

# Pedestrian and Bike Rider Crashes on National Highway: A Unique Case of Pakistan

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**Abstract:** - The collisions between bike riders and pedestrians are a severe problem in Pakistan as well as other countries of the world. Most of the research efforts in this regard focus on urban areas. However, these crashes could be much severe on national highways, which can happen in countries like Pakistan with lack of obstructions and facilities for crossing. This study aims to find the factors resulting in pedestrian and bike-rider injury and fatality crashes and to suggest effective strategies to mitigate them. The collision data including bike riders and pedestrians is collected from police stations located on the national highway of Pakistan N-80 from Jand to Kohat city of Pakistan. The total number of crashes involving pedestrian or Bike were 151, which were reported from Feb 2021-Feb 2022. This was found to be a high occurrence involving a lot of severe crashes, which is comparable to large urban areas in Pakistan in spite of only including the crashes reported to police. Analysis of Variance (ANOVA), logit models and statistical distribution tests were applied for analysis of the data. Results show that 78.14% of the available crashes occurred due to over speeding. Other reasons included overtaking, carelessness and driving in the wrong way. Parametric tests show that crashes involving bike and vehicles, during afternoon and evening times and due to over-speeding are significantly higher than other crashes. The logit model, developed for these crashes, shows that overtaking is the single most significant factor in causing fatal crashes involving pedestrians and bikes.

**Key-Words:** - Pakistan, crashes, pedestrians, bike riders, over speeding

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## 1 Introduction

Motorbike (referred to with their shortform bikes from henceforth) is an important mode of transport

in Pakistan. They are often allowed to operate in mixed traffic without any exclusive lanes or crossings. They are often used by 2 people or more family members including kids which sit in front of

the drivers. The important safety regulation enacted in Pakistan is the wearing of helmets from the riders. However, only drivers show any compliance to this rule and the use of helmet by pillion riders is overlooked by the riders and the authorities. Although, it offers an effective way to reduce car pollution, and traffic congestion, however, there are few disadvantages associated with the use of these bikes. One of them is the higher proportion of bikes in road crashes compared to the other modes of transportation, invariably resulting in higher severity of crashes [1].

Similar to bikes, pedestrians have also become a safety concern all around the world and there is greater emphasis being put in to detecting their presence in traffic incidents [2]. Pedestrian crashes may occur due to negligent behaviour of the pedestrians, and poor interaction between drivers and pedestrians. One of the common examples of such behaviour is the selection of crossing locations for the roads which is done on the basis of convenience and ease rather than potential safety implications [3, 4].

In the year 2015, out of all the crashes reported in the city of Lahore, 25% fatalities involved pedestrians. Similarly, almost 45,000 crashes were recorded in the city in 2016. 70 percent of the victims in such crashes were left unstable; 55 percent of the victims were bikers, bicycles, and pedestrians; 25 percent had been caused by over speeding; and 10 percent were minors and distracted drivers. The disproportionate number of pedestrian deaths, according to city traffic police, might be related to the unsafe walking habits of pedestrians, especially during busy junctions [5].

According to Minhas et al. [6], there were 16,000 traffic accidents in Karachi between January to June of 2012. Motorcycle riders and pilferers, or those who travel as passengers in the backseat of bikes, comprised about 63% of the injuries, and 47% of injuries were fatal. There were a lot of women riding as pillion riders. Pakistani women have historically covered their heads and upper bodies with a long, dangling dupatta. This dupatta has a very high incidence of getting trapped in the driving chain and rear wheel of the motorbikes when they sit with both legs on one side which is seen only in this part of the world. Approximately 986 of the 9,915 traffic crashes in Karachi between January 2007 and December 2009 were related to clothing, and 73.9% of the victims were female [6].

It is found from the previous literature that the studies related to bike and pedestrian crashes have focused more on urban areas. However, there is a lack of obstruction, and facilities provided on

national highways in Pakistan which can regularize the movement of bikes and pedestrians on and across these highways. This allows unrestricted movement on bikes and pedestrians on these highways which should be considered more critical than urban areas due to the higher speed of vehicles. Considering these facts, this study aims to find the main cause of the pedestrian and bike rider crashes in which these road user groups are involved. The analysis of this study resulted in highlighting features which could be unique to the case of involvement of bikes and pedestrians in crashes on national highways. Moreover, the study also provides suggestions to devise and implement effective strategies in reducing the crashes involving these vulnerable road users which is expected to help the authorities and researchers.

## 2 Methodology

The crash data was collected for the period of February 2021 to February 2022, from the Police Stations in the form of FIR (First Information Report). There were 151 crashes reported during this period on N-80 in the police stations for Tehsil Jand and Kohat, which involved bikes and pedestrians. This is an alarm number considering the fact that the police reported crashes in Pakistan only represent a minor proportion of the actual number of crashes [7]. Moreover, the number of fatalities in these crashes are comparable to mega cities, such as Karachi [8]. These points demand due consideration to be given to crashes of vulnerable road users on National highways in Pakistan.

From the police reports, the data was converted in tabular form for analysis. To analyse the data, Analysis of Variance (ANOVA) and Logit Model were applied. ANOVA compares the mean of two or more independent groups to determine whether there is statistical evidence that the associated population means are significantly different from each other.

On the other hand, logit model is used to calculate the likelihood of a specific event to happen or choice to be taken because of certain values or categories of appropriate parameters [9]. The likelihood is calculated by applying the logit function on the multivariate utility function of the event or choice. The utility function is developed using the maximum likelihood approach [10]. The use of logit model was decided due to the binary nature of predicted outcome (fatal crash), and ease of interpretation.

The road section considered in this study is National Highway N80. The National Highway 80, often known as the N-80, is a national highway in

Pakistan that travels via Fateh Jang and Jand from the capital city of Islamabad to the city of Kohat in the province of Khyber Pakhtunkhwa. Its 146 km overall length is split into 38 km in Khyber Pakhtunkhwa Province and 108 km in Punjab Province [11].

The data was collected from the police records of two cities, namely Jand and Kohat. Kohat has a population of over 220,000 people and is the fourth largest city in Khyber Pakhtunkhwa province. Tehsil Jand has a population of 295,513 distributed among 82 villages. Fig. 1 shows the location of the highway and the cities chosen for the study.

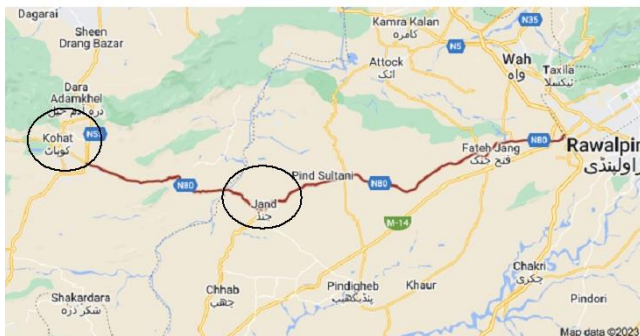


Fig. 1. Study Area

### 3 Data Description & Analysis

The data included several factors namely location, time of the day, month, causality, severity, crashes including motorcycle riders and pedestrians. All parameters were extracted from the police reports of the crashes. As mentioned earlier, data analysis techniques of ANOVA and logit models were applied on these factors to further investigate the significant effects of these factors. These are explained in detail in the following section.

#### 3.1 Time of the Day Analysis

To investigate the effect of natural light on crashes, the data was organised in a way so that the number of crashes can be associated with the time of the day. Crashes occurring during 06 AM to 06 PM are considered as day whereas crashes occurring during 06 PM to 06 AM are considered as night crashes. The division of these times was done as per the observations of sunrise and sunset times in the study areas which is shown in Fig. 2. It was found that 16.56% crashes occurred during night and 83.44% occurred during day. This implies that the probability of crash occurrence during day is more than during the night. In this context, Chen et al. [12] have stated that the traffic flow itself changes in a non-linear and periodic manner, which could affect traffic crashes. The higher frequency of the

crashes in daytime could be linked to higher exposure in peak traffic hours, which has been found in other studies [13].

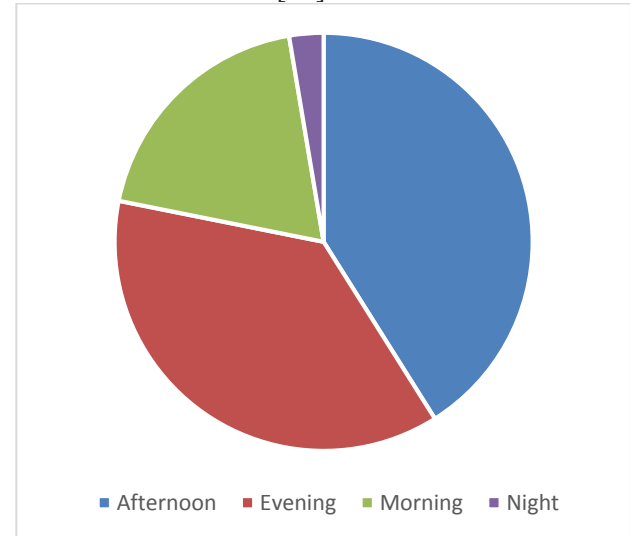


Fig. 2. Day/night wise distribution of crashes

#### 3.2 Severity Analysis

Fig. 3 shows the Casualty distribution among the fatalities and non-fatalities. Total number of victims that are affected by these collisions were 183. The number of people died were 55 which is 30.05 % of the total number of victims. The number of people injured during these crashes were 128 which are 69.90%. The number of fatalities is very high since these crashes included pedestrians and bike riders which are considered vulnerable road users which has been corroborated by other studies [14].

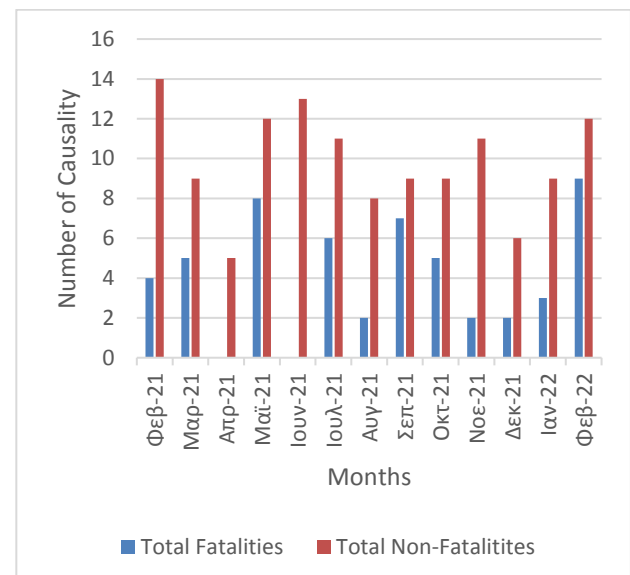


Fig. 3. Causality wise analysis

The severity index (SI) is defined as the number of fatalities per crash. It can be computed by dividing the total number of fatalities by the total

number of accidents. As a statistical metric for characterising the relative crash's severity, the severity index is frequently employed [15]. It can be observed from Fig. 4 that the maximum severity index has been calculated for the month with an SI of 0.563 which means there that 0.563 fatalities occurred per crash in the month of February 2022 or in other words every second crash had a fatality. On the other hand, the least number of severity index observed for the month of Nov 2021 which is 0.200 which could be interpreted as 1 out of 5 crashes having a fatality. There were no fatal crashes in April and July 2021, resulting in SI of 0 for these months. The available data was only for a period of 13 months (February 2021 to February 2022); hence, it was not considered appropriate to conduct any statistical analysis for the effect of months or compare it with previous studies.

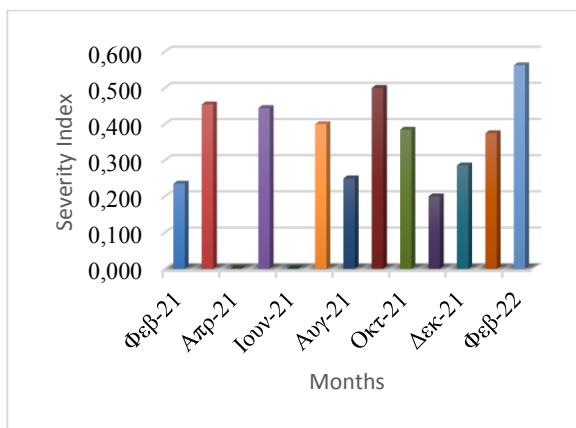


Fig. 4. Severity Wise Analysis

### 3.3 Crash Causes Analysis

During the time for which the data was collected, the main causes of these collisions were identified. It shows that out of the total 151 collisions, 118 were due to overspeeding which are (78.14%). 16 collisions took place due to overtaking which are (10.59%) of the total. Carelessness of the drivers/pedestrians caused 9 collisions which are (5.96%) of the total and driving on wrong way caused 8 collisions which are (5.29%) of the total number of collisions. Fig. 5 shows the main causes of the collisions. Similar to previous studies, such as Xu et al. [16], human factors are more prevalent in causing crashes then environmental or design aspects in the current study as well, which is evident from Fig. 5. Another prevalent factor is the violation of traffic laws (over-speeding and driving on the roadside) which has also proven to drivers to behave rashly and causing crashes [17].

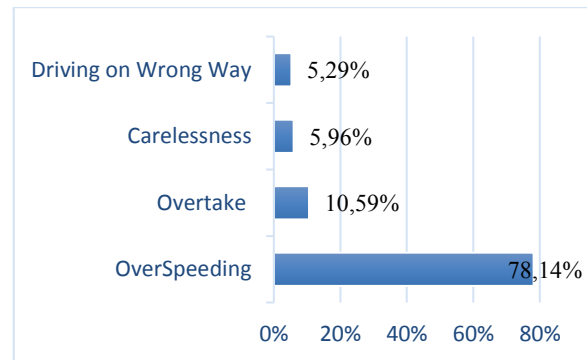


Fig. 5. Crash Causes wise Analysis

### 3.4 Involvement of Road Users

Out of the total 151 crashes that took place, bike riders' crashes were 101 which are 66.80% of the total and 50 crashes involved pedestrians, which are 33.10% of the total. Fig. 6 shows the percentage between bike riders vs pedestrian's collision.

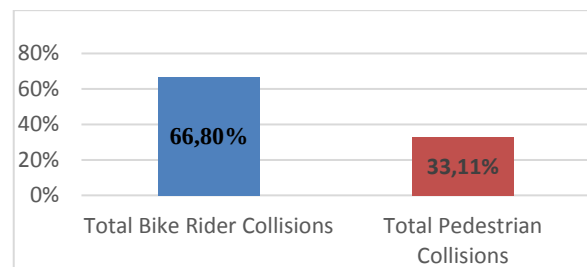


Fig. 6. Percentage between bike rider's vs pedestrian's collision

### 3.5 ANOVA

ANOVA was conducted on the following variables:

- Different times of the day: Afternoon, Evening, Morning, Night (Fig. 2)
- Reasons of crashes: Overspeeding, Overtake, Other (Fig. 5)
- Types of crashes: Bike Collision with Vehicle, Pedestrian Collision with Vehicle, Bike Collision with Pedestrian (Fig. 6)

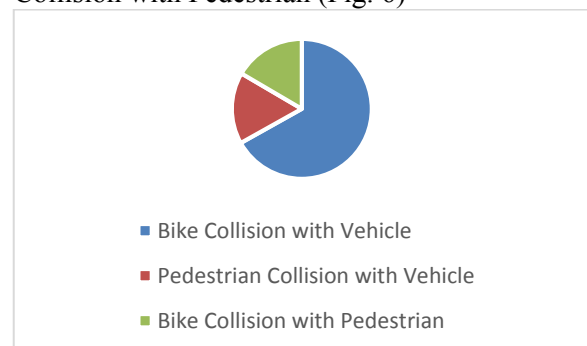


Fig. 6. Distribution of crash types

ANOVA was performed on the available crash data to investigate the following null hypotheses:

- There is no significant effect of different times of the day on the crashes involving pedestrians and bike riders.
- There is no significant effect of different reasons of crash on the crashes involving pedestrians and bike riders.
- There is no significant effect of type of crash on the crashes involving pedestrians and bike-riders.

Table 1 shows the results of ANOVA performed on different crash types while Fig. 2 shows the pie-chart for the distribution of crashes, based on types. It can be observed that the F statistic for the test is higher than the critical F-value, having a p-value of virtually '0'. This points to the fact that crash types have a significant effect on the crashes involving pedestrians and bike riders. Fig. 6 shows that bike collision with vehicles is significantly higher than any other type of crash in the available dataset. It could be due to two reasons; firstly, the data was taken for a national highway in which case the pedestrian crossing is expected to be lower. Secondly, motorbikes have become a popular mode of travel in Pakistan due to their affordability and convenience [18]. Hence, their involvement in crashes is expected to be higher than those involving pedestrians.

Table 1: ANOVA for crash types

| Source of Variation | SS  | df  | MS    | F   | P-value  | F <sub>crit</sub> |
|---------------------|-----|-----|-------|-----|----------|-------------------|
| Crash types         | 26  | 2   | 12.75 | 7.6 | 2.85E-29 | 3.015             |
| Within Groups       | 75  | 450 | 0.166 |     |          |                   |
| Total               | 101 | 452 |       |     |          |                   |

Table 2: ANOVA for different times of the day shows the results of ANOVA performed on different times of the day while Fig. 2 shows the pie-chart for the distribution of crashes on the basis times of the day. From the test, null hypothesis is rejected as F statistic is higher than F-critical with p-value of almost 0. Fig. 2 shows that evening and afternoon crashes are much higher as compared to other times. There can be a couple of possible reasons for this trend. One could be related to the peak hours of the day which are normally during these hours which are considered as afternoon and evening in this research [19, 20]. Wang et al. [21] have also linked the safety aspects with fatigue which could be a common a feature among drivers who are driving at these times. But more traffic studies are recommended to be done at the study

locations to support this theory. Another possible reason could be the glare from the setting sun. This could be extremely dangerous for bike riders, which often do not wear helmets [22]. The previous analysis has already shown a high prevalence of bike riders in crashes.

Table 2: ANOVA for different times of the day

| Source of Variation | SS       | df  | MS       | F        | P-value  | F <sub>crit</sub> |
|---------------------|----------|-----|----------|----------|----------|-------------------|
| Times of day        | 14.15066 | 3   | 4.716887 | 28.55854 | 2.85E-17 | 2.619754          |
| Within Groups       | 99.09934 | 600 | 0.165166 |          |          |                   |
| Total               | 113.25   | 603 |          |          |          |                   |

Table 3 shows the results of ANOVA performed on reasons of the crashes while Fig. 5 shows the pie-chart for the distribution of crashes based on reasons of crashes. It should be noted that some of the crash reasons were merged into the 'Others' category as they had very low proportion in the crashes involving pedestrians and bike riders. The null hypothesis is rejected for this test due to high F statistic and '0' p-value, implying that there is a significant difference in reasons for crashes with bike riders and pedestrians due to different reasons. Fig. 5 shows that over speeding is by-far the most common reason for these crashes. Hence, strategies to reduce this behaviour, through enforcement, awareness, or design, would help in reducing these crashes.

Table 3: ANOVA for different crash reasons

| Source of Variation | SS  | df  | MS    | F    | P-value  | F <sub>crit</sub> |
|---------------------|-----|-----|-------|------|----------|-------------------|
| Crash reasons       | 45  | 2   | 22.5  | 18.5 | 1.78E-59 | 3.015             |
| Within Groups       | 55  | 450 | 0.122 |      |          |                   |
| Total               | 101 | 452 |       |      |          |                   |

### 3.6 Logit Model

A logit model was developed to predict fatal crashes, from among the crashes involving bike riders and pedestrians. It is acknowledged that the available data was not sufficient to develop a model for the prediction purposes, hence, the model is included in the study for the purpose of

understanding the combined effects of factors on fatal crashes. The utility function of the model is given in the equation given below.

$$U_{\text{fatal}} = -0.86 + 1.12 (\text{Overtaking}) \quad (1)$$

The initial log-likelihood of the model was -95 while the final was -93. The only variable which had a significant effect on the model, in terms of coefficient, was the crash reason of overtaking. All other variables had a statistically insignificant effect on the model at a confidence level of 5%. The model accuracy was found to be 69% on the available dataset, which could be considered satisfactory for the sake of understanding the relationships of variables. The accuracy was calculated as the proportion of correct predictions made by the model from the complete dataset. Application of the model to find out the probabilities of crashes showed that bike riders/pedestrians crashes, which happen due to overtaking, have 26% higher chances of being a fatal crash as compared to other crashes. A possible reason for this trend could be that bike riders are reported to show zig-zag behavior while attempting overtaking, this involves frequent changes of multiple lanes. This puts them at greater risk of being involved in a crash at dangerous angles [23].

### 3.7 Root Cause Analysis

Considering the simplistic univariate utility function of logit model, it was decided to extend the analysis using root cause analysis. The analysis was performed by using Chi-square statistics to see the individual and interactive effects of variables on the occurrence of deaths in crashes. The chi-square test was performed for comparison of the crashes with or without deaths for different variables. It was not used for prediction purposes so only the chi-square value of the test and its p-value are reported. The analysis results are shown in Table 4 with a limit of 5% of significance on the probability, test was considered significant when the p-value was equal or less than 5%. As shown by the logit model that overtaking has a high chance of contributing to occurrence of death. However, this analysis adds to it by highlighting the interaction between the overtaking and ped-veh crashes. This could be indicative of the fact that vehicles often use the shoulders for overtaking resulting in such severe crashes.

Table 4. Root Cause Analysis for Occurrence of Deaths

| Variable           | Chi-square | p-value |
|--------------------|------------|---------|
| Ped-veh/Overtaking | 7.22       | 0.02    |
| Overtaking         | 4.62       | 0.03    |

To further extend this analysis, another variable was introduced with the addition of the number of injuries and deaths in a crash. Similar root cause of analysis was performed for this variable by using Fisher's statistic (F-value) due to the continuous nature of this variable. The results of this test are shown in Table 5. The limit of significance was also set as 5%, as done for the rest of the analysis.

Table 5. Root Cause Analysis for Death+Injuries

| Variable               | F-value | p-value |
|------------------------|---------|---------|
| Ped-veh                | 7.12    | 0.01    |
| Ped-veh/Overtaking     | 3.69    | 0.02    |
| Ped-veh/Night          | 3.62    | 0.02    |
| Bike-veh               | 4.76    | 0.03    |
| Ped-veh/Overspeeding   | 2.97    | 0.03    |
| Ped-veh/Other reasons  | 2.85    | 0.03    |
| Bike-veh/Overspeeding  | 2.83    | 0.04    |
| Bike-veh/Other reasons | 2.79    | 0.04    |

The death + injury analysis shows that crashes involving a vehicle with any of the vulnerable road users are contributing more towards the severity. Additionally, ped-veh crashes at night also contribute to the severity which is the only time related factor shown significant in this analysis. As shown in the analysis related to severity, overtaking is a major reason for severe crashes. This phenomenon is unique on the national highways with crashes involving vulnerable road users as the previous studies related to the urban areas do not show any significant impact of such behavior on severe crashes with vulnerable road users in Karachi [8] or Lahore [24].

#### Mitigation Measures

The results of this study have shown that the interaction between bikes and vehicles is causing the majority of crashes. The primary reasons for these crashes are over speeding and overtaking, with the latter causing most of the fatal crashes. Furthermore, more crashes are observed during the afternoon and evening as compared to other times of the day. However, crashes at night are found to be more severe in terms of injuries and/or deaths. Moreover, interaction of vehicles with bikes and pedestrians have been found to contribute significantly to the general severity of the crash as well as the occurrence of death in it. Considering

these issues, the following countermeasures are suggested to reduce the occurrence and severity of crashes.

Stringent enforcement of helmet use will not only reduce the severity of crashes directly, but it may also save the crashes due to the possible impact of sun glare during evenings and late afternoons. Use of dedicated lanes and speed calming techniques will reduce the interaction between vehicles and bike riders. This will also control the aggressive behaviour of drivers due to peak times as they get involved in over speeding and overtaking manoeuvres. Site observations of the study area also revealed a lack of pedestrian crossing facilities. In Pakistan, the lack of infrastructure to protect pedestrians at intersections with highways is a significant concern. Several factors contribute to this issue:

- Absence of Pedestrian Bridges and Underpasses
- Poorly Designed Crosswalks
- Inadequate Traffic Signals for Pedestrians
- Lack of Footpaths
- Insufficient Enforcement of Traffic Laws

All these shortcomings were primarily found on the study locations. Hence, it is also recommended to provide such facilities while maintaining obstructions (barriers) to stop crossing of pedestrians from potentially dangerous locations. These locations may include curves, steep gradients, and other parts of the road with lower sight distances. The interaction effect of pedestrian-vehicle with overtaking and night-time crashes call for the awareness of the pedestrians to avoid using shoulders and wear bright colours when walking during night.

## 4 Conclusion

This study aimed to investigate the trends in motorcycle and pedestrian crashes in Kohat and Jand, Pakistan. The occurrence and severity of crashes was found to be comparable to Mega cities, in spite of being on national highway which are expected to have lower interaction with vulnerable road users. It should also be noted that the crash data was extracted from police reports which only represent a minor proportion of actual crashes. These facts, combined together, justify the need for such studies which focus on crashes involving vulnerable road users on national highways or other rural areas. Crashes involving pedestrians and bike-riders are highly influenced by the crash type, time of the day and crash reason. A significantly higher proportion of crashes was found to be between bike-

riders, pedestrians, and vehicles. Hence, measures could be taken to reduce their interaction on the road. This could be done using dedicated lanes for certain types of vehicles and/or restriction on the operation of bikes on high-speed locations. More awareness is also required to caution them for the use of roadside walking paths, especially during night, which were found to be resulting in more severe crashes.

Times of the day are also shown to have a significant influence on the crashes involving pedestrians and bike riders. Further studies would be required to check if they are linked with the higher volume of traffic on the study locations during afternoons and evenings, which were found to have significantly higher proportion of crashes. This trend could also be linked with the glare of the setting sun. More stringent enforcement strategies, to increase helmet use, may help in reducing these crashes.

With regards to the reasons of crashes, ANOVA showed that over speeding is causing the higher proportion of crashes. However, the logit model and distribution analysis for the severity of crashes showed that overtaking increases the chance of a fatal crash, involving pedestrians and bike riders. This aspect seems to be unique to the crashes of such nature on national highways and as overtaking is not reported to have a significant impact on them in urban areas. Speed calming techniques and measures may reduce the number of fatal crashes, however, overtaking behavior of bike-riders is reported to be aggressive in previous studies as well. Hence, it is suggested that dedicated lanes are used to segregate them from the rest of the traffic, which is also suggested above due to their higher involvement in crashes. There is also a lack of pedestrian bridges and crosswalk in that area which also causes these crashes.

The research team recommends future studies to investigate the effects of traffic congestion on these crashes. The current research had data limited to specific areas and a single year. Therefore, it is recommended to expand such analysis to a dataset of longer duration and wider network to analyse the seasonal effects on these crashes, if any.

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The authors equally contributed in the present research, at all stages from the formulation of the problem to the final findings and solution.

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#### **Conflict of Interest**

The authors have no conflicts of interest to declare that are relevant to the content of this article.

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