
	Vehicle maneuver	−0.30	0.075	<0.005
	Vehicle maneuver × Seatbelt status	0.36	0.084	<0.005
Environmental/ roadway characteristics	Highway system	0.29	0.110	0.005
	Highway system × Seatbelt status	−0.59	0.115	<0.005
	Lighting condition	−0.30	0.069	<0.005
	Lighting condition × Seatbelt status	0.41	0.088	<0.005
	Icy road condition	−1.08	0.110	<0.005
	Icy road condition × Seatbelt status	0.47	0.118	<0.005
Drivers' demographic characteristics	Gender	0.06	0.091	0.27
	Gender × Seatbelt status	0.27	0.085	<0.005
	Age category	−0.11	0.077	0.08
	Age category × Seatbelt status	0.20	0.087	0.009
Drivers' actions	Drive too fast for condition	0.34	0.136	<0.005
	Drive too fast for condition × Seatbelt status	−0.24	0.147	0.051
	Follow too close	0.68	0.193	<0.005
	Follow too close × Seatbelt status	−0.57	0.210	<0.005
	Failure to keep proper lane	0.42	0.118	<0.005
	Failure to keep proper lane × Seatbelt status	−0.22	0.129	0.05
	Improper lane change	0.50	0.138	<0.005
	Improper lane change × Seatbelt status	−0.60	0.343	0.04
Drivers; characteristics/conditions	Alcohol involvement	0.90	0.116	<0.005
	Alcohol involvement × Seatbelt status	0.33	0.151	0.015
	Driver license validity	1.01	0.175	<0.005
	Driver license validity × Seatbelt status	−0.45	0.208	0.016
	Drivers' citation record	−0.50	0.045	<0.005
	Drivers' citation record × Seatbelt status	0.85	0.116	<0.005
	Proximity of drivers' residency	0.02	0.092	0.43
	Proximity of drivers' residency × Seatbelt status	−0.29	0.106	<0.005
	Driver condition, inattention	0.93	0.268	<0.005
	Driver condition, inattention × Seatbelt status	−0.34	0.291	0.12
	Residency, Wyoming	0.04	0.033	0.13
Random parameters	Mean, AADT	−0.03	7×10^{-3}	<0.005
	SD, AADT	−0.08	2×10^{-2}	<0.005
	Mean, emotional condition of driver	0.02	0.310	0.480
	SD, emotional condition of driver	1.82	0.752	0.008
	Mean, type of vehicle	−0.70	0.111	<0.005
	SD, type of vehicle	2.34	0.224	<0.005

5.1. Crash Characteristics

It was found that the impact of belting condition on the severity of crashes varies based on various crash characteristics. For instance, belted conditions reduce the severity of crashes more for non-single vehicle crashes compared with single-vehicle crashes, when drivers experienced ejection compared with no ejection, and for those vehicles that took other maneuvers compared with going straight ahead. The interpretation of the interaction terms is straightforward. For instance, we found that the seatbelt reduction of severity of crashes is greater for ejected compared with not ejected, belted drivers (as 1), for ejected (as 1) versus non rejected (as 0), and there is $(-4.94 \times 1 + 1 \times 1.13 - 0.07)$ compared with $(0.07 + 0 + 0)$ for nonejected, respectively.

5.2. Environmental/Roadway Characteristics

Moving to environmental and roadway characteristics, the results in Table 2 highlight that belted conditions reduce the severity of crashes on interstate systems, in non-dark conditions, and on icy road conditions more, compared to other groups. For instance, the impact of non-dark conditions might be linked to the fact that drivers drive more cautiously with a lower speed limit, so seatbelt use is more effective in more challenging conditions and possible aggressive behaviors of drivers, but the impact of seatbelt use is not stable but varies based on light conditions and estimated speed. Here, due to the complexity of three-term interactions, those terms were not considered.

5.3. Drivers' Demographic Characteristics

Two variables of drivers, age and gender, were considered along with their related interaction terms with seatbelt use. Here we considered the binary characteristics of age instead of its continuous characteristics. We found that seatbelt use varies based on gender, being more effective for male drivers than female drivers, and also changes based on age group: it is more severity preventive for younger age groups.

5.4. Drivers' Actions

Four drivers' actions were considered and all their interaction terms with seatbelt use were found to be important. In other words, the impacts of seatbelt use vary based on different actions that drivers take before crashes. Seatbelt use is less effective for drive too fast for conditions, follow too close, and failure to keep proper lane compared with other types of drivers' actions. However, it is more effective in reduction of the severity of crashes for improper lane. The impacts are expected to be due to the nature of drivers' actions and the point of impact that those actions imposed on drivers and consequently impact the effectiveness of seatbelt use.

5.5. Drivers' Characteristics/Conditions

Regarding drivers' characteristics/conditions, it is interesting to note that for the so-called risky drivers with alcohol involvement, lack of drivers' license validity, having citation record or inattention, the seatbelt use is less effective compared with less-risky drivers.

5.6. Random Parameters

Three predictors were considered as random and based on normal distribution, with significant standard deviation (SD). Those are AADT, emotional condition of drivers, and passenger car type of vehicles. Again, the comparison across the standard model and model accounting for heterogeneity highlights the necessity of accounting for heterogeneity in the dataset.

To highlight the complex relationship between various predictors and seatbelt use, and the severity of crash severity, Figure 1 is provided. As can be seen from Figure 1, almost all predictors interact with the seatbelt use while impacting the severity of crashes. The double line arrows highlight the interaction, while the single line arrow highlights the impacts of predictors on the severity of crashes. Again, due to the binary nature of seat belt use and other explanatory variables, there are 4 scenarios for each of them, where in Figure 1 we considered belted drivers as 1 and other non-reference predictors.

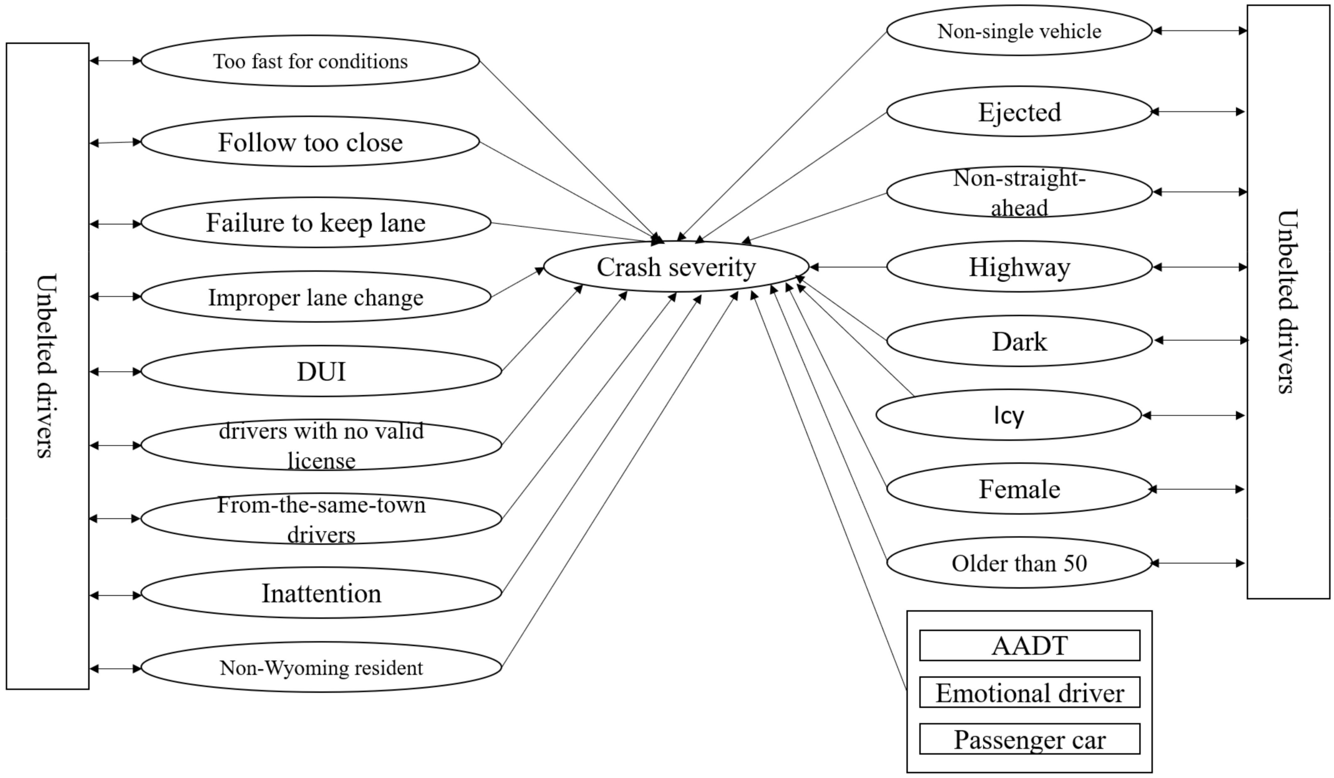

Figure 1. Complex relationship between seatbelt use and other predictors. The double arrows highlight the interactive variables with seatbelt use.

For instance, consider drunk drivers, where both interaction and main effects are positively impacting the severity of crashes. So, considering belted drivers, being belted drunk drivers, compared with belted sober drivers, increases the severity of crashes.

6. Discussion

WYDOT is responsible for collecting traffic safety data and implementing safety countermeasures in the state of Wyoming. Traffic safety stakeholders rely on WYDOT to provide reliable and accurate data so they will fulfill their strategic goals. However, a gap still exists between the expectations of stakeholders, especially due to a lack of deep understanding regarding the real impact of seatbelt use on the severity of crashes. Is the impact of seatbelt use on the severity of crashes stable or varied based on various predictors? or, is the impact of seatbelt use is different for female, versus male drivers? is the impact of seatbelt use is constant for drunk versus normal drivers?

Answering those questions is especially important as seatbelt use has an important impact on the safety of road users, and better understanding regarding its complex impacts will help to improve the road safety in a more efficient way.

To achieve the objectives, statistical analysis was conducted on the non-additive impact of seatbelt use on the severity of crashes. We challenged the non-multidimensionality assumption of seatbelt use on the severity of crashes. So, we considered the interaction terms across all factors and seatbelt use while modeling the severity of crashes. The results highlight the importance of seatbelt use in the reduction of ejected driver's crash severity, and more protection of male drivers compared to female. In summary, it was found that seatbelt use is mainly related to drivers' behaviors and psychology, and the identified results could expand the understanding of the importance of considering the interaction terms.

The lower effectiveness of seatbelt use for the so-called risky drivers with alcohol involvement, lack of drivers' license validity, having a citation record and inattention is concerning and calls for more investigation to better understand the underlying causes of those impacts. Those effects are especially important as the majority of past studies ignored their interactive relationship with seatbelt use. The reasons for the impacts could be due to many unseen factors that have not been recorded at the time of crash.

For instance, it is possible that in cases of buckled drivers being under the influence, or being distracted, the seatbelt is not properly set due to a possible reason of lack of attention, or those drivers are making so many unexpected actions that the seatbelt loses some of its effectiveness, compared to normal drivers.

Moreover, the reason for being buckled up for drunk drivers could be linked to a few reasons. The first reason could be linked to the risk homeostasis theory [10], stating that drivers try to alleviate their risky behaviors by taking precautionary actions. The second reason might be linked to the fact that those drivers try to draw attention away from getting caught by the highway patrol.

Educational programs could play an important role for the above risk-taking behavior to modify the perceived risk to the realistic risks so the more prudent behaviors could be expected. Policy makers, besides focusing on just buckling up, should equally emphasize risky driving behaviors as seatbelt use is expected to lose its effectiveness further for those behaviors. Driver training and mandatory classes for those drivers involved with risky behavior could help to alleviate their negative impacts.

In this paper, only two-term interaction terms were included for simplicity and applicability of result interpretations. It is very likely that considering more terms in the interaction terms, e.g., 3-term interaction terms, would be significant and important. However, those terms were not considered due to the complexity of interpretation of the 3 term interaction terms, especially the provision of that information for the WYDOT.

It is expected that seatbelt use is somehow cultural and thus varies across geographical regions. We highlighted that the western state of Wyoming has one of the lowest rates of seatbelts use in the country. Caution should be taken while generalizing the results to other areas with different characteristics, and more studies are needed to confirm our results. Caution also should be observed while interpreting the results of emotional and inattentive drivers. That is because those factors are transient states, and it might be challenging to be discerned by highway patrol after crashes.

7. Conclusions

Despite the efforts in the literature review in highlighting the importance of seatbelt use in the severity of crashes, the majority of past studies ignored the importance of inclusion of interaction terms of seatbelt use with other predictors. In other words, they assumed the impacts of seatbelt use on the severity of crashes are stable. The results of this paper highlighted the importance of accounting for the interaction terms of related variables in expanding the understanding regarding the complex nature of seatbelt use in reductions of crash severity.

Finally, it should be reiterated that solely using the seatbelt variable as a main effect could not provide adequate information for policy makers and the interaction terms across all important predictors and seatbelt status should be provided to offer more reliable and comprehensive information regarding the underlying impact of seatbelt use in various scenarios. Future studies should focus on the complexity of that relationship to confirm the obtained results and expand the complexity of relationships across other predictors.

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References

1. Elvik, R. How much do road accidents cost the national economy? *Accid. Anal. Prev.* **2000**, *32*, 849–851. [CrossRef]
2. Beck, L.F.; Downs, J.; Stevens, M.R.; Sauber-Schatz, E.K. Rural and urban differences in passenger-vehicle–occupant deaths and seat belt use among adults—United States, 2014. *MMWR Surveill. Summ.* **2017**, *66*, 1–13. [CrossRef] [PubMed]
3. Pickrell, T.M.; Li, H.R. Seat Belt Use in 2015—Overall Results. 2016. Available online: https://trid.trb.org/view/1398129 (accessed on 1 January 2020).
4. Moomen, M.; Rezapour, M.; Ksaibati, K. An investigation of influential factors of downgrade truck crashes: A logistic regression approach. *J. Traffic Transp. Eng.* **2019**, *6*, 185–195. [CrossRef]
5. Rezapour, M.; Ksaiabti, K. Factors Impacting the Choice of Seatbelt Use, Accounting for Complexity of Travelers' Behaviors. *Future Transp.* **2022**, *2*, 237–248. [CrossRef]
6. Noh, Y.; Yoon, Y. Elderly road collision injury outcomes associated with seat positions and seatbelt use in a rapidly aging society—A case study in South Korea. *PLoS ONE* **2017**, *12*, e0183043. [CrossRef] [PubMed]
7. Cummings, P.; Wells, J.D.; Rivara, F.P. Estimating seat belt effectiveness using matched-pair cohort methods. *Accid. Anal. Prev.* **2003**, *35*, 143–149. [CrossRef]
8. Adams, S.; Cotti, C.; Tefft, N. Seatbelt use among drunk drivers in different legislative settings. *Econ. Inq.* **2015**, *53*, 758–772. [CrossRef]
9. Crandall, C.S.; Olson, L.M.; Sklar, D.P. Mortality reduction with air bag and seat belt use in head-on passenger car collisions. *Am. J. Epidemiol.* **2001**, *153*, 219–224. [CrossRef] [PubMed]
10. Wilde, G.J. Risk homeostasis theory: An overview. *Inj. Prev.* **1998**, *4*, 89–91. [CrossRef] [PubMed]