Impact of helmet usage and other crash conditions on bicycling injuries and fatalities: Analysis and recommendations

Rony Islam | December 11, 2019

Abstract

The changing urban landscape in the United States of America, rising concerns for the environment, need for affordable housing and mobility, and many more factors have led to an increase in the number of cyclists and bicycle commuters in the United States. In 2017, nearly 48 million Americans, or 14.6 percent, cycled on a regular basis [1]. Unfortunately, as the number of cyclists has increased, so has the number of cycling-related deaths and injuries. The number of cyclist fatalities in 2018 was the highest since 1990, at 859 fatalities and in 2017, there were 329,477 nonfatal injuries [2]. A review of cycling safety literature quickly reveals a fixation on helmet usage when it comes to preventing injury for cyclists.

As manufacturers produce safer vehicles, cities improve roads, and drivers become more adept, traffic fatalities tend to decline. This phenomenon, known as Smeed's Law, only seems to hold up for people in motor vehicles and not for other road users, such as pedestrians and cyclists [3].

However, an examination of data from the National Highway Traffic Safety Administration (NHTSA) suggests that helmets do not statistically impact the chance of injury or fatality in a crash. Instead, factors such as speed limit, vehicle type, lighting conditions, involvement of alcohol, and road configuration contribute significantly to the injury severity and rate for cyclists. For example, although only 10% of crashes occurred on North Carolinian roadways where the speed limit was between 50-55 MPH, 43% of fatalities occurred there.

Recommendations and conclusions based on this analysis may also be applicable to safety for pedestrians and other Light Individual Transportation (LIT) users.

Data Sets

In a survey of available crash data involving pedestrians and cyclists, it becomes clear that police departments and government agencies do not have a standard for recording crash attributes. A car-centric perspective on crash data leads to a loss of information regarding attributes such as safety equipment and position of bike on the road. Inconsistency and lack of data makes it difficult to properly analyze certain data sets. For this reason, two different sets were analyzed in this paper.

North Carolina Department of Transportation Bike Crash Data

The North Carolina Department of Transportation (NCDOT) crash data set includes 11,266 datapoints for bicycle-involved crash from 2007-2018 [4]. The information is collected in hopes of helping road safety practitioners, partners, and the public understand prevalent crash and injury related factors. In turn, this understanding can help suggest a focus for potential treatment targets and road designs. This rich dataset lends itself to analysis regarding vehicle type, road configuration, speed limits, the environment, etc. However, data from NCDOT does not include information on safety equipment utilized by cyclists involved in the crash.

Although the North Carolina dataset is quite extensive and thorough, some critics claim that North Carolina's cities do not fit the profile of easily bikeable cities, with population densities far lower than cities with large numbers of bicycle commuters. For example, the densest city in North Carolina, Raleigh, is the 367th most dense city in the United States, according to the 2016 census [5]. However, this should not discount analysis or further biking infrastructure improvements since there are cities with some of the highest percentage of bike commuters with similar or even lower densities. For example, Madison, WI ranks 357th in density but 13th in share of bike commuters of any US city [6].

The National Highway Traffic Safety Administration Crash Report Sampling System

The National Highway Traffic Safety Administration (NHTSA) publishes an annual Crash Report Sampling System (CRSS) [7]. The 2017 edition includes 54,969 total crashes and 1,946 bicycle crashes. The CRSS obtains its data from a nationally representative probability sample selected from the more than seven million annual police-reported crashes. The CRSS is limited to police-reported crashes in order to highlight crashes of greatest concern to the highway safety community. This may lead to severe underreporting in cycling accidents that result in no property damage and minor injury. Although this dataset does not include as many datapoints as the NCDOT set, there is information on safety equipment, travel speed, etc.

Helmet Usage Analysis: Do helmets protect cyclists?

It is commonly accepted that wearing a helmet, much like other pieces of safety equipment, make cyclists safer. This is further emphasized by an immense effort by local, state, and federal agencies to increase helmet usage for children and adults. The NHTSA lists bicycle helmet laws as one of their top countermeasures to improve bicycle safety [8]. Most proponents of bicycle helmets cite the work, *Bicycle helmet efficacy: a meta-analysis*¸ a paper that analyzes various cycling injury studies from the late-1980s through the mid-1990s and found a great reduction in head, brain, and facial injury by wearing a helmet [9]. However, since the article was first published in 2001, the study has been re-analyzed to show that the analysis reported inflated estimates of the effects of bicycle helmets due to the influences of publication bias and time-trend bias [10].

Examining the NHTSA crash data gives insight into a possible connection between injury and helmet usage. Of the 2,005 individuals in a bike crash with known injury severity, 38% of cyclists were not wearing a helmet, 15% were, and 46% of helmet usage was not reported. The missing helmet data would have lent another 763 data points, another reason why crash data analysis could benefit from standardization of police reporting. While Figure 1 suggests that wearing a helmet may reduce the chance of collision or injury from occurring, caution is required not to jump to conclusions and interpret this association as causation. Further analysis will clarify this.

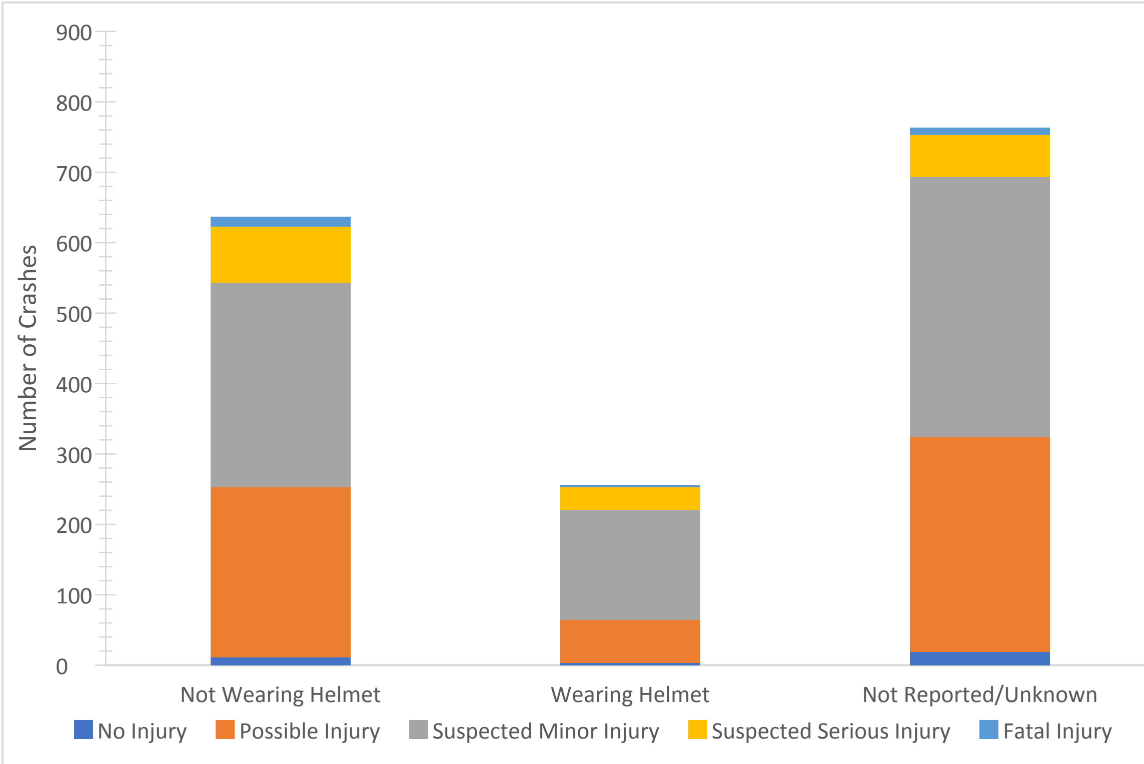

Figure 1. Breakdown of crashes by injury severity for helmet use cases.

Linear regression analysis was used to test if helmet usage significantly predicted severity of injury. The results of the regression indicated the predictor does not explain a significant portion of the variance, however still indicates a real relationship between helmet usage and severity of injury (R^2=.003, F(1,1215)=5.06, p=0.025). The use of helmets correlates to a higher severity of injury in case of a crash (β = .11, p<.01).

Logistic regression analysis was used to test if helmet usage significantly predicted the chance of an injury. The results of the regression indicated the predictor does not have a statistical significance (p=0.33). The lack of crashes where there were no injuries, 1.6% of crashes, does not allow for significant analysis on whether a helmet can help prevent an injury. The same limitation applies to analyzing fatalities, which comprises of only 1.9% of crashes in this set.

Although the statistical significance of helmet usage on chance of injury or fatality cannot be analyzed, the data does suggest that wearing a helmet is related to an increase in the severity of an injury due to a crash. This seems counterintuitive but helmets are only designed to protect against head injury, so it is possible that head injuries are not the primary cause of severe cycling injuries. In other words, even though helmets may reduce head injuries, cyclists involved in these crashes may suffer greatly from other types of injuries that helmets do not protect against.

Another interesting trend to look at is helmet usage, fatality rates, and number of cyclists in other countries with large number of cyclists. Figure 2 looks at percent trips completed by bicycle and helmet usage versus fatality rates [11].

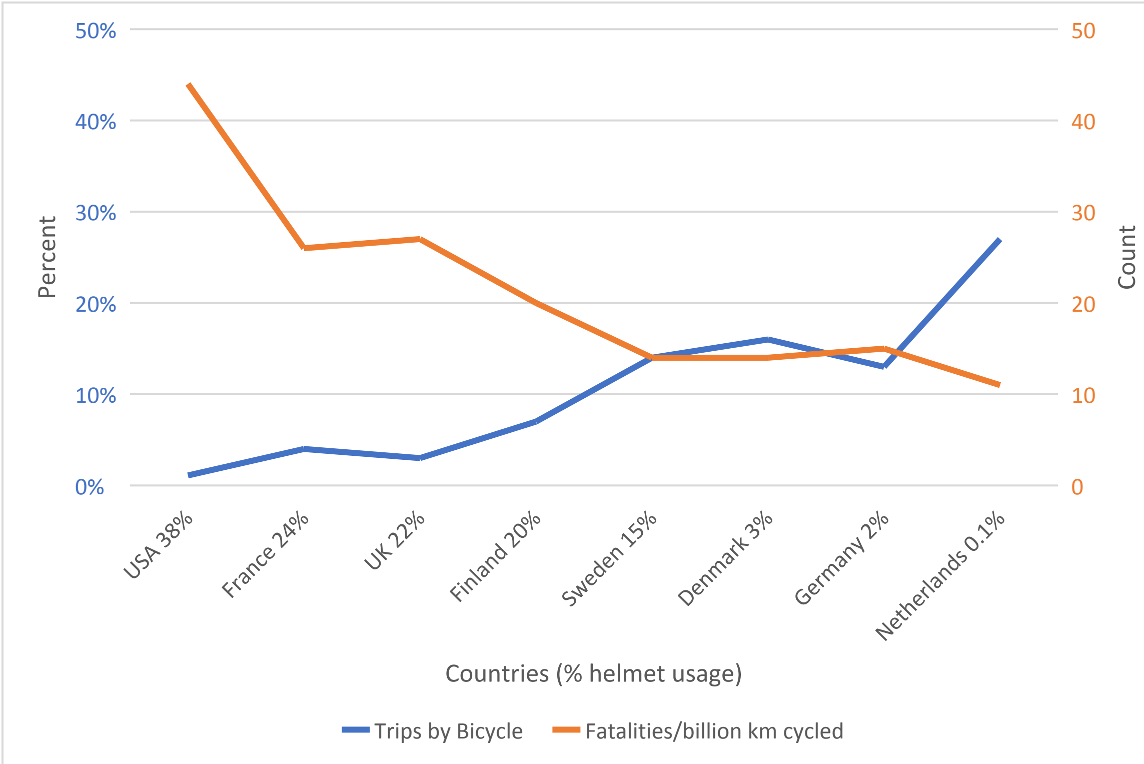

Figure 2. Trips by bicycle and fatalities by country.

There is a surprising association between lower helmet usage and lower fatality rates by country, which seems to contradict much of the literature found in the United States regarding cycling safety. However, there is also an association between percent trips by bicycle and fatality rates.

"Safety in Numbers"

The phenomenon that may explain this trend is known as "Safety in Numbers". This suggests that increasing the number of cyclists in itself is a safety measure that can lead to fewer crashes, injuries, and fatalities. Mandatory helmet laws could discourage cyclists from making trips and negatively impact Safety in Numbers.

If helmets are not shown to reduce the severity of injury, then more analysis must be done to understand the nature of cycling crashes in order to find ways to reduce the severity and number of injuries and fatalities.

Crash Conditions Analysis: What contributes to crash injuries/fatalities?

Since there is more variability in injury severity data when compared to looking at injury and fatality as binary/categorical, we will first investigate injury severity. Unsurprisingly, many conditions that impact severity of injury also impact the probability of an injury or fatality. Before analyzing the statistical significance of various conditions, it is important to understand where crashes are occurring on the road. This variable in the NCDOT data is referred to as the bicycle position. Figure 3 shows the breakdown of the number of crashes by bicycle position.

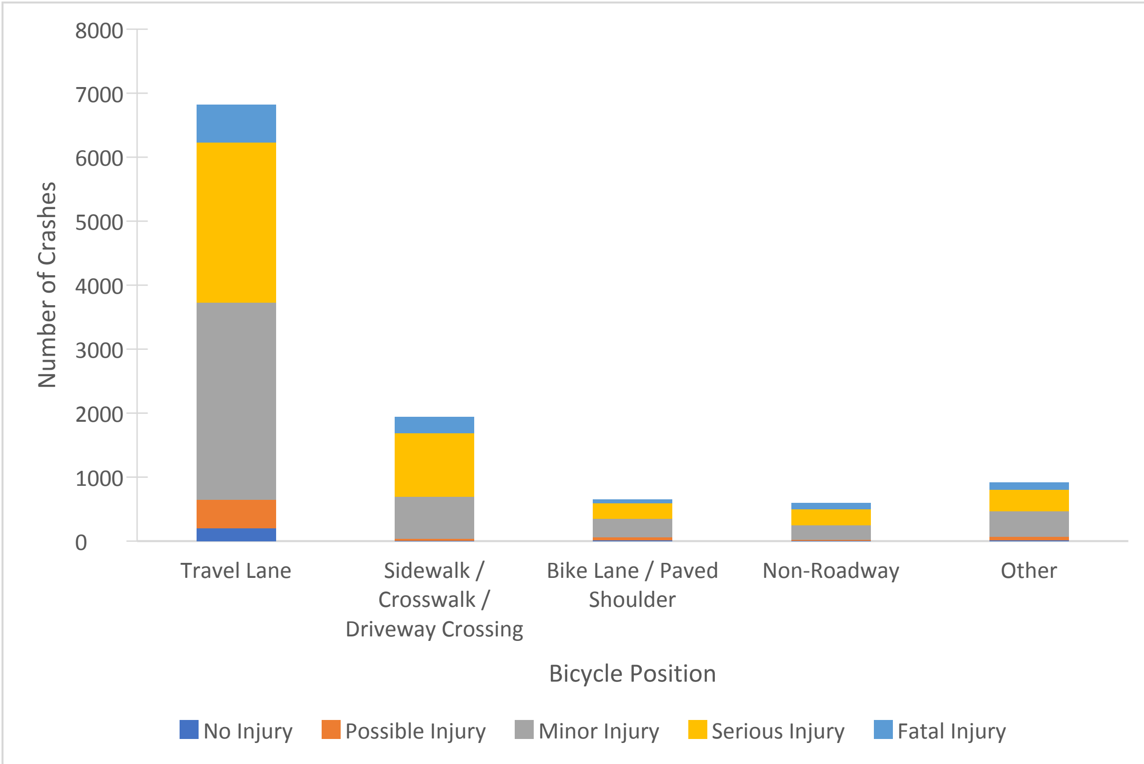

Figure 3. Breakdown of crashes by injury severity for bicycle positions.

This breakdown is important in understanding how to develop safer roads for pedestrians and bicyclists because it is apparent that improvements to travel lanes has the opportunity to minimize the most crashes. A quick survey of the crashes that take place in bike lanes and paved shoulders show that most bike lane crashes occur at the intersection with motor vehicle travel lanes.

Analysis on Injury Severity

Linear regression analysis was used to test if:

1. the type of crash,
2. bicycle position on the road,
3. speed limit,
4. vehicle type, and
5. involvement of alcohol

significantly predicted the severity of injury in the event of a crash.

Bicycle position and type of crash were found to be significantly collinear (VIF = 5.11). This suggests that the type of crash that may occur is related to where the bicycle is on the road. For example, a cyclist positioned in a travel lane is likely to be hit by a vehicle attempting to overtake it, not a vehicle driving out. Whereas, if a cyclist is hit by a vehicle driving out, this is likely to happen while they are in a crosswalk or driveway. Crash type had greater importance than bicycle position in this model and removing the bicycle position predictor did not significantly impact the results.

Base levels were manually chosen for categorical fields based on hypotheses or based on which term had the highest number of crashes. The base level selected for type of crash was “Motorist Drive In/Out”, for speed limit it was “5-15 MPH”, for vehicle type it was “Passenger Car” (highest number of crashes), and for involvement of alcohol it was “False”.

The results of the regression indicted that some values for **all four predictors were statistically significant** (R^2=.077, F(1,32)=29.39, p=0). Figure 4 and Table 1 show the significant coefficients and their characteristics.

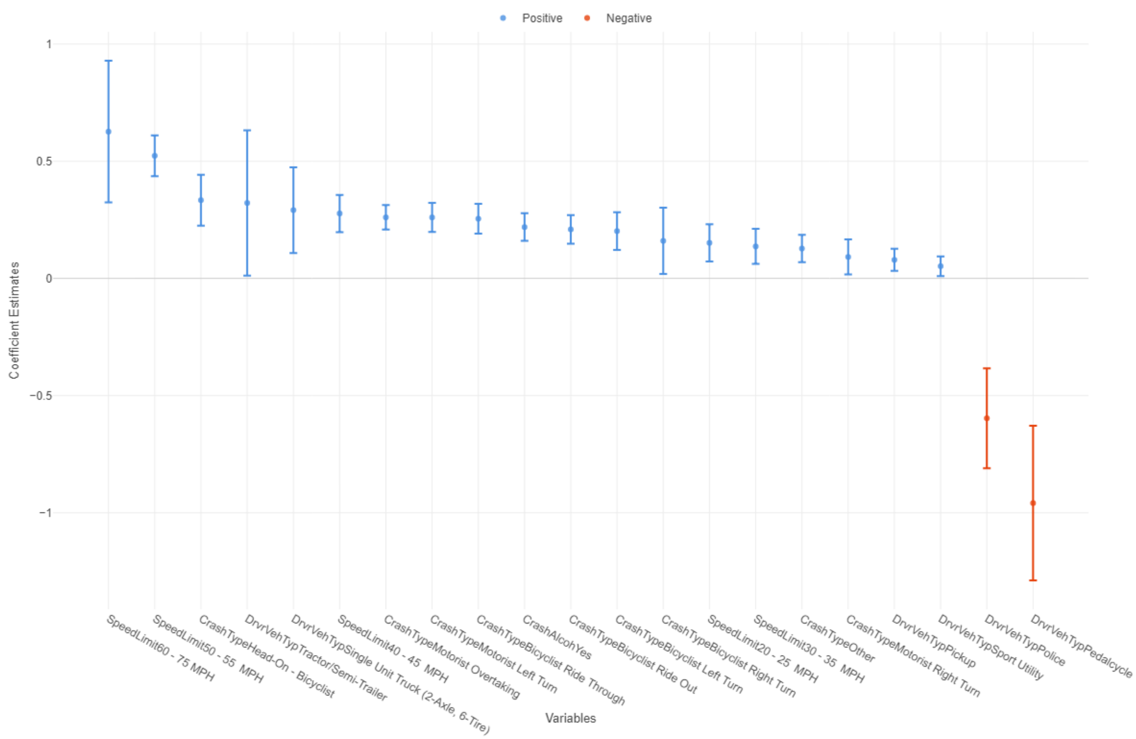

Figure 4. Significant coefficients for injury severity regression.

Table I. Significant coefficients for injury severity regression.

Predictor	Term	Coefficient	Std Error	t Ratio	P Value	Conf High	Conf Low	Base Level
-	(Intercept)	1.111	0.038	29.617	0.000	1.184	1.037	NA
Alcohol Involvement	True	0.219	0.030	7.274	0.000	0.278	0.160	False
Crash Type	Head-On - Bicyclist	0.334	0.055	6.017	0.000	0.443	0.225	Motorist Drive In/Out
Crash Type	Motorist Overtaking	0.261	0.027	9.778	0.000	0.313	0.208	Motorist Drive In/Out
Crash Type	Motorist Left Turn	0.260	0.032	8.257	0.000	0.322	0.199	Motorist Drive In/Out
Crash Type	Bicyclist Ride Through	0.255	0.032	7.867	0.000	0.318	0.191	Motorist Drive In/Out
Crash Type	Bicyclist Ride Out	0.209	0.031	6.743	0.000	0.270	0.148	Motorist Drive In/Out
Crash Type	Bicyclist Left Turn	0.202	0.041	4.941	0.000	0.282	0.122	Motorist Drive In/Out
Crash Type	Bicyclist Right Turn	0.160	0.072	2.215	0.027	0.302	0.018	Motorist Drive In/Out
Crash Type	Other	0.127	0.030	4.271	0.000	0.186	0.069	Motorist Drive In/Out
Crash Type	Motorist Right Turn	0.092	0.038	2.408	0.016	0.166	0.017	Motorist Drive In/Out
Driver Vehicle Type	Pedalcycle	-0.959	0.168	-5.699	0.000	-0.629	-1.288	Passenger Car
Driver Vehicle Type	Police	-0.597	0.109	-5.483	0.000	-0.383	-0.810	Passenger Car
Driver Vehicle Type	Tractor/Semi-Trailer	0.322	0.158	2.034	0.042	0.632	0.012	Passenger Car
Driver Vehicle Type	Single Unit Truck (2-Axle, 6-Tire)	0.291	0.093	3.120	0.002	0.474	0.108	Passenger Car
Driver Vehicle Type	Pickup	0.079	0.024	3.286	0.001	0.126	0.032	Passenger Car
Driver Vehicle Type	Sport Utility	0.052	0.022	2.415	0.016	0.094	0.010	Passenger Car
Speed Limit	60 - 75 MPH	0.626	0.154	4.058	0.000	0.929	0.324	5 - 15 MPH
Speed Limit	50 - 55 MPH	0.523	0.045	11.718	0.000	0.611	0.436	5 - 15 MPH
Speed Limit	40 - 45 MPH	0.277	0.041	6.838	0.000	0.357	0.198	5 - 15 MPH
Speed Limit	20 - 25 MPH	0.152	0.040	3.756	0.000	0.231	0.073	5 - 15 MPH
Speed Limit	30 - 35 MPH	0.137	0.038	3.576	0.000	0.211	0.062	5 - 15 MPH

The most important terms are shown in Figure 5. Further analysis will be done to show the impact of speed limits on injury severity.

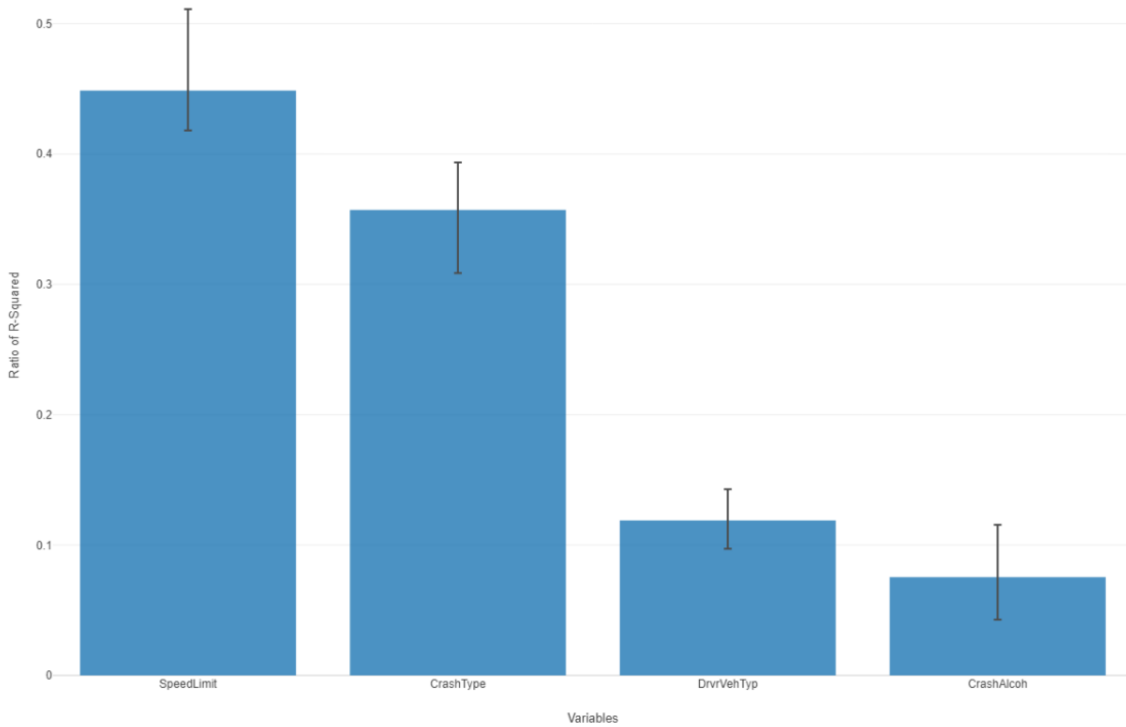

Figure 5. Importance of variables for injury severity regression.

Notable findings include:

- the speed limit is the most important variable when it comes to predicting the severity of injury;
- being struck by a police vehicle or bicycle reduces the likelihood of severe injury;
- trucks and large personal vehicles increase the likelihood of severe injury, suggesting that weight and size of a vehicle is incredibly significant;
- not only are crashes where motorists are overtaking bicyclists very common, they also significantly contribute to the severity of an injury;
- there is a large jump in the coefficient values (impact) for speed limits between 30-35 MPH and 50–75 MPH, suggesting that linear change in speed limit does not result in linear change in severity of possible injury.

The explanation for the large jump in coefficient values for the speed limits can also be visualized in Figure 6.

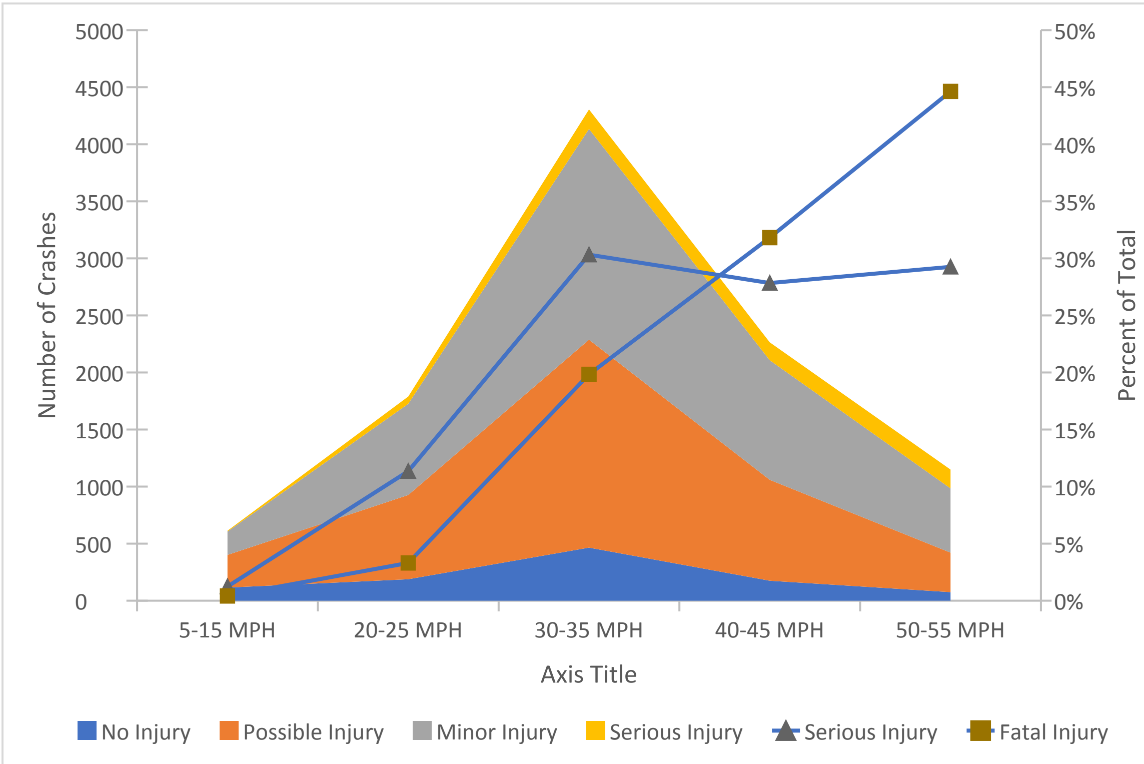

Figure 6. Breakdown of crashes by injury severity for speed limits.

A majority (over 62%) of the crashes that occurred on roadways with speed limit indications, occurred on roads with speed limits of 35 MPH or less. However, a larger portion of severe injuries occur on higher speed roads. Over 15% of bicyclists struck on roads with speed limits of 35 MPH and lower received fatal or serious injuries, but the proportions rose to 74% of those struck on 50-55 MPH roads.

Analysis on Probability of Injury

Logistic regression analysis was used to test if:

1. the type of crash,
2. speed limit,
3. vehicle type,
4. involvement of alcohol, and
5. light condition

significantly predicted the probability of injury in the event of a crash.

Base levels were manually chosen for categorical fields based on hypotheses or based on which term had the highest number of crashes. The base level selected for type of crash was "Motorist Drive In/Out", for speed limit it was "5-15 MPH", for vehicle type it was "Passenger Car" (highest number of crashes), for involvement of alcohol it was "False", and for light condition it was "Daylight".

The results of the regression indicted that some values for **all five predictors were statistically significant** (F1=.949, Accuracy=90.3%, p=0). Figure 7 and Table II show the significant coefficients and their characteristics.

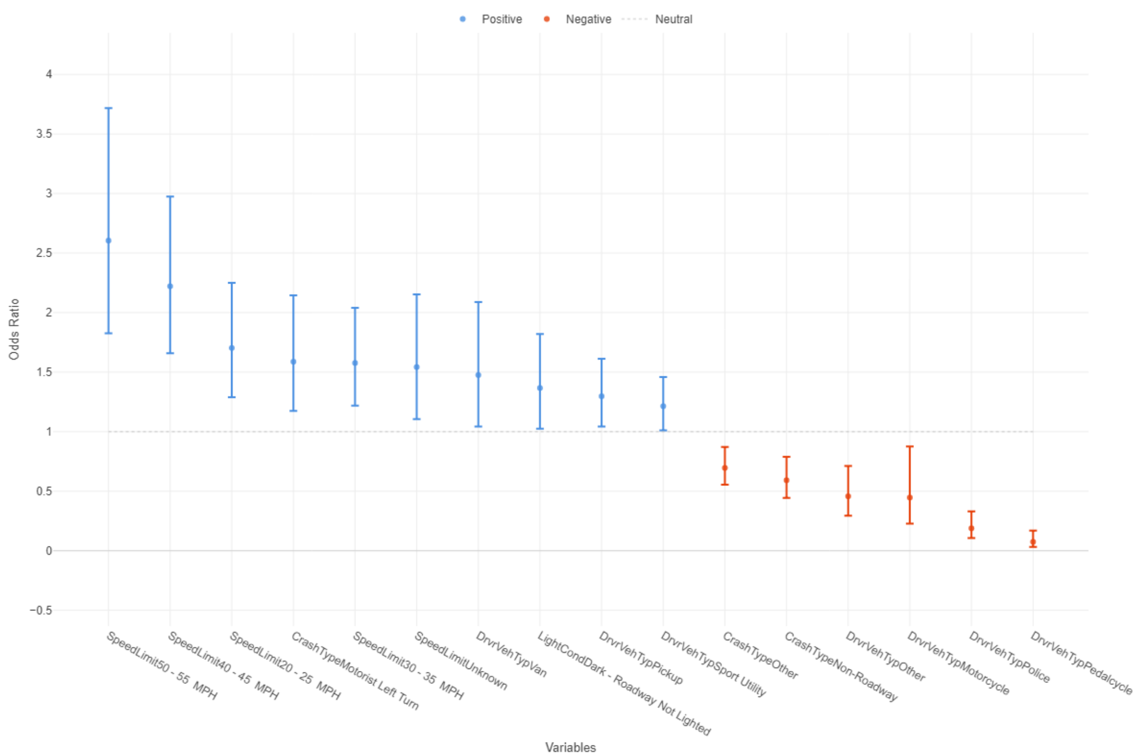

Figure 7. Significant coefficients for probability of injury regression.

Table II. Significant coefficients for probability of injury regression.

Variable	Term	Coefficient	Std Error	t Ratio	P Value	Conf High	Conf Low	Odds Ratio
-	(Intercept)	1.655	0.130	12.759	0.000	1.910	1.401	5.235
Crash Type	Non-Roadway	-0.523	0.146	-3.577	0.000	-0.237	-0.810	0.592
Crash Type	Motorist Left Turn	0.462	0.154	3.010	0.003	0.763	0.161	1.588
Crash Type	Other	-0.363	0.115	-3.144	0.002	-0.137	-0.589	0.696
Driver Vehicle Type	Pedalcycle	-2.592	0.418	-6.206	0.000	-1.773	-3.411	0.075
Driver Vehicle Type	Police	-1.668	0.288	-5.794	0.000	-1.104	-2.232	0.189
Driver Vehicle Type	Motorcycle	-0.806	0.343	-2.350	0.019	-0.134	-1.477	0.447
Driver Vehicle Type	Other	-0.782	0.226	-3.458	0.001	-0.339	-1.225	0.457
Driver Vehicle Type	Van	0.389	0.177	2.196	0.028	0.736	0.042	1.476
Driver Vehicle Type	Pickup	0.260	0.111	2.346	0.019	0.478	0.043	1.297
Driver Vehicle Type	Sport Utility	0.194	0.094	2.065	0.039	0.378	0.010	1.214
Light Condition	Dark - Roadway Not Lighted	0.312	0.146	2.135	0.033	0.599	0.026	1.367
Speed Limit	50 - 55 MPH	0.957	0.181	5.277	0.000	1.313	0.602	2.605
Speed Limit	40 - 45 MPH	0.798	0.149	5.358	0.000	1.090	0.506	2.221
Speed Limit	20 - 25 MPH	0.532	0.142	3.742	0.000	0.811	0.254	1.703
Speed Limit	30 - 35 MPH	0.456	0.132	3.464	0.001	0.713	0.198	1.577
Speed Limit	Unknown	0.433	0.170	2.547	0.011	0.767	0.100	1.543

Notable findings include:

- several of the same terms that made a significant impact on the severity of injury and trends also impact the probability of injury;
- the addition of lighting condition demonstrates the statistical significance of lighting conditions on probability of injury;
- a cyclist in a 20-25 MPH speed limit zone is nearly 2 times more likely to be injured than in a 5-15 MPH zone.

Analysis on Probability of Fatality

Logistic regression analysis was used to test if:

1. the type of crash,
2. speed limit,
3. vehicle type,
4. involvement of alcohol, and
5. light condition

significantly predicted the probability of fatality in the event of a crash.

Base levels were manually chosen for categorical fields based on hypotheses or based on which term had the highest number of crashes. The base level selected for type of crash was “Motorist Drive In/Out”, for speed limit it was “5-15 MPH”, for vehicle type it was “Passenger Car” (highest number of crashes), for involvement of alcohol it was “False”, and for light condition it was “Daylight”.

The results of the regression indicted that some values for **all five predictors were statistically significant** (F1=0.0079365079365, Accuracy=97.8%, p=0). Figure 8 and Table III show the significant coefficients and their characteristics.

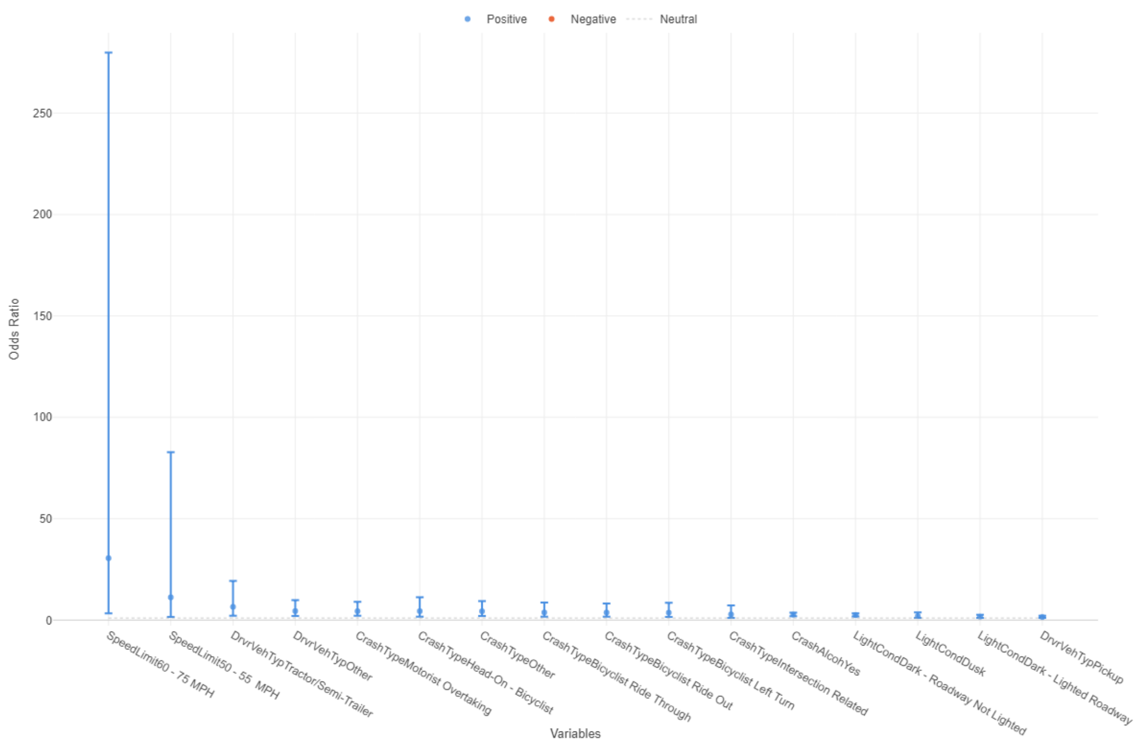

Figure 8. Significant coefficients for probability of fatality regression.

Table III. Significant coefficients for probability of fatality regression.

Variable	Term	Coefficient	Std Error	t Ratio	P Value	Conf High	Conf Low	Odds Ratio
-	(Intercept)	-6.917	1.035	-6.686	0.000	-4.890	-8.945	0.001
Alchol Involvement	True	0.983	0.167	5.886	0.000	1.310	0.656	2.673
Crash Type	Motorist Overtaking	1.486	0.361	4.114	0.000	2.194	0.778	4.420
Crash Type	Head-On - Bicyclist	1.486	0.478	3.106	0.002	2.423	0.548	4.418
Crash Type	Other	1.471	0.391	3.765	0.000	2.237	0.705	4.353
Crash Type	Bicyclist Ride Through	1.330	0.425	3.128	0.002	2.164	0.497	3.783
Crash Type	Bicyclist Ride Out	1.318	0.402	3.274	0.001	2.107	0.529	3.735
Crash Type	Bicyclist Left Turn	1.298	0.432	3.008	0.003	2.144	0.452	3.663
Crash Type	Intersection Related	1.040	0.480	2.165	0.030	1.981	0.098	2.828
Driver Vehicle Type	Tractor/Semi-Trailer	1.878	0.554	3.392	0.001	2.964	0.793	6.542
Driver Vehicle Type	Other	1.496	0.404	3.702	0.000	2.288	0.704	4.463
Driver Vehicle Type	Pickup	0.423	0.176	2.408	0.016	0.767	0.079	1.526
Light Condition	Dark - Roadway Not Lighted	0.891	0.169	5.271	0.000	1.223	0.560	2.439
Light Condition	Dusk	0.708	0.318	2.224	0.026	1.332	0.084	2.030
Light Condition	Dark - Lighted Roadway	0.540	0.223	2.423	0.015	0.976	0.103	1.715
Speed Limit	60 - 75 MPH	3.419	1.130	3.026	0.002	5.634	1.204	30.546
Speed Limit	50 - 55 MPH	2.419	1.019	2.375	0.018	4.416	0.422	11.236

Notable findings include:

- several of the same terms that made a significant impact on the severity of injury and probability of injury also impact the probability of fatality;
- tractor/trailers and pickup trucks are the only vehicle types that significantly contribute to probability of fatality;
- speed limit is the dominating factor for chance of fatality; a cyclist is 10 times more likely to be fatally injured in a 50-55 MPH zone than in a 20-25 MPH zone.

Analysis of crash conditions leading to higher severity of injury, increased probability of injury, and increased probability of fatality should aide safety practitioners, partners, and the public understand how to be safer on the roads. The regression suggests that instead of looking at helmet usage as a way of improving safety for cyclists, contributors in the safety value chain should look at road configuration and conditions to protect cyclists and pedestrians where they are most vulnerable, travel lanes. The next section discusses what road features and infrastructure developments can protect all road users.

Recommendations

As discussed in the analysis of helmet usage on injury, mandatory helmet laws and simple policy changes distract from what is significant in reducing the probability of crashes, injuries, and fatalities. Unfortunately, these policy changes and laws are what dominate the cyclist safety discussion in the United States.

The international-level analysis of fatality rates suggests that the priority of safety-focused development should be to increase the number of cyclists. Mandatory helmet laws and burdening cyclists with the responsibility of being the primary safety stakeholder discourages cyclists and is counterproductive. Instead, development should be focused on how to make cyclists feel safer while they are riding.

Statistical tests demonstrate the there are various road and crash conditions that impact the probability of injury and fatality as well as the severity of injury in the event of a crash. Thus, by changing the potential impact that those conditions have, cyclists can feel safer and encouraged to cycle. This can be done through Light Individual Transportation (LIT) focused infrastructure development. Unprotected bike-lanes and paved shoulders do not satisfy this requirement.

As previously discussed, lack of information on safety equipment and bicycle specific conditions make analysis of cycle crashes difficult. A car-centric perspective on crash data leads to a loss of information regarding attributes such as safety equipment and position of bike on the road. Police departments should expand the datapoints they report to various local, state, and federal agencies.

Based on the findings, the five recommendations that agencies should keep at the forefront of their safety campaigns and road development are:

1. Increase number of cyclists
2. End aggressive promotion of mandatory helmet usage laws
3. Reduce speed limit in cycling networks
4. Develop complete, better, and more LIT-focused infrastructure networks
5. Record bicycle related accidents with all relevant information

Recommendation 2-4 are also a non-exhaustive list of suggestions on how to increase the number of cyclists. Uncomfortable and unsafe conditions on the road are prohibitive for those who would otherwise be interested in cycling. In Atlanta, 70% of residents feel uncomfortable biking with traffic on the street and 65% of residents feel unsafe due to the **speed** of vehicles [12]. By providing safe spaces for pedestrians and cyclists, more people will feel comfortable using those resources.

Clearly, a concerted effort must be made to develop complete streets and protected lanes of travel for bicyclists and pedestrians. By separating motor vehicle traffic from bicyclists: the impact of vehicle type, speed limit, and light condition can be minimized. Given that motorists overtaking cyclists was one of the most common crash types, this can be totally avoided with protected and separated bike lanes. In general, urban development should improve overall density of cities to enable pedestrians and cyclists and encourage mobility.

In a study of 37 complete street projects, Smart Growth America found that those projects tended to improve safety for everyone, increased biking and walking, and had the ability to decreases motor vehicle traffic. These projects are also far more affordable when compared to conventional road and transit projects. The same study also found that the safer conditions created by complete street projects avoided a total of $18.1 million in collision and injury costs in one year alone [13].

Further, cities cannot simply develop unconnected and inadequate networks of cycling infrastructure, protected or not. Patchwork of streets make navigation and mobility difficult for cyclists, who are left to try to connect bits and pieces of cycling lanes with busy and unprotected streets. Gaps in cycling networks create connectivity issues that leave riders vulnerable and more likely to be struck by moving vehicles.

Car manufacturers are also critical players in making streets safer for all road users. Although motor vehicles have been getting significantly safer for occupants, they have not been improving as rapidly for pedestrian safety [14]. Manufacturers can change the design of front bumpers, such as by lowering them, to make them less dangerous for pedestrians. As autonomous vehicles become more prevalent in society, manufacturers should also consider how vehicles will interact with pedestrians and other road users, and protect those who are most vulnerable.

The quality of recording cycling crashes is important in analyzing what efforts work to minimize injuries and what does not. A car-centric perspective on crash data leads to a loss of information regarding attributes such as safety equipment and position of bike on the road. Inconsistency and lack of data makes it difficult to properly analyze crashes and police departments and state/federal agencies should collaborate on improving this.

Conclusion

The burden of safety while cycling should not lie on the most vulnerable of road users, pedestrians and cyclists. Although helmets may prevent acute head injury, cyclists suffer greatly from other types of injuries that are severe or fatal. Data from the National Highway Transportation Safety Administration demonstrates a lack of statistical significance between helmet usage and probability of injury in the event of a crash. On the contrary, helmet usage contributes to higher severity of injury.

Other countries, with lower helmet usage, have shown that they can achieve safer roads for cyclists. Having Safety in Numbers is a critical part of ensuring safer roads for all. Those in the safety value chain should keep in mind that policies and development should encourage more cyclists and keep them safe.

This paper demonstrates the factors that significantly impact chance and probability of injury or fatality include speed limit, lighting conditions, bike position on the road, vehicle type, and alcohol involvement.

Speed limit is the dominating factor for chance of fatality; a cyclist is 10 times more likely to be fatally injured in a 50-55 MPH zone than in a 20-25 MPH zone (OR=10.04, p=0); and a cyclist in a 20-25 MPH speed limit zone is nearly 2 times more likely to be injured than in a 5-15 MPH zone (OR=1.7, p=0).

Areas where bicyclists and motor vehicles interact, such as intersections of bicycle lanes and travel lanes and shoulder where motorists overtake cyclists, are especially dangerous. Motorists overtaking bicyclists (β=.261, p=0) is the second most dangerous crash type, after head-on collisions (β=.334, p=0), when it comes to impact on injury severity.

Larger and heavier vehicles, such as trucks, pickups, and SUVs, contribute to severity and chance of injury. A cyclist struck by a truck is nearly 7 more times to suffer from fatal injuries than if they were struck by a passenger vehicle (OR=6.542, p=0). And a cyclist struck by a van (OR=1.476, p=0), pickup (OR=1.297, p=0), or SUV (OR=1.214, p=0) is up to nearly 2 times more likely to be injured than if they were struck by a passenger vehicle.

Lastly, the involvement of alcohol is related to the increase of severity of injury in the event of a crash (β=.219, p=0).

Those in the safety value chain must attempt to increase the number of cyclists on roads by providing safer and more comfortable riding conditions. This can be done through a multitude of ways including: reducing speed limits, providing better lit roads, and mostly by creating networks of connected and protected travel lanes for pedestrians and cyclists.

Reengineering motor vehicles and roads clearly steps in making roads safer, however, there is a more fundamental culture shift that most also occur. The way residents and planners view cities need to change.

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