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A Simplified Method for Analyzing Factors Contributing to Motorcyclists' Fatal Injuries in Ohio

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Abstract

The aim of this paper was to analyze traffic crash data by using a simplified method in determining significant factors that increase the risk of a motorcyclist being fatally injured once involved in a motorcycle crash in Ohio. The concept of overrepresentation, which is similar to relative risk, was used in identifying significant variables associated with the elevated risk of a motorcycle crash resulting into a fatality. The overrepresentation factor (ORF) was calculated for each variable of interest. The ORF offers a simple but powerful procedure of determining whether a certain factor significantly occurs more or less frequently in one subset than in its complementary subset. The procedure involved determining the magnitude of the overrepresentation by computing the ORF values and determining whether or not the overrepresentation is statistically significant by computing the confidence intervals over ORF values at a 5% alpha level. The results show that being age 65 and over, riding while speeding, riding while under the influence of alcohol or drugs, riding without a helmet, riding at nighttime, being male, and being the operator were statistically significant motorcyclist-related characteristics that elevated the risk of being fatally injured. The significant roadway characteristics included crashes occurring on major roads, on horizontal curves (bends), on graded road segments, and on open roadway segments (non-intersections). Environment conditions such as dark with light or dark with no light and when the weather condition was cloudy had significant effects of increasing the chances of motorcyclists' fatal injuries once they get involved in traffic crashes. Moreover, crashes occurring on Saturdays pose significantly higher risks of fatalities when compared with other days of the week. In terms of crash type characteristics, a motorcyclist had elevated risks of being fatally injured when involved in single-vehicle crashes especially running off-the-road, crossing the median/centerline, and hitting a curb. Head-on and angle collisions in multivehicle crashes were significant causes of fatal injuries. The overrepresentation method was able to correctly identify similar fatal risk factors that were identified in previous studies that used more advanced and rigorous methods.

Keywords – overrepresentation factor, risk factor, relative risk, motorcycle rider, ,motorcycle operator

1. Background

A review of recent literature indicates that a number of statistical methods have been employed in analyzing factors affecting traffic crash-related injury severity. Examples include: Abdel-Aty et al. [1] used the log-linear models when investigating the relationship between driver age and crash factors; O'donnell and Connor [23] used the ordered logit and ordered probit models when predicting the severity of motor vehicle injuries; Shankar and Mannering [30] used the multinomial logit models when assessing factors affecting motorcycle injury severities; Eluru and Bhat [7] examined the factors affecting seat belt use and crash-related injury severity by using a joint binary logit-ordered logit structure; Milton et al. [19] used the mixed logit model when examining highway accident severities. The literature review reveals that ordered models (logit and probit) have been the most preferred modeling methods (e.g. [2, 11, 13, 23, 25]). Also, unordered models (multinomial and nested logit) have been highly used (e.g. [12, 29, 30, 32]). Alam and Spainhour [3] used a simplified statistical method based on relative risk (by use of overrepresentation factors) when studying the contributing factors for young at-fault drivers in fatal traffic crashes in Florida. The literature review reveal that varied statistical methodologies have been successfully utilized in the analysis of risk factors. Although most of the researchers have used more advanced models, a study by Alam and Spainhour [3] shows that simple but powerful statistical methods can achieve the intended results and conclusions.

Even the advanced models have their own limitations in terms of assumptions and provisions. According to Savolainen and Mannering [29] one potential problem with ordered probability models to injury severity levels is the underreporting of non-injury crashes, which may result in biased and inconsistent model coefficient estimates. Another problem with the ordered probability model is their restrictive nature of parallel lines (same slope) condition, which dictates that the location parameters are equivalent across the levels of the dependent variable [17]. This is a very restrictive condition that needs to be met in order to use these models [17, 26]. Most studies normally don't mention whether or not this very important restrictive condition was met.

Several studies have examined risk factors affecting fatal motorcycle crashes. Some of the notable studies include Shankar and Mannering [30], Quddus et al. [25], Clarke et al. [5], Chang and Yeh [4], Elliott et al. [6], and Savolainen and Mannering [29] whereby each of the studies used different sets of data and applied different statistical procedures as mentioned above.

Shankar and Mannering [30] found that alcohol-impaired riding, rider's age, speeding, helmeted-rider/fixed object interaction and no-helmet/alcohol-impaired riding interaction increased the likelihood of fatality. Quddus et al. [25] using motorcycle accident data in Singapore found that increased engine capacity, collisions with pedestrians and with fixed objects increased the probability of severe injuries. Savolainen and Mannering [29] found that horizontal curves, vertical curves, darkness, unsafe speed, alcohol use and non-helmet use led to more severe injuries. Mannering and Grodsky [18] when surveying motorcyclists' perceived likelihood of being involved in accidents found that exposure in miles ridden, regularly speeding, and overtaking on the shoulder or passing between lanes of traffic were the main factors. Preusser et al. [28] found that alcohol and excessive speed were main factors influencing motorcycle fatal crashes.

Overall, nationally, motorcycles are substantially overrepresented in fatal crashes. Motorcycle related fatalities have been on the rise in Ohio over a number of years. In Ohio, motorcycles account for just fewer than 3% of all registered motor vehicles but they account for more than 13% of all traffic fatal crashes. As for the year 2008 alone, the motorcycle fatalities constituted 15.0% of all motor vehicle fatalities in the state of Ohio. The Ohio Comprehensive Highway Safety Plan has estimated that 80% of motorcycle crashes result in injury or death as compared to only 20% of the passenger vehicle crashes [24]. For that reason, we aimed at studying factors contributing to the most severe injury type (i.e., fatal) to one of the most vulnerable road user (i.e., the motorcyclist). The objective of this paper was to analyze traffic crash data by using a simplified method in determining significant factors that increase the risk of a motorcyclist being fatally injured given that he/she was involved in a motorcycle crash in Ohio.

2. Methodology and data collection

2.1. Crash data

The data for this study were obtained from Ohio Department of Public Safety (ODPS). ODPS is the state agency mandated with analyzing, storage, and reporting of traffic crashes in the state of Ohio.

Crash data for five years from 2003 through 2007 were used in this study. Each crash is assigned with a severity level based on the existence of injuries sustained by people involved in the crash. For instance, if at least one fatality occurred due to a crash, it was then identified as a fatal crash and where there was no fatality, it was classified as a non-fatal crash. Records of all other types of units, other than motorcycles (e.g., cars, trucks, vans, etc.) that were involved in motorcycle crashes were further deleted from the dataset. Records with missing fields and unknown factors were deleted from the data set. The final data set contained 23727 records, with complete motorcycle crash information.

2.2. Analysis

Variables were grouped in terms of motorcyclist characteristics, roadway characteristics, environmental characteristics, and crash type characteristics. All motorcyclists involved in traffic crashes were grouped according to their injury severities, which were deduced into a binary form (i.e., fatally injured or not fatally injured).

The fatally injured formed a success outcome (case group) and non-fatally injured formed a failure outcome (control group) in line with the objectives of this study. The concept of overrepresentation, which is similar to relative risk, was used in identifying significant variables associated with elevated risk of a motorcycle crash resulting into a fatality. The overrepresentation factors (ORF) were calculated for all variables of interest. The ORF offers a simple but powerful procedure of determining whether a certain factor significantly occurs more or less frequently in one subset than in its complementary subset [3]. The procedure involves determining the degree or magnitude of the overrepresentation by computing the ORF values by using the relationship shown in Equation (1):

$$ORF = \frac{R_s}{R_c} = \frac{A/(A+C)}{B/(B+D)} \tag{1}$$

where:

R_s = proportion of positive (success) outcomes for the set of interest

R_c = proportion of positive outcomes for the complement (comparison) set

A = number of positive (success) outcomes for the set of interest

B = number of positive outcomes for the complement set

C = number of negative (failure) outcomes for the set of interest

D = number of negative outcomes for the complement set

For example, if we want to study whether male motorcyclists are overrepresented in fatal crashes compared to female counterparts, the variable gender is investigated and the set of interest is male motorcyclists and the female motorcyclists form a complement set.

The data show that out of the 19,824 male motorcyclists involved in traffic crashes in Ohio, 702 were fatally injured while 81 female motorcyclists were fatally injured out of 3,723 females involved in traffic accidents. The proportion of success in the set of interest is 702/19824 = 0.0354 and the proportion of success in the complement set is 81/3723 = 0.02176.

This means that male motorcyclists were overrepresented in fatal injuries with an ORF = 0.0354/0.02176 = 1.63 compared to female motorcyclists. This implies that an estimated fatal risk of a male motorcyclist is 163% of that of a female counterpart, or a male motorcyclist has a 63% higher risk of fatality than a female motorcyclist.

An ORF of one indicates that the success or desired event under study is equally likely in both groups. An ORF greater than one indicates that the successful event is more likely to occur in the group of interest than in the complement group and an ORF less than one indicates that the successful event is less likely in the group of interest. It is important to determine whether or not the overrepresentation is statistically significant by computing the confidence intervals (CI) over ORF values. The ORF values for each variable were summarized according to their significance performed by standard tests of proportions at 5% alpha level. The confidence intervals for ORF values were calculated by utilizing techniques used in relative risk factors by using a logarithmic transformation as shown in Equation (2) [9].

The standard error of the overrepresentation factor is also calculated by using the formula presented in Equation (3).

$$CI = EXP[\ln(ORF) \pm 1.96 \times SE(\ln(ORF))] \tag{2}$$

$$SE(\ln(ORF)) = \sqrt{\frac{C}{A(A+C)} + \frac{B}{B(B+D)}} \tag{3}$$

where:

CI = confidence intervals on ORF value (lower limit and upper limit)

SE(ln(ORF)) = standard error of the natural logarithm of ORF value

If both the confidence intervals for the ORF value are higher than 1.0, then the risk of fatality is higher in the group of interest than the complement group. Likewise, if both limits are lower than 1.0, then the risk of fatality is lower in the group of interest than the complement group. However, if the value of 1.0 is contained within the interval limits, then the results are inconclusive or unsure.

3. Results and discussion

The analysis of the characteristics of crash data can provide a general idea on motorcycle safety and its safety countermeasures. The final dataset with all required valid data fields had 783 motorcycle fatalities, which is equivalent to 98.4% of all 796 reported motorcycle fatalities in Ohio for the period 2003-2007 [22]. The purpose of this analysis was to get an understanding of the factors that increase the risk of motorcyclist being fatally injured given that he/she was involved in a motorcycle crash in Ohio by using a simplified but statistically significant procedure.

3.1. Motorcyclist driving errors

The estimated fatality risks related to motorcycle rider’s operating errors contributing to motorcycle fatalities were analyzed and are summarized in Table1. Exceeding speed limit is the most overrepresented driving error in fatal injuries followed by left center, i.e., crossing the centerline of undivided roadways.

Other driving errors with significant overrepresentation include unsafe speed, operating vehicle in negligence, and improper lane change.

Tab. 1 - Driver errors contributing to motorcycle fatal injuries

Contributing driver error	No. of people involved		ORF	Confidence interval		Rank
	Fatality	Non-fatality		Lower	Upper	
Failure to control	132	4959	0.742	0.617	0.893	Under
Unsafe speed	128	1594	2.497	2.080	2.999	Over
Improper lane change	65	1193	1.617	1.262	2.071	Over
Operating vehicle in negligence	63	756	2.447	1.910	3.136	Over
Followed too closely	30	1611	0.536	0.374	0.770	Under
Left of center	29	198	3.982	2.814	5.634	Over
Exceeded speed limit	15	98	4.082	2.535	6.572	Over
Ran red light/stop sign	12	200	1.726	0.992	3.004	Unsure
Driver inattention	9	350	0.757	0.396	1.448	Unsure
Failure to yield	7	371	0.557	0.267	1.165	Unsure
Swerving to avoid collision	7	572	0.361	0.172	0.756	Under
Operating defective vehicle	3	256	0.349	0.113	1.076	Unsure
Improper turn	3	134	0.662	0.216	2.032	Unsure
Other improper action	1	216	0.139	0.020	0.980	Under
Improper start from parked position	1	16	1.784	0.266	11.957	Unsure
Improper backing	0	11	0.000	N/A	N/A	N/A
Not available	278	10409	0.672	0.582	0.776	Under
Total	783	22944				

Failure to control the vehicle was highest on the list contributing 26.1% of all the motorcycle fatalities for which the crash causing errors were reported but it is not overrepresented as a cause of fatal injuries, followed with unsafe speed contributing 25.3% of all motorcycle fatalities. Improper lane change was third in the list contributing 12.9% of all motorcycle fatalities and operating vehicle in negligence manner was the fourth error causing 12.5% of all motorcycle fatalities.

Then, following another vehicle too closely was responsible for 5.9% of all motorcycle fatalities.

The results in Table 1 reveal that some of the less frequent driving errors happen to be more deadly than some of the more frequent crash causing errors and vice versa.

3.2. Motorcyclist related characteristics

Table 2 provides the estimated fatal risks related to motorcyclist characteristics. When examining the fatally injured motorcyclists by age groups, the older motorcyclists (65+ years' olds) are overrepresented in sustaining fatal injuries with a 152.5% fatality risk compared to other age groups.

The higher death rates of older drivers have been found mainly to be due to their fragility, which starts to be more apparent starting at age 60, i.e., they die in some of the crashes that younger people would have survived [8, 10, 15].

Riding under the influences of alcohol and drugs pose the two highest fatal risk factors of 668% and 488%, respectively as compared to a sober motorcyclist when involved in traffic crashes.

Alcohol and drug use have been mentioned in a number of previous studies as two notable factors that increase the risk of a motorcyclist being fatally injured (e.g. [5, 14, 28-30]).

Tab. 2 - Motorcyclist characteristics contributing to fatal injuries

Motorcyclist characteristics		No. of people involved		ORF	Confidence limits		Rank
		Fatality	Non-fatality		Lower	Upper	
Age group	Young (<25)	161	4709	0.995	0.839	1.180	Unsure
	Middle (25-64)	595	17588	0.942	0.802	1.106	Unsure
	Old (65+)	27	513	1.525	1.049	2.217	Over
Person type	Rider	721	20165	1.582	1.224	2.044	Over
	Passenger	62	2779	0.632	0.489	0.817	Under
Gender	Male	702	19122	1.628	1.297	2.043	Over
	Female	81	3642	0.614	0.489	0.771	Under
Alcohol involved	Yes	354	2254	6.682	5.840	7.646	Over
	No	429	20690	0.150	0.131	0.171	Under
Speeding involved	Yes	253	3925	2.234	1.930	2.585	Over
	No	530	19019	0.448	0.387	0.518	Under
Drug involved	Yes	49	271	4.883	3.738	6.380	Over
	No	734	22673	0.205	0.157	0.268	Under
Helmet use	Yes	215	8738	0.625	0.535	0.729	Under
	No	568	14206	1.601	1.371	1.869	Over

Unsafe speed (speeding) was another factor being highly overrepresented with a 223.4% fatality risk compared to non-speeding motorcyclists. This finding is consistent with a number of earlier studies (e.g. [5, 14, 18, 20, 28-31]).

Riding without wearing a helmet was also overrepresented with a 160% fatality risk compared with those wearing a helmet. This finding is supported by several other studies, which have consistently reported the effects of helmet use in reducing motorcyclists' fatalities (e.g. [4, 14, 16, 21, 27, 29, 33]).

In addition, the current study has found that a motorcycle operator has an elevated risk of fatal injuries when compared to a motorcycle passenger.

This may be due to positioning on a motorcycle, with the operator being in the front seat and the passenger being behind. The operator is likely to be the first one to experience the full impact of the collision (especially in multivehicle crashes and in cases of hitting fixed objects). In our literature search we did not find a study that analyzed the effect of the type of motorcycle occupants on risk of fatality in traffic crashes.

3.3. Roadway related characteristics

The estimated fatal risks related to roadway characteristics are shown in Table 3. The results show that the roadway alignment plays a significant role in determining whether or not a motorcyclist's crash will result into fatal injuries. Graded and curved sections are overrepresented in causing fatal injuries.

Combinations of level/curves and curves/grades increase the chances of fatal risks of motorcyclists. The study by Savolainen and Mannering [29] also agree that horizontal and vertical curves play part in raising the occurrence of motorcyclist severe injuries. Moreover, major roads pose a significantly higher fatal risk to motorcyclists than local roads. This can be contributed by higher speeds and traffic volumes on major roads compared with local roads.

Furthermore, motorcycle crashes occurring on open roadways are overrepresented in causing fatal injuries when compared with those occurring on intersections.

Tab. 3 - Roadway characteristics contributing to fatal injuries

Roadway characteristics	No. involved		ORF	Confidence limits		Rank
	Fatality	Other		Lower	Upper	
Roadway alignment						
Level	490	16319	0.782	0.704	0.869	Under
Graded	293	5733	1.514	1.338	1.714	Over
Straight	483	16961	0.722	0.649	0.802	Under
Curved	300	5091	1.771	1.566	2.001	Over
Roadway alignment combination						
Straight & level	353	14168	0.514	0.448	0.591	Under
Straight & graded	130	3276	1.181	0.982	1.421	Unsure
Curved & level	137	2641	1.591	1.329	1.905	Over
Curved & graded	163	2750	1.869	1.580	2.211	Over
Roadway type						
Local road	284	10498	0.624	0.541	0.721	Under
Major roads	487	11058	1.601	1.387	1.849	Over
Work zone related						
Yes	11	389	0.812	0.451	1.460	Unsure
No	772	22017	1.232	0.685	2.215	Unsure
Location						
Intersection	287	9990	0.752	0.652	0.867	Under
Non intersection	495	12830	1.330	1.153	1.535	Over

Although motorcyclists crashing in non-work zone areas have higher fatality rates than those occurring in work zone-related areas, however, the differences are not statistically significantly different due to generally small data of fatal injuries available that occurred in work zone areas.

3.4. Environmental related characteristics

The results of the effects of the environmental characteristics on the risk of fatal injuries are summarized in Table 4.

The motorcycle crashes occurring at nighttime are overrepresented in fatal injuries as it is estimated that nighttime crashes are 64.9% more likely to result into fatal injuries when compared with the daytime crashes. In terms of light condition, dark surrounds with either light or with no light, seem to be overrepresented in contributing to motorcycle fatal injuries. It was estimated that when the surrounding environment is dark with light, the risk of a crash being fatal increases by 43.1% and when it is dark with no light, it increases by 82.6%. Savolainen and Mannering [29] also found that darkness led to more motorcyclist severe injuries.

The effect of weather condition to the likelihood of a motorcyclist being fatally injured needs to be analyzed carefully because motorcycles are normally rarely used during adverse weather conditions such as during snow, heavy rain, etc.

This makes data for some bad weather conditions such as snow, fog/smoke, sleet/hail, and severe winds to be very low and thus difficult to make reliable statistical conclusions. In the period 2003-2007, 578 (73.8%) motorcycle fatalities occurred during good weather conditions, 179 (22.9%) when it was cloudy, 13 (1.7%) when it was raining, 6 (0.8%) when there was fog/smoke/smog, and severe crosswinds contributed 1 (0.1%) death.

Tab. 4 - Environmental characteristics contributing to fatal injuries

Environmental variable	Number involved		ORF	Confidence limits		Rank
	Fatality	Non-fatality		Lower	Upper	
Time of crash						
Daytime	495	17045	0.606	0.526	0.699	Under
Nighttime	288	5899	1.649	1.431	1.902	Over
Light condition						
Day Light	473	16125	0.655	0.569	0.754	Under
Dawn / Dusk	33	1035	0.934	0.662	1.316	Unsure
Dark Lighted	130	2767	1.431	1.191	1.721	Over
Dark no light	139	2369	1.826	1.527	2.183	Over
Unknown	8	648	0.363	0.182	0.725	Under
Weather condition						
Good	578	18010	0.780	0.667	0.911	Under
Cloudy	179	4057	1.364	1.158	1.606	Over
fog/smoke/smog	6	96	1.789	0.820	3.899	Unsure
Rain	13	594	0.643	0.374	1.106	Unsure
Sleet/Hail	0	4	0.000	N/A	N/A	N/A
Snow	0	12	0.000	N/A	N/A	N/A
Severe Crosswinds	1	13	2.166	0.327	14.337	Unsure
Unknown	6	158	1.109	0.504	2.441	Unsure
Day of the week						
Sunday	160	4689	1.000	0.843	1.186	Unsure
Monday	89	2600	1.003	0.808	1.246	Unsure
Tuesday	70	2439	0.830	0.652	1.058	Unsure
Wednesday	93	2689	1.015	0.820	1.255	Unsure
Thursday	86	2584	0.973	0.781	1.213	Unsure
Friday	96	3076	0.906	0.734	1.117	Unsure
Saturday	189	4867	1.175	1.001	1.380	Over
Season of the year						
Winter	27	1062	0.742424	0.508	1.085	Unsure
Spring	290	8446	1.009413	0.875	1.164	Unsure
Summer	373	10593	1.058672	0.922	1.215	Unsure
Fall	93	2843	0.95445	0.771	1.181	Unsure

Table 4 shows that only cloudy weather can reliably be concluded to be overrepresented by increasing the risk of fatal injuries by about 36.4%.

Although severe winds and smog/smoke conditions happen to increase the risk by 216.6% and 78.9%, respectively, however, their conclusions are not reliable due to their very low samples. As expected, most motorcycle crashes occurred when the weather was good but the proportion of deaths to survivors makes this weather condition not to be statistically overrepresented.

For the day of the week, Saturday is the only day that seems to be overrepresented in contributing to fatal injuries by increasing the fatal risks by about 17.5%. When analyzed in terms the season of the year when the motorcycle crashes occurred, i.e., winter, spring, summer, or fall, the data show that there is no significant difference.

Tab. 5 - Crash type characteristics contributing to fatal injuries

Crash type	No. involved		ORF	Confidence limits		Rank
	Fatality	Non-fatality		Min CI	Max CI	
Collision type						
Multi-vehicle	319	11594	0.681	0.592	0.784	Under
Single-vehicle	459	11217	1.468	1.276	1.690	Over
Collision involving multiple vehicles in transport						
Rear-end	65	3668	0.438	0.336	0.571	Under
Head-on	70	663	3.376	2.633	4.329	Over
Rear-to-rear	3	34	2.504	0.842	7.443	Unsure
Angle	216	5317	1.468	1.201	1.794	Over
Backing	0	265	0.000	N/A	N/A	N/A
Sideswipe	23	1263	0.520	0.343	0.790	Under
Collision involving a single vehicle in transport						
Overturn/rollover	62	2336	0.593	0.455	0.772	Under
Run off road	242	4264	1.731	1.447	2.071	Over
Cross median/centerline	60	667	2.228	1.717	2.892	Over
Other non-collision	18	1275	0.322	0.202	0.514	Under
Animal	30	1181	0.594	0.412	0.856	Under
Pedestrian/bicycle	2	101	0.484	0.122	1.916	Unsure
Parked motor vehicle	2	224	0.218	0.055	0.870	Under
Road furniture	7	99	1.665	0.809	3.425	Unsure
Curb	29	363	1.911	1.330	2.746	Over
Fixed objects	7	531	0.316	0.150	0.662	Under

3.5. Crash related characteristics

The results of crash related characteristics are presented in Table 5. Motorcyclists involved in single-vehicle crashes have an elevated fatal injury risk compared with those involved in multivehicle crashes.

The results show that single-vehicle crashes are generally overrepresented in motorcycle fatal injuries by increasing the fatal risk by about 46.8% when compared with multi-vehicle crashes. Some studies have reported a strong association between single-vehicle crashes and speeding [34].

However, when multivehicle crashes are analyzed separately, some types of multivehicle crashes seem to be more dangerous to motorcyclists than others.

Specifically, the head-on and angle crashes are overrepresented in fatal injuries as estimated to increase the fatal risk by about 337.6% and 46.8%, respectively when compared with other multivehicle crashes.

The rear-to-rear collisions are overrepresented by increasing the fatal risk by 250.4% but this result is inconclusive due to the very small sample involved.

The single-vehicle collisions were overrepresented in fatal injuries include running off-the-road, crossing median/centerline, hitting road furniture and hitting curbs as shown in Table 5. The action of crossing median/centerline, which poses the highest risk when compared with all other listed single-vehicle collisions by increasing the risk by 222.8%, may possibly end up in a collision with opposite side on-coming vehicles as a secondary multivehicle collision.

3.6. General remarks

The foregoing discussion reveal that a simple but statistically powerful procedure presented in this study has the ability of identifying risk factors akin to those identified by using other more sophisticated and rigorous methods. The overrepresentation analysis does not require special statistical software to run the models. The analyst just requires Equations (1) through (3) as specified in the Methodology Section, which are easily implemented in Microsoft Excel spreadsheets. Therefore, the statistical knowledge level required to implement the analysis is minimal. The risk factors identified in this study have also been previously well-known from various studies, which signifies that the overrepresentation method was able to produce equivalent conclusions as previous done by more powerful and rigorous methods. It is our opinion that this simple method will be attractive to practitioners who need quick, easy but still reliable results when determining risk factors for countermeasures based on traffic crash data they have at hand.

While most of the risk factors identified in this study have been known for both motorcyclists and motor vehicle fatal crashes, it is the identification of a motorcycle rider (operator) being at higher risk than the motorcycle passenger that was new to this study. In our literature review, we did not find a study that looked into this factor. Therefore, the positioning of the two motorcyclists, that is, rider and passenger on the motorcycle may play a role in risk level between the two.

4. Conclusions

The findings in this study demonstrate that several risk factors are associated with the risk of a motorcyclist being fatally injured when involved in a traffic crash. The overrepresentation analysis showed that there are higher risks of a motorcycle crash resulting in a fatality when alcohol/drugs or excessive speeding are involved. This study also shows that the risks of being fatally injured when not wearing a motorcycle helmet are significantly higher than when a helmet is used. Older motorcyclists, age 65 and above, have a higher risk of dying in a traffic crash. Motorcycle crashes occurring at non-intersection locations (open roadway) and single-vehicle crashes pose elevated risks of fatal injuries (most likely due to speeding) compared to intersection locations and multi-vehicle crashes. Additionally, motorcycle crashes occurring on horizontal bends, graded segments, and on major highways have an elevated risk of resulting into fatal injuries. A motorcyclist who is either the operator or a male has an increased risk of fatal injuries when involved in a crash. Other factors increasing the motorcyclist’s fatal risks include riding on major roads, and riding at nighttime especially when the surrounding environment is dark with light or no light. The overrepresentation analysis has shown that although it is a simple method, but yet it is a powerful tool that can correctly specify risk factors like any other powerful and rigorous methods provided by commercial statistical packages. Like any other statistical methods, the overrepresentation analysis method also requires a large sample of data in order to draw reliable statistically significant conclusions.

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