Explaining risky driving behaviour among the young motor riders in Manipal, Karnataka, India

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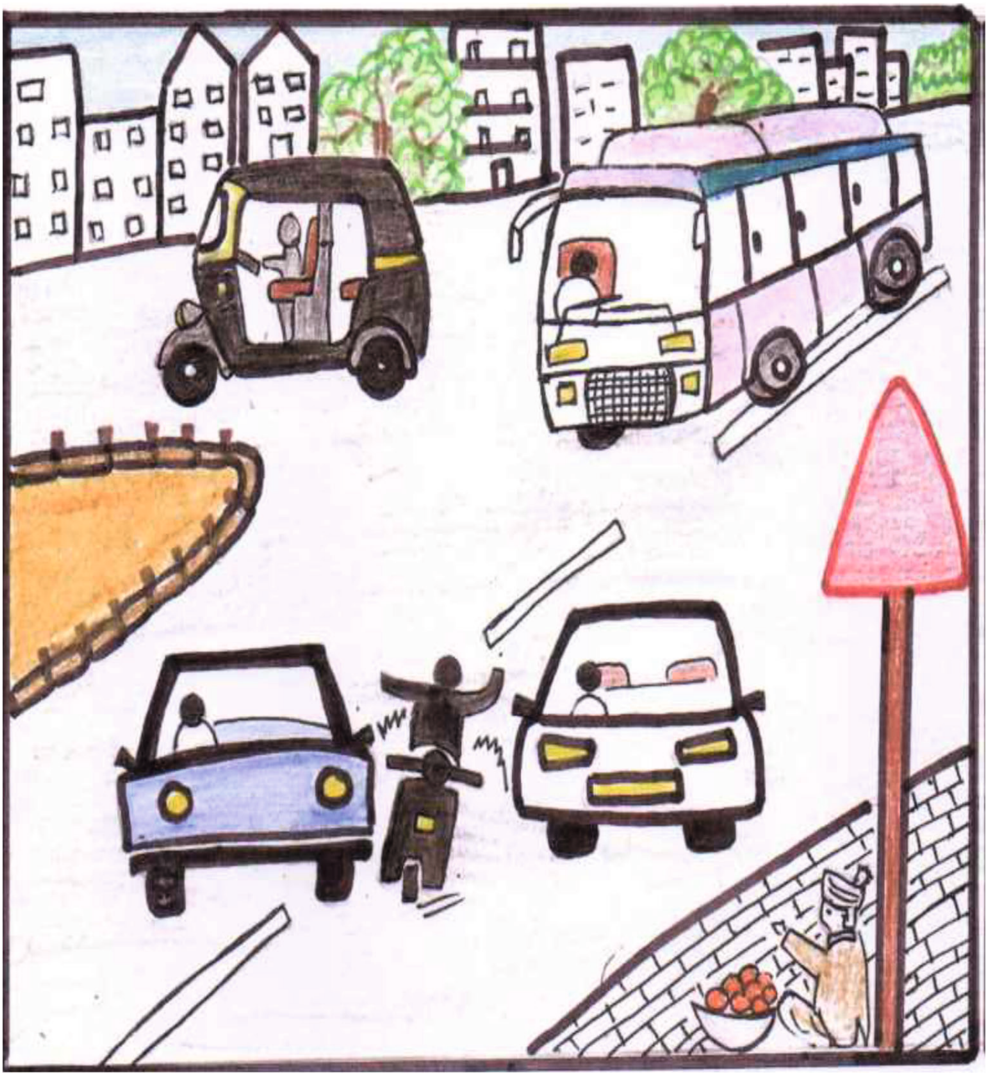

Kumar Sumit

Explaining Risky driving behaviour among the young motor riders in Manipal, Karnataka, India: A psychosocial study on objectives for educational interventions

Dissertation

By

KUMAR SUMIT

Explaining Risky driving behaviour among the young motor riders in Manipal, Karnataka, India: A psychosocial study on objectives for educational interventions

DISSERTATION

to obtain the degree of Doctor at the Maastricht University
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Prof. dr. Pamela Habibović
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at the Hasselt University
on the authority of the Rector Magnificus,
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Chapter 2

An exploration of characteristics and time series forecast of fatal road crashes in Manipal, India

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Abstract

Road crashes are the sixth leading cause of death in India. There has been a fourfold increase in the number of road traffic crashes in India in the last four decades and an increase of 9.8 times in the fatalities associated with that exponential increase. Manipal is a coastal place with a population of approximately 50,000 inhabitants lying in between the western Mountain range and the Arabian sea. The study's objective is to explore the characteristics of fatal road crashes in Manipal from 2008–2018 using the data pertaining to fatal crashes retrieved from the office of the superintendent of police. Furthermore, it aims to forecast crashes by time series analysis prediction. The results show that most of the fatal crashes are due to exceeding the lawful speed limit, followed by driving under the influence of alcohol and going ahead and overtaking. The time series analysis forecasted the number of fatal crashes until the year 2025 and predicted that there will be an increase in the number of fatal road crashes by 4.5%. The results also provide essential leads for initiating specific intervention programmes targeting the causes of fatal road crashes.

1. Introduction

Internationally, road traffic crashes have become the major public health challenge of the 21st century. Every year more than 1.35 million people lose their lives due to road crashes, making it one of the leading causes of death worldwide (WHO, 2018). Road crashes have become the 8th leading cause of death worldwide for all age groups and the 1st leading cause of death among children and young adults aged 5–29. Globally, the burden of road crashes is disproportionately borne by vulnerable road users living in low- and middle-income countries (LMICs), where the growing number of deaths is aggravated by increasingly motorized transport (Chang et al., 2020). It was observed that between 2013 and 2016, there was no reduction in the number of crashes in LMICs (WHO, 2018; Chang et al., 2020; Singh, 2017; Gururaj et al., 2014).

With a population of close to 1.37 billion people, India now faces the worst ever road congestion in most cities and towns, and Indian roads have become more vulnerable to road crashes. As per the report published by the Ministry of Road Transport and Highways, 151,417 persons were killed and 469,418 injured in road traffic crashes in India in 2018 (MoRTH: Annual report, 2019). The number of crash-related fatalities has increased by 6–8% per year since 2004 (Singh, 2017; Mohan et al., 2014). Every hour, there are 15 fatalities and 53 injuries associated with road crashes in India. The roads, which were constructed during the pre-liberalization era, are not able to support the ever-increasing traffic load. One other point of concern is the mixing of heavy vehicles with daily commuting vehicles on the road (Mohan et al., 2014). There has been a construction boom in India due to rapid urbanization. Consequently, the plying of heavy vehicles is a common sight nowadays to support the logistic demand of the construction sector. In, India, the total number of vehicle fleets has increased exponentially, from 12.77 billion to 23 billion from 2009 to 2016, respectively (MoRTH: Annual report, 2019). With the addition of six million new motor vehicles every year, it is expected that India will have the maximum number of vehicles on the road by 2050 (Road Safety in India: Status Report, 2016).

The government of India has proposed a National Urban Transport policy to improve transportation planning in Indian cities (Sustainable Transport Policy Archives, 2020). It stresses the need to prioritize the movement of people and not vehicles in the cities. Furthermore, it proposes to create adequate road space for sustainable transport modes, such as walking, cycling and public transport. The guidance envisages creating safe, reliable and sustainable transport modes and argues for participatory decision making involving relevant stakeholders such as town planners, transport providers and commuters. As such, the national government has taken cognizance of the country's road safety situation due to the increased number of crash fatalities in recent years. It acknowledges that road crashes have become a major public health threat of the 21st century. In view of this, the government of India has come up with a National Road Safety Policy, which aims to reduce mortality and morbidity resulting from road crashes. The key policy statements of the National Road Safety Policy are: (1) raise awareness about road safety issues; (2) establish a road safety information database in the future; (3) ensure safer road infrastructure; (4) safer vehicles; (5) safety of vulnerable road users; (6) road traffic safety education and training; (7) enforcement of safety laws (Brodsky & Hakkert, 1988). The expansion of the road network in India is not in pace with the exponential growth in motorization in the last two decades. The total number of vehicles in India was 295.8 million in 2019. With an estimated 37 million motorcycles, India is home to the largest number of motorized two-wheelers in the world (MoRTH: Annual report, 2019).

India's transportation system follows a federal decision-making structure, and most of the country's transport decisions are made by the national ministries and government departments, particularly the Ministry of Housing and Urban Affairs (Mo-HUA) and Ministry of Road Transport and Highways of India (MoRTH: Annual report, 2019; Katagiri et al., 2009; Pal et al., 2019; Ponkshe, 2018; Ruikar, 2013). The largest budgetary allocation and political power rest in the hands of the MoRTH, along with the Ministry of Urban Development, NITI Aayog and various state and local transport corporations and road development corporations. A significant part is played by the different implementation agencies, such as local, national and international contractors, consulting firms and donor agencies. In addition, technical and research institutions and advocacy organizations have a significant role in formulating future policies and building consensus among stakeholders for their implementation. Each of the actors or agencies is continuously influencing each other actions. The complexity in the number of agencies involved and difficulty in coordinating across them impedes the decision-making process and subsequent work on the ground. The proposed sustainable transport policy will also minimize the existing delayed decision-making process in the current bureaucratic system and ensure a better coherent approach. For instance, cities with a population of one million or above are expected to establish a "Unified Metropolitan Transport Authority" and an "Urban Transport Fund" to manage financial resources for all transportation projects. This will ensure that each agency coordinates and follows an identical vision (Sustainable Transport Policy Archives, 2020; Ponkshe, 2018).

Globally, the developing countries account for more than half of motorized two-wheelers (MTWs). For example, Dandona et al. (2008) stated that while the percentage of MTWs in developed countries such as the USA is around 2%, it stands at 95% in Vietnam. Furthermore, they contribute to about 28% of the total fatalities associated with road crashes (WHO, 2018). In India, motorized two-wheelers comprise 70% of the total vehicle population, and motorcycle users are considered the most vulnerable road users. Out of the total fatal road crashes, 68% of them consist of vulnerable road users, i.e., motorized two-wheelers in India (Road Safety in India: Status Report, 2016). Empirically, this is also reflected in the studies conducted by Singh (2017) and Mohan et al. (2014), who found that the MTWs are more vulnerable to road crashes as evidenced by their vulnerability to hazards of road conditions and weather. It can be well-argued that a two-wheeler rider is more vulnerable to road crashes as their bodies are exposed directly to an obstacle or another vehicle (Gururaj et al., 2014). The issues related to road safety in India are very diverse. They range from individual, environmental, infrastructure, poor implementation of laws and the absence of a graduated driving licensing programmes (Ruikar, 2013). Essentially, the trends, patterns and causes of road crashes can be unique depending upon the environment, population distribution and law enforcement. It should be noted that India is the 7th largest country in the world with unique diversities in the environment, geographical features, population distribution, road condition, public awareness and law enforcement. These factors all make the trends, patterns and causes of road crashes in India unique in their own way (Ruikar, 2013; Pal et al., 2019).

The study is based in Manipal, which is situated on the southwest coast of India bordering the Arabian Sea in the state of Karnataka. This coastal town receives a prolonged annual average rainfall of 2893 mm spread from May to October. Manipal is home to the Manipal Academy of Higher Education (MAHE) and it hosts approximately 30,000 young students from all across India and 60 countries all over the world. The study setting is different in its own way due to varied demographical characteristics and climatic conditions. The student population in Manipal is a floating population as they mostly stay for a duration of 4–6 years. Due to this demographical characteristic, they intend to drive as they do in their native settings, which may be substantially different from the current setting. Furthermore, the study setting is a popular tourist destination that attracts tourists from all over India, making the roads congested and prone to road crashes (Rosselló & Saenz-de-Miera, 2011). It is noteworthy to mention that from the last decade, more university towns have been coming up in other parts of India where this study can be replicated on the same analysis variables, including time series for subsequent evidence generation and planning interventions.

Furthermore, the study highlights the existing deficiencies in the crash recording system as many places in India do not have computerized road crash recording units and, therefore, the crash storage and retrieval systems are quite poor. In the majority of the states, it is recorded manually on some register, and only one person is responsible for keeping the records. Moreover, the uniformity in recording crash data is not maintained. Few states in India publish their annual crash statistics in a comprehensive way, which is essential from a road safety point of view for the in-depth understanding of characteristics of crashes such as information about crash-prone locations and exact circumstances in which crashes happen. As mentioned, the government of India has planned to establish a "National Road Safety Information System" to improve the quality of crash reporting and subsequent investigation (MoRTH: Annual report, 2019). Furthermore, the awareness about the utility of the existing crash statistics is deficient, and there is a lack of trained, skilled personnel for this work. As the data is not computerized, hardly any meaningful crash analysis is performed to find vulnerable road users, the age and socio-economic background of drivers and other road users involved in crashes and causes of crashes, which are factors that are of paramount importance for providing leads in taking preventive measures. To sum up, in India, road crash data is hardly used for taking appropriate traffic enforcement measures (Indian Road Congress, 2019). In view of the above-mentioned contexts, the applicability of the current study is twofold: (1) utilization of existing crash data to generate informed evidence to reduce fatal road crashes in university towns of India and (2) emphasizing the importance of improving the existing crash recording system in India, so that much more detailed analysis and informed evidence can be generated in the future.

Several previous studies in the urbanized township of India have reported the vulnerability of young drivers for road crashes (Singh, 2017; Sustainable Transport Policy Archives, 2020; Dandona et al., 2008). Reasons for this increased vulnerability in young drivers are likely to resemble those related to young car drivers. In a study conducted by Robbins and Chapman (2019), it was reported that young people are more prone to crashes due to two factors, i.e., experience and age. Firstly, crash risk is higher for young drivers due to lack of experience, for instance, in comprehending, assessing and responding to hazards (Pal et al., 2019; Ross et al., 2014). Secondly, age-related, risky driving amongst young drivers has been theoretically explained by neurocognitive evidence that suggests an imbalance between the development of the social-affective brain and the cognitive control system during the transition period from child to adult (Ross et al., 2016). The brain's socio-emotional reward system shows early adolescent remodelling while the cognitive control system (e.g., inhibitory control, working memory, mental flexibility and planning) matures more gradually, well into people's 20s. This maturational gap between both brain systems makes it difficult for youngsters to self-regulate impulsive responses, which is even more profound in males than in females. A possible explanation for this sex difference is that male road users, compared with female road users, prioritize the benefits of risk-taking over the costs associated with it (Robbins & Chapman, 2019; Ross et al., 2016).

The proposed study is an attempt to highlight the importance of understanding the characteristics of fatal road crashes in the university towns of India with a substantial young student population. Furthermore, it will provide valuable leads for initiating specific intervention programmes with a multi-sectoral approach targeting the causes of crashes and sensitizing the local authorities for priority-based actions. The findings of the current proposed study will generate evidence for the local policymakers to reduce crash risk in Manipal. The objectives of the study are (1) to explore the characteristics of fatal road crashes in Manipal from 2008–2018 and (2) to forecast the number of fatal road crashes for the upcoming years using time series analysis. The remaining part of this paper is structured as follows: section two elaborates on the literature review; section three provides an overview on the methodology; section four presents the results of the current study. Furthermore, in Section 5, the study findings are discussed in detail in the discussion section, followed by limitations and future research, recommendations and conclusions in Sections 6–8.

2. Literature Review

With respect to age and gender distribution for fatal crashes, in the Indian setting, young adults in the age group of 18–45 years account for nearly 69.3% of total crash victims (MoRTH: Annual report, 2019). Furthermore, most of the studies have reported that it is basically the youth population in India who are vulnerable to crashes (Ruikar, 2013; Gururaj et al., 2014). Young drivers are more prone to road crashes primarily due to two inter-correlated factors, i.e., age and experience (Pal et al., 2019). Crash risk is higher among young road users due to perceived difficulty in comprehending, assessing and responding to hazards (Robbins & Chapman, 2019; McKnight & McKnight, 2003; Sleet et al., 2010). Furthermore, crash risk among the young drivers has been theoretically explained by neurocognitive evidence that suggests an imbalance between the development of the social-affective brain and the cognitive control system during the transition period from child to adult (Ross et al., 2016). Moving to gender distribution, previous studies have highlighted the vulnerability of males for fatal road crashes as compared with females (Singh, 2017; Gururaj et al., 2014). Men contributed to 85.6% of total fatal crashes in India in 2019 (MoRTH: Annual report, 2019). It is argued that male drivers prioritize the benefits of risk-taking over the cost associated with it as compared with their female counterparts (Robbins & Chapman, 2019). With respect to the causes of fatal crashes, over-speeding happens to be the leading cause of road crashes, contributing to 71.1% of total crash (MoRTH: Annual report, 2019). Previous studies have identified speeding as the main cause for fatal road crashes in India, too (Gururaj et al., 2014; Mohan et al., 2014; Ruikar, 2013; Sivasankaran et al., 2021). Speeding can be either excessive (driving beyond the lawful limit) or inappropriate (driving within limits but too fast for the traffic condition), and it poses a significant risk for fatal crashes (Begg & Langley, 2001). Speeding is influenced by several psychological factors such as beliefs and perceptions associated with speeding; intentions for speeding include impression management, risk-taking and sensation-seeking (Manning, 2009). The contributions of other causes of road crashes, such as driving under the influence of alcohol, were found to be less compared with speeding (Dash et al., 2019; Kanchan et al., 2012). Furthermore, "hit and run" accounted for the largest share, 19.4% of total persons killed in 2019 (MoRTH: Annual report, 2019). Previous studies have reported similar findings (Ruikar, 2013; Dash et al., 2019). Finally, the literature review for crash prediction highlights the importance of the time series analysis prediction technique. This technique is used for forecasting future events based on past data. The utility of time series analysis for crash forecasting has been explained by several previous studies (Vaziri et al., 1990). Furthermore, time series analysis has demonstrated its effectiveness in the right prediction for crashes (Popescu, 2020; RK Singh & Suman, 2012). The results of the few studies conducted in India forecast an increase in the number of road crashes. For instance, Sunny et al. (2018) in Kerala predicted an increase in the number of crashes for the upcoming years. Other studies also (RK Singh & Suman, 2012) forecasted and reported that there will be an overall increase in the number of road crashes in their respective study setting. For instance, RK Singh and Suman (2012) pointed out the upsurge in mixing heavy vehicles with daily commuting vehicles on the road due to rapid urbanization, subsequently making the roads vulnerable to crashes in their study setting.

3. Materials and Methods

3.1. Data Source and Process of the Crash Recording System in India

To be able to design informed road safety programmes and understand the underlying causes of crashes, detailed documentation of crash incidents is essential. At this moment, police records are the only significant and reliable source of crash data in India (Dandona et al., 2008), but only a few studies in India have used police crash data as a source to identify the underlying factors for road crashes (Gururaj et al., 2014). Accurate and intense crash records are the backbone of crash analyses. The efficient use of crash records depends on three factors: accuracy of data, maintenance of records and data analysis. The need for a high standard of crash reporting is the principal prerequisite for using the crash records in working out road safety measures. In India, the crash details are recorded by the police in the form A-1. Furthermore, the authorities prepare the crash summary annually in the A-4 form. The police station uses the A1 form to record individual crash details happening in their jurisdiction. It captures information on the crash identification details, crash location, vehicle and victim details (Indian Road Congress, 2019). The A4 form is a format for reporting crash data by the police authorities to the transport research wing of the Ministry of Road Transport and Highways, government of India. It consists of aggregate data on road crashes (collected and compiled from the police authorities) on the total number of crashes classified according to the types of area, types of roads, types of collision according to weather condition, location, victim and vehicle details. For the current study, the data from A4 forms from 2008–2018 were collected from the office of the superintendent of police and analysed. The current study is based on secondary data (2008 to 2018) and consists of variables on different characteristics of fatal road crashes in Manipal.

3.2. Study Area

The current study is based in Manipal city. It is a coastal place lying in between the western Mountain range and the Arabian sea. The population of Manipal is approximately 50,000 inhabitants. It is also home to the Manipal Academy of Higher education, which hosts around 30,000 students from all corners of India and 60 countries across the world (Figure 1).

Figure 1- *Map of India with the location of Manipal indicated. Source-Maps of India.com (accessed on 7 February 2022)*

3.3. Study Design

The current study is an observational study based on secondary data (2008 to 2018) obtained from the office of the superintendent of the police. The dataset included variables on different characteristics of fatal road crashes in Manipal.

3.4. Statistical Analysis

The study mainly involved the use of descriptive statistics and time series analysis. Descriptive statistics denoting percentages were used to describe the crash-related details such as nature of the crash, days of the week on which the crash happened, suspected vehicle, victim's gender and cause for the crash. This analysis was performed in SPSS (version 24) software. In addition, the study also involved time series analysis. The main objective of the time series analysis was to forecast future fatal crashes. Time series analysis was performed using a time-dependent exponential smoothing model with Holt–Winters method for forecasting. This technique is used for examining a forecast based on more recent experience in exponential smoothing. The latest observations are given more weightage as compared with previous observations (Kalekar, 2004). The following equation describes exponential smoothing.

$$\mathbf{S_{t+1} = \alpha X_t + (1 - \alpha) S_t}$$

where, S_{t+1} is the next forecasted value, S_t is the previous forecasted value, X_t is the observation and α is the parameter which is to be estimated. Furthermore, other technical details about time-dependent exponential smoothing and Holt–Winter's forecasting can be found in "Time Series Analysis and its Applications" by Shumway and Stoffer (2019). Time series analysis was applied for the data on the number of fatal crashes from the year 2008 to 2018 and fatal crashes were forecasted up to the year 2025. R software version 3.5.1 was used for performing this analysis. R software is an open-source software The step-by-step procedure of study's methodology is presented in Figure 2 .

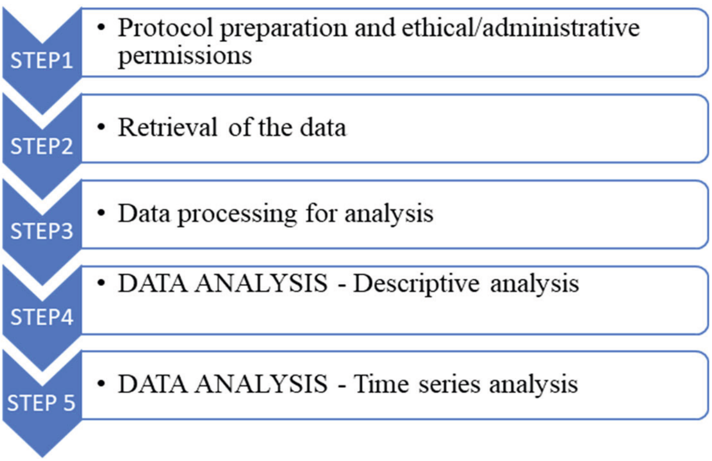

Figure 2- Study procedure (Author's own creation)

4. Results

4.1. Trend of Fatal Crashes in Manipal

There has been a consistent increase in the fatal road crashes in Manipal, except for the years 2014 and 2018, which noticed a minor decrease than the respective previous years (Figure 3).

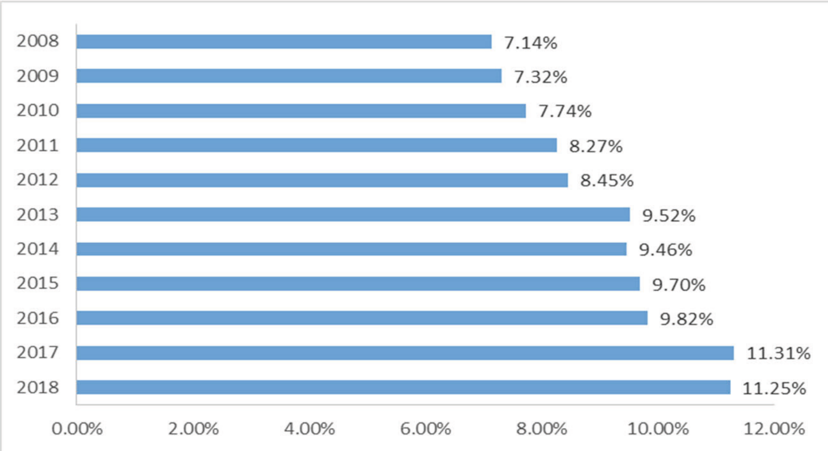

Figure 3- Year-wise distribution of fatal crashes in Manipal.

4.2. Distribution of Fatal Crashes

Figure 4 describes the nature of fatal crashes in Manipal from the year 2008 to 2018. It can be observed that most of the fatal crashes in the last ten years have happened due to head-on collision (43.87%) followed by rear-end collision (12.18%) and skidding (10.24%), respectively.

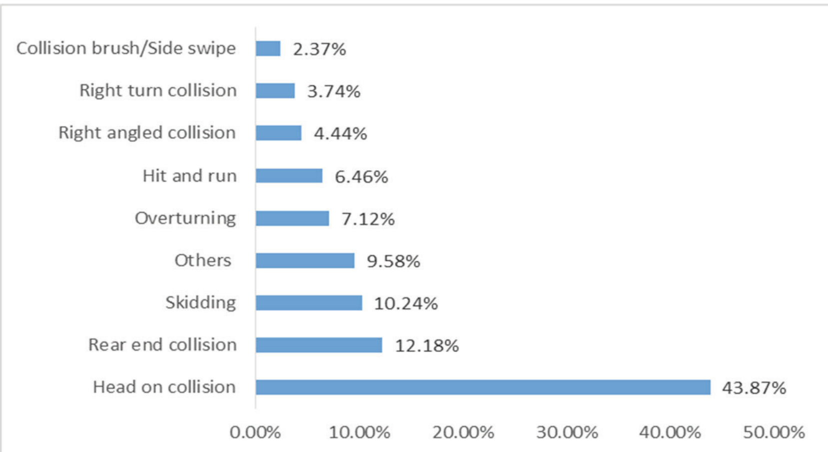

Figure 4- Nature of fatal crashes (2008–2018).

4.3. Causes of Fatal Crashes in Manipal

Speeding beyond the lawful limit is the major cause of fatal crashes in Manipal, contributing to 50.77% of the total share, followed by driving under the influence of alcohol (12.74%) and going ahead and overtaking (9.34%) (Figure 5).

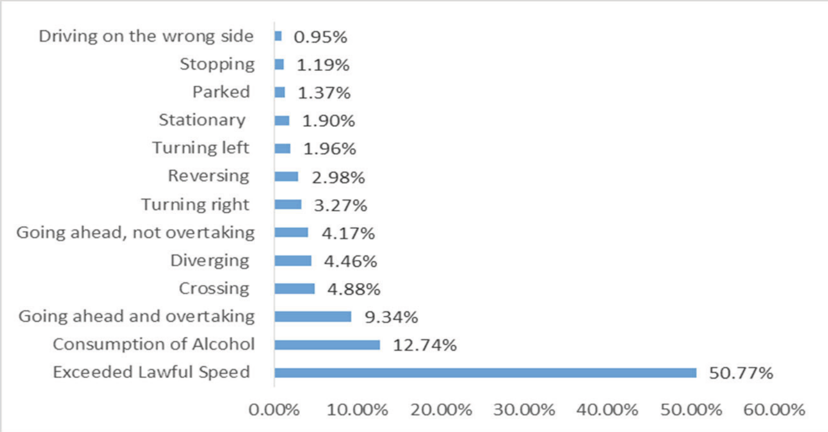

Figure 5- Causes of fatal crashes.

4.4. Age and Gender Distribution of the Drivers Involved in Fatal Crash

Out of the total cases, 54% of crashes were reported in the age group of 18–25 years, followed by 32% in the 26–40 year-old age group and 14% for the drivers above 40 years old. Men were involved in 86.76% of fatal crashes.

4.5. Type of Vehicles Involved in Fatal Crashes

With respect to vehicle involvement, motorcycles contribute 45.32%, followed by scooters (30.10%) and cars (17.02%) (Figure 6).

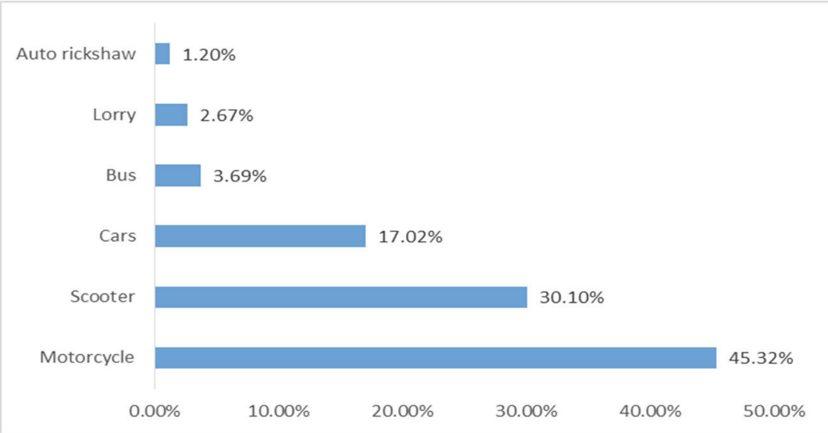

Figure 6- Type of vehicles involved in fatal crashes.

4.6 Distribution of Fatal Crashes According to the Days of the Week

The highest proportion of fatal crashes have occurred on Saturday (34.13%), followed by Sunday (28.10%) and Friday (26.29%) (Figure 7).

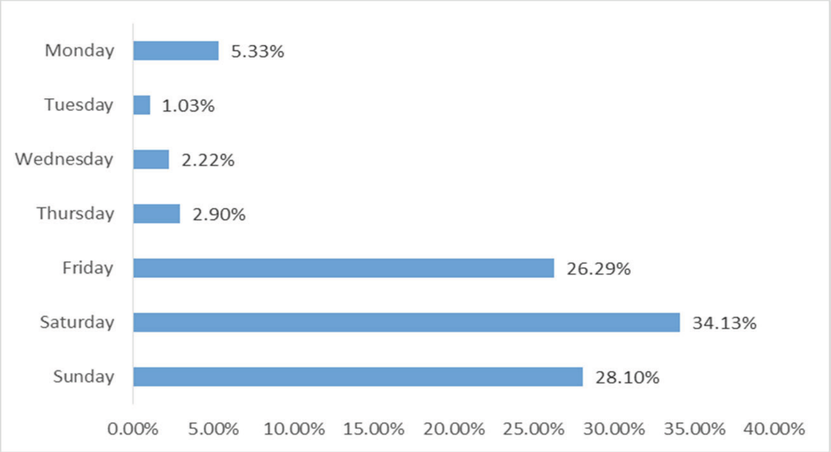

Figure 7- Distribution of fatal crashes according to the days of the week.

4.7. Distribution of Fatal Crashes According to the Types of Roads

With respect to types of road, the highest proportion of fatal crashes have occurred on national highways (55.60%), followed by state highways (25.34%) and other roads (19.06%).

4.8. Location of Fatal Crashes

Fatal crashes predominantly occurred near educational institutions (35.56%), followed by crashes happening near recreation centres (22.32%) and near a religious place (15.10%) (Figure 8).

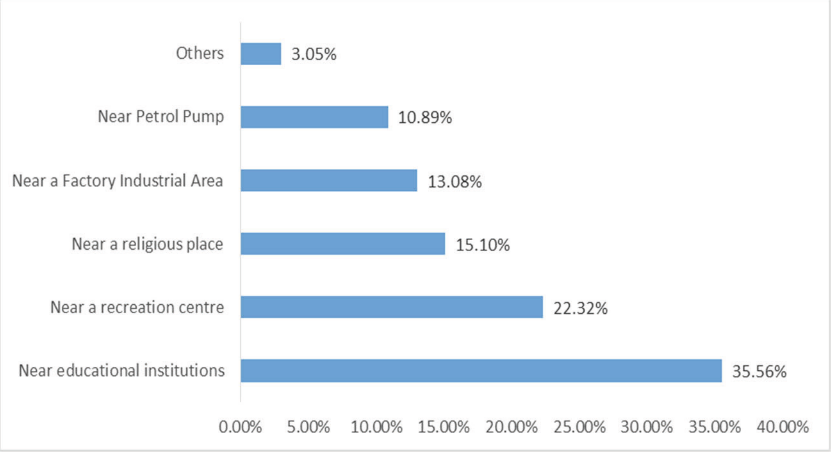

Figure 8- Location of fatal crashes.

4.9. Distribution of Fatal Crashes as Per the Local Weather Conditions

The highest proportion of fatal crashes were found to take place during heavy rains (52.75%), followed by light rain (23.15%) and cloudy weather (22.15%) (Figure 9).

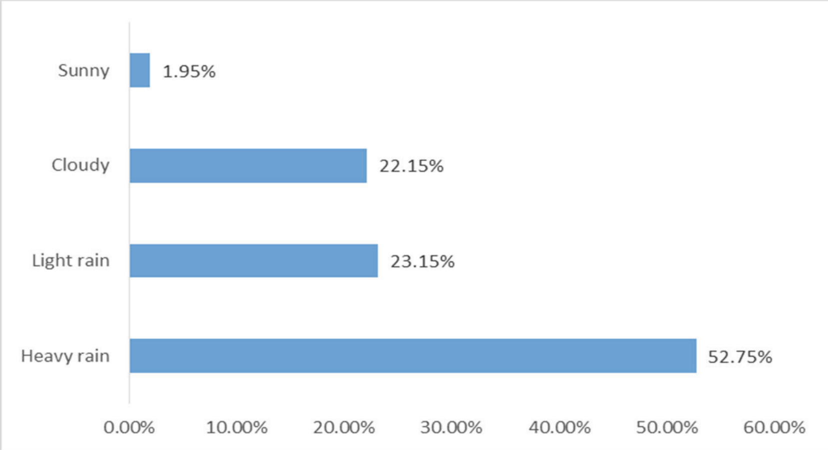

Figure 9- Distribution of fatal crashes as per the local weather conditions.

4.10. Distribution of Fatal Crashes as Per the Vehicular Defects

With respect to vehicular defect, defective brakes contribute 24.35% of fatal crashes, followed by worn out tyres (23.05%) and defective lighting systems (22.26%) (Figure 10).

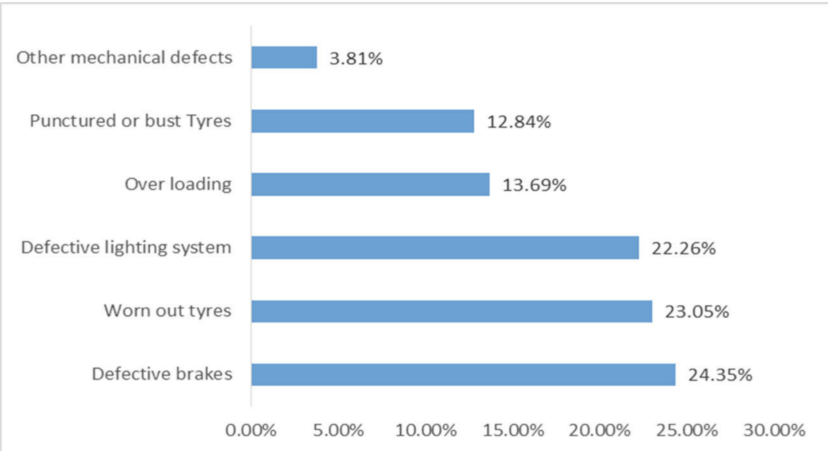

Figure 10- Distribution of fatal crashes as per vehicular defects.

4.11. Crash Prediction

As shown in Table 1, the number of crashes has been predicted from 2019 to 2025 using time series analysis. The results from the analysis predict that if the current trend of fatal crashes continues in Manipal, there will be annual average increase of 4.5% in the number of fatal crashes for the upcoming years (Table 1, Figure 11).

Table 1. Estimates of time series analysis.

	Months												
Year	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec	Total with 95% CI
2019	10	8	10	9	9	12	16	17	16	14	13	12	146 (54,238)
2020	11	10	9	11	10	13	17	19	14	15	11	13	153 (56,255)
2021	9	9	11	12	12	15	17	19	17	16	10	13	160 (59,265)
2022	12	11	11	11	13	16	19	18	19	15	11	12	168 (62,277)
2023	13	12	12	11	16	17	20	19	16	15	13	11	175 (67,294)
2024	15	13	14	15	14	17	21	20	17	13	12	12	183 (72,305)
2025	16	14	13	18	17	19	22	19	19	12	11	11	191 (77,317)

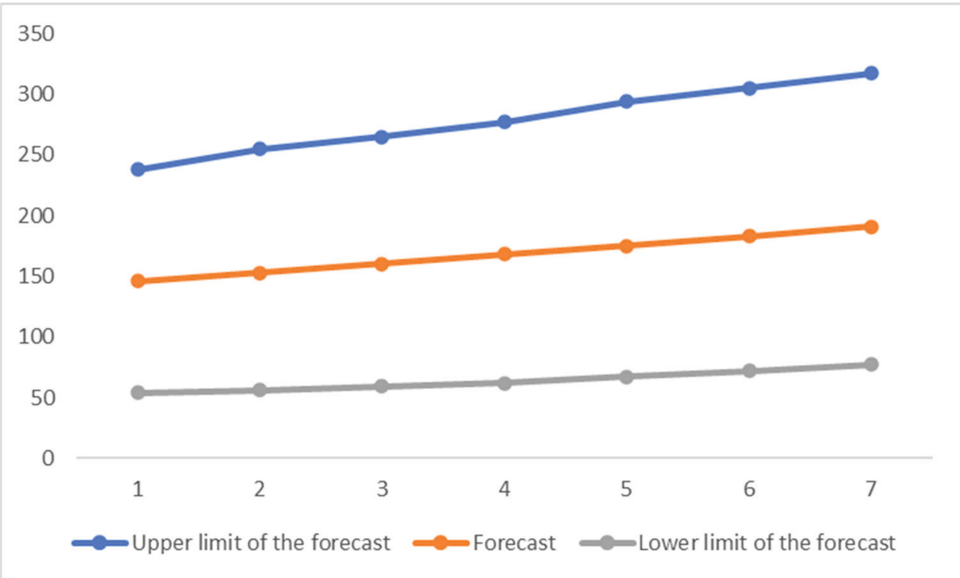

Figure 11- Estimates of time series analysis (2019–2025).

Orange line indicates the forecasted value, blue line indicates the upper limit of the 95% confidence interval of the forecasted value and grey line indicates the lower limit of the 95% confidence interval of the forecasted value.

5. Discussion

The current study was based in the university town of Manipal, which is unique in its own way, due to ostensibly varied demographical characteristics and climatic conditions. The study setting has a high concentration of floating young students. Because of this demographical characteristic, they intend to drive as they do in their native settings, which may differ from the current setting. The proposed study is novel in its own way due to unique demographical and driving conditions. The study aimed to explore the characteristics of fatal road crashes in Manipal from 2008–2018. Furthermore, it also aimed to forecast the number of fatal road crashes for the upcoming years using time series analysis. The results show that most of the fatal crashes are due to exceeding the lawful speed limit, followed by driving under the influence of alcohol (Figure 5). Moreover, drivers in the age range of 18–25 years contribute 54% of total fatal crashes. With respect to vehicle involvement, motorcycles contribute 45% of total fatal crashes, followed by scooters (Figure 6). The highest proportion of fatal crashes have occurred on national highways (55.60%), followed by state highways (25.34%) and other roads (19.06%). Finally, the highest proportion of crashes was observed on weekends (Figure 7). With the time series analysis, the number of fatal crashes was forecasted until the year 2025, and it was found that there will be an increase in the number of fatal road crashes by 4.5% (Table 1). This research contributes to the existing literature regarding the possible use of crash data in understanding the characteristics of fatal road crashes in a study setting with some unique demographical and driving conditions.

There is a paucity of information on the real extent of the problem about trends, patterns, distributions and outcomes of crash fatalities in India. As the data is not computerized, hardly any meaningful crash analysis is conducted to find out factors that are associated with higher crash risks (MoRTH: Annual report, 2019; Indian Road Congress, 2019). However, to be able to design informed road safety programmes, understanding the underlying causes of crashes is essential. In order to improve road safety, the availability of crash data and an understanding of the circumstances that lead to crashes are of vital importance. For instance, detailed crash data and its subsequent analysis can provide evidence for the authorities to detect black spot treatments and in designing appropriate improvement measures (Road Accident Investigation Guidelines for Road Engineers, 2018). It is noteworthy to mention the European Union policy for road safety management emphasizes road safety inspections (RSI) based on crash analysis as an effective technique in reducing crash risk (Vaiana et al., 2021). The government of India has taken cognizance of the situation due to the increased number of crash fatalities in recent years. It acknowledges that road crashes have become a major public health threat of the 21st century. In view of this, the government of India has proposed establishing a "Road Safety Information Database" in the future to improve the quality of crash investigation and data collection, transmission and analysis.

The crash data analysis indicates an upswing in the number of fatal crashes in Manipal in the last few years. The findings related to the increase in fatal crashes are consistent with the study results conducted in several studies across India (Singh, 2017; Sivasankaran et al., 2021). It was reported by Singh (2017) that road crash fatalities have increased by 5% from 2003 to 2013. Furthermore, in a study conducted by Sivasankaran et al. (2021) in Tamil Nadu, the number of road crashes has doubled in the last five years. With respect to the current data analysis, the majority of fatal crashes is due to speeding beyond the lawful limit, followed by driving under the influence of alcohol and going ahead and overtaking (Figure 5), which confirms the report published by the Ministry of Road Transport and Highways, government of India (MoRTH: Annual report, 2019) and several previous studies (Pal et al., 2019; Sivasankaran et al., 2021).

The present study reported that out of the total crashes, the majority of the fatal crashes were reported in the age group of 18–25 years, followed by the 26–40 year-old age group and drivers who are above 40 years old, respectively. This finding indicates that ultimately it is the young drivers in the age range of 18–25 years who are the major victims of fatal crashes. This aligns with the findings of several previous studies in the Indian context (Ruikar, 2013; Kanchan et al., 2012). Furthermore, it also aligns with the findings of some studies conducted in Southeast Asia (Bhalla et al., 2010; Pervez et al., 2021). For instance, Pervez et al. (2021) in Pakistan and Bhalla et al. (2010) in Sri Lanka reported the vulnerability of young drivers in the age range of 18–25 years for fatal crashes. Furthermore, in detail, the results indicate that with increasing age, crash severity decreases, which is in line, for example, with Singh (2017), Rhodes et al. (2015), Nguyen et al. (2021) and Damani and Vedagiri (2021). At first glance, it can be argued that with increasing age, crash severity increases due to increased frailty and visible decrease in certain driving abilities and performance. Furthermore, it is evident that from the last two decades, crash fatalities among motorcyclists aged 40–60 years have increased in several regions across the world (United States, Canada, Europe and Australia). Puac-Polanco et al. (2016) referred to this phenomenon as the "baby-boomer cohort effect". It is noteworthy to mention frailty prevalence is associated with age groups of 65 years old and older, with further increase in prevalence in the 65–75 age group and 85+ group (Xue, 2011; Bhalla et al., 2016). Opposite that, in the current study, more than three fourths of the population involved in fatal crashes are in the age range of 18–40 years, with just 14% of the recorded cases being for drivers aged more than 40 years. This somewhat explains why increasing age in the current study is not associated with increased crash severity. Undoubtedly, the question which arises here is why with increasing age crash severity decreases. Is it that with increasing age the adherence to use protective equipment such as helmet increases, or do they drive responsibly due to family liabilities? This all warrants further exploration.

For the type of vehicle, the present study's analysis shows that motorcyclists contribute to the maximum amount of fatal crashes, followed by scooters (Figure 6). This is in confirmation with earlier studies that report on the high contribution of motorcyclists to fatal road crashes (Damani & Vedagiri, 2021; Puac-Polanco et al., 2016). For instance, Bhalla et al. (2016) reported 44% motorcyclists' involvement in their study in northern India. This result might also be transferred to other countries of Southeast Asia with traffic and road safety situations similar to India. In a study conducted by Pervez et al. (2021) in Pakistan, it was reported that 74% of the total registered vehicles were motorcycles and that motorcyclists' involvement is maximum for fatal crashes. Similar results were reported by Nguyen et al. (2021) in Hanoi, Vietnam, where the share of motorcyclists for crashes was 44%.

As for the causes of crash, speeding the vehicle beyond the lawful limit is the most common cause of fatal crash, which is similar to the findings of several previous studies (Singh, 2017; Gururaj et al., 2014; Sivasankaran et al., 2021; Dash et al., 2019). This is also reflected in the report published by the Ministry of Road Transport and Highways, where it is stated that over-speeding is the leading cause of fatal road crashes, accounting for 71.1% of total crash (MoRTH: Annual report, 2019). The tendency for speeding can be discussed by citing the work of Sharma et al. (2014)] in Bangalore, where "liking for chasing and competing", "sense of power and control" and "relief from anger" were identified as the main correlates. Looking at it from a psychological perspective, speeding behaviour is strongly predicted by social norms and negative attitudes towards respecting speed limits (Paris & Broucke, 2008). It is noteworthy to mention speeding behaviour may not always be intentional. Unintentional speeding may occur due to, for example, lack of awareness of the current speed limit/travelling speed and not paying regular attention to the speedometer on the vehicle (Etika et al., 2021). For the next major cause of fatal crash, i.e., driving under the influence of alcohol, the analysis revealed that it contributes to almost one-fifth of the total fatal crashes. This is in alignment with the MoRTH annual report (2019) (MoRTH: Annual report, 2019) and with some previous studies (Dash et al., 2019). Here, it should be noted that in addition to driving under the influence of alcohol, the role of other factors such as vehicle and environment should also be given importance in future investigations.

For the distribution of fatal crashes according to the days of the week, the study analysis reported that fatal crashes are more prevalent on weekends (Figure 7). Crashes are more common on Saturday evenings, probably due to driving under the influence of alcohol after the weekend parties and getting together. Furthermore, the study setting is one of India's most prominent student towns and hosts close to 30,000 young students in the age range of 18–25 years. This corroborates the findings from the WHO Global status report on alcohol and health, which reported increased instances of crashes under the influence of alcohol among young drivers due to weekend get-togethers (WHO, 2018). Additionally, it is also in alignment with the MoRTH Annual report (2019) and with some previous studies (Ruikar, 2013; Dash et al., 2019).

As for gender, males accounted for more than four times the number of fatal crashes compared with their female counterparts. This confirms the results reported in previous studies carried out in India, such as those by Pal et al. (2019). However, valid justifications between gender and fatal crash are inconclusive as increased crash severity has also been reported among females (De Lapparent, 2006; Islam & Brown, 2017). For the distribution of fatal crashes according to the types of roads, the study reported that the highest proportion of fatal crashes have occurred on national highways, followed by state highways and other roads. This is in alignment with the MoRTH Annual report (2019) and also with some other previous studies (Naqvi & Tiwari, 2017).

With respect to crash location, maximum fatal crashes have occurred near the educational institute, followed by a recreation centre's vicinity (Figure 8). This aligns with the fact mentioned in the introduction section that the study setting is a university town with a predominantly student population. Around one-fifth of total fatal crashes occur near the recreation centre's vicinity. One possible explanation is that watching movies is immensely popular among the youth, including students in this part of India, and they regularly visit movie theatres for recreation (Rang, 2020). As for the distribution of fatal crashes with respect to the local weather conditions, most fatal crashes were found to occur during heavy rains followed by light rain. It is noteworthy to mention the study setting is one of the wettest places in India, receiving a prolonged annual average rainfall of 2893 mm spread from May to October. The brief monsoon season damages the roads, reduces visibility and makes the road riskier for users (Brodsky & Hakkert, 1988).

For the distribution of fatal crashes per vehicular defects, defective brakes, worn-out tyres and defective lighting systems contribute to around 60% of the total share of fatal crashes. This is in accordance with the work of Singh (2017) and Ponnaluri (2012). For instance, Ponnaluri (2012) pointed out that vehicular defects account for 20% to 40% of total crashes. One possible explanation for that in the current study setting, which is a university town, is that the students receive limited pocket money from their parents/guardians. It is noteworthy to mention vehicle maintenance may be less prioritized for students in a university town due to limited pocket money. To the best of our knowledge, there is no empirical evidence to substantiate this claim. This warrants further exploration.

Finally, crash prediction was performed for the upcoming years using time series analysis forecasting by the Holt–Winters method (Table 1). The results from the analysis predict that there will be an overall increase in the number of fatal crashes for the upcoming years by 4.5%. In a similar study conducted by Sunny et al. (2018) in Kerala, using Holt–Winters exponential smoothing, an increased number of crashes was predicted for the upcoming years in that region. Furthermore, other studies also (RK Singh & Suman, 2012) have forecasted and reported that there will be an overall increase in the number of road crashes in their respective study settings. It is noteworthy to mention, even this increase, i.e., 4.5% in the number of fatal road crashes, can have a substantial impact, as around 75% of the city population comprises young adults. It is well known that the loss of an individual at an early age due to road crashes can cause immense socio-economic loss to the country (Gururaj et al., 2014; MoRTH: Annual report, 2019; Bhalla et al., 2016). Several reasons at the local level can be attributed to the increase in road crashes. The city has witnessed an exponential rise in the youth population and the number of vehicles on the road that can be attributed to an increase in the number of crashes (personal communication, 5 May 2020). One other possible explanation for the potential surge in the number of crashes is that there is very minimal or no improvement in the road safety infrastructure, with the primary focus of the authorities remaining on controlling infectious disease (Pal et al., 2019). Finally, there is the future scope of comparing the actual data (if accessible in the future) with the predicted data to further validate the model as previously reported by Jha et al. (2016).

6. Limitations and Future Research

There are certain limitations in this study. First of all, the data set used is limited both in place and time. It comprises crash records recorded by the authorities in between

2008 and 2018. More research taking into account the data of longer time periods and other similar townships in India is required to further validate the findings obtained in this study. Secondly, the data only consists of fatal crash records, thereby failing to consider the actual number of crashes occurred. Furthermore, no records were available for safety critical events such as near crashes, which are a proxy for safety. Thirdly, the data had limited variables to conduct detailed meaningful analysis. Fourthly, it is not known whether the fatal crashes had happened due to the drives' fault or because of other road users' fault. This means it is difficult to conclude on the exact causality of road crashes, which in turn can impact the effectiveness of the intervention measures. Fifthly, access to individual crash data with details of geographical coordinates, which is required for the construction of a map indicating the accumulation of fatal crashes, was not available. Finally, the latest data available was till 2018. However, the recent data is not available due to administrative issues. It is noteworthy to mention, because of the nationwide lockdown imposed in the year 2020 due to the COVID-19 pandemic, the estimates of the year 2020 may be inaccurate.

There is a need for future research in several domains. As discussed, the relationship between age and vulnerability to crashes is not clearly understood. Detailed information on crash configuration should be recorded to support future in-depth research such as geographical information systems (GIS) to understand crash-prone locations better and initiate subsequent intervention. The role of these factors requires further exploration.

7. Recommendations

Local policymakers can use the findings from this study to reduce crash risk in Manipal, India. There has been a sharp increase in the number of road crashes in the last decade, and police authorities should prioritize traffic management and enforcement apart from their law-and-order responsibility. The local authorities should also think about improving the safety systems. It is noteworthy to mention here the concept of "safe system approach". The safe system is based on well-established safety principles of the known tolerance of the human body to crash forces, speed thresholds for managing crash impact energies to survivable levels and the capacities of vehicles and forgiving infrastructure to reduce crash impact energy transfers to humans. Furthermore, the safe system approach—a core feature of the WHO Decade of Action for Road Safety — recognizes that road transport is a complex system and places safety at its core. It also recognizes that humans, vehicles and the road infrastructure must interact in a way that ensures a high level of safety (WHO: Decade of Action for Road Safety, 2020). In continuation of the above-mentioned approach, it can be recommended that road infrastructure can be improved by structural designs that convert a part of kinetic energy into deformation energy, minimizing excessive deceleration while guiding and reorienting vehicle movements to avoid excessive impact forces. This kind of road design is required on roads prone to crashes (Nguyen et al., 2021; Bekiaris & Gaitanidou, 2012). Furthermore, adequate lighting systems are required to improvise visibility, particularly during the daytime (Yousif et al., 2020). Interestingly, as per the government of India guidelines, all new motorcycles and scooters that roll into the market need to feature "Automatic Headlamp ON" (AHO) from 1 April 2017 onwards. AHO is required to improve visibility during day and at dawn and dusk (Yousif et al., 2020). For owners of vehicles that came out before 1st April 2017, policymakers can organize programmes to raise the awareness level about the utility of AHO among the local population and strategies to incorporate it in older vehicles. Furthermore, this recommendation fits in quite well in the study setting, as it experiences prolonged monsoon seasons with significantly reduced visibility. However, in a middle-income country such as India, users are reluctant to exchange their old running vehicles or pay to incorporate AHO. There is undoubtedly a cost component involved with it. Furthermore, a mix of new vehicle technologies/or telematics with existing infrastructure are a more economical solution to reduce road crashes (Liu & Ho, 2010). In this regard, there is substantial evidence suggesting that advanced rider assistance systems (ARAS) such as anti-lock braking systems (ABS), assist and slipper clutches (A&S clutch), adaptive cruise controls (ACC), airbags and collision warning systems can reduce crash risk with acceptance and adherence from the drivers (Katagiri et al., 2009; Biral et al., 2014). It is noteworthy to mention that the current study reported defective braking systems as one major vehicular defect responsible for crashes. However, as mentioned in the case of AHO and the underlying cost component involved, it will be arduous for all these technologies to percolate in the Indian automobile industry. Enforcements of strict measures to follow speed limits can reduce the number of crashes due to speeding (Singh, 2017; Gururaj et al., 2014). Since crashes are more common on Saturday evenings (Dash et al., 2019), random checkpoints to check for drunk driving and reckless driving can be installed (Pal et al., 2019). The current findings thus provide valuable leads for initiating specific intervention programmes targeting the causes of crashes and sensitizing the local authorities to priority-based actions.

It is essential for a country such as India with a significant burden of fatal crashes to incorporate a transport policy in the future. The current study's findings highlight the importance of implementing the proposed National Road Safety Policy by the government of India. Adoption of such a system will raise awareness about road safety issues and ensure safer road infrastructure and road traffic education and training, which is currently lacking in India (MoRTH: Annual report, 2019; Sustainable Transport Policy Archives, 2020). Awareness about the utility of the existing crash statistics is deficient, and there is a lack of trained, skilled personnel for this work. The government of India has planned to establish a "National Road Safety Information System" to improve the quality of crash investigation and of data collection, transmission and analysis (MoRTH: Annual report, 2019). However, due to the ongoing COVID-19 pandemic, the entire focus of the government has shifted towards it, and it will not be easy for LMICs such as India in the immediate future to invest in the National Road Safety Information System.

Awareness programmes targeting risky behaviours such as reckless driving, speeding and driving under the influence of alcohol should be initiated at the local level. Furthermore, policymakers are advised to pay sufficient attention to underlying determinants that guide those driving behaviours. For instance, age and gender are significant determinants for speeding and reckless driving (Singh, 2017; Gururaj et al., 2014). The policymakers can initiate targeted intervention programmes considering these determinants for a specific risky driving behaviour. The current study findings have highlighted the vulnerability of motorcyclists for road crashes. Previous studies have highlighted the importance and effectiveness of self-protective measures such as helmets and protective clothing (Araujo et al., 2016) in reducing crash-related fatalities. In addition, the policymakers should implement strict regulations for drivers driving underage or without a proper valid licence, because unless the licensing procedure in India is regulated and closely monitored, the quality of the driver will be questionable (Gupta et al., 2021). Graduated driving licence programmes for better driving skills that already exist in the European Union and Australia (Senserrick et al., 2017) are the need of the hour in a country such as India as well. Finally, the local authorities are advised to improve monitoring at crash-prone locations of the study setting, such as near educational institutes and near recreation centre's vicinity.

8. Conclusions

The current study attempts to understand trends, distributions and causes for fatal road crashes in Manipal, India. Speeding and driving under the influence of alcohol were identified as the main cause of crashes in the last ten years. The study also identified that young male drivers contribute to the major share of fatal road crashes. Finally, the study predicts an increase in fatal crashes by 4.5% for the upcoming years. Local policymakers are advised to focus on these factors while planning future interventions to achieve a reduction in the number of road crashes. Similar studies in other settings of India, particularly the university towns, can be undertaken for evidence generation and subsequent localized interventions.

Chapter 3

Risky motorcycle riding behaviour among young riders in Manipal, India

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Abstract

Motorcycles are one of the most commonly used transportation modes in low and middle-income countries. In India, motorized two-wheelers comprise 70% of the total vehicle population, and motorcycle users are considered the most vulnerable road users. It is essential to understand the risky riding behaviour and associated factors among the motorcyclists to develop evidence-based traffic safety programmes targeting motorcycle riders. The purpose of the current study was two-fold. First, it aimed to determine the appropriate structure of a modified version of the MRBQ among young riders in Manipal, India. Second, it assessed to what extent MRBQ factors were associated with self-reported crash involvement and violations. The motorcycle rider behaviour questionnaire (MRBQ) is a 43-item scale that assesses five aspects of risky motorcycle rider behaviour, i.e., violations, control errors, traffic errors, stunts, and protective equipment. The MRBQ, along with measures of socio-demographic variables and the number of motorcycle crashes, was filled out by 300 young motorcycle riders who were in the age group of 18–25 years and had been riding for at least the past three years (93% males, 92.3% students). Five factors emerged out of the MRBQ after an exploratory factor analysis: traffic errors, control errors, stunts, protective equipment, and violations. Cronbach's alpha for these factors ranged from .66 to .82. Reports of performing stunts and committing violations were positively associated with self-reported near-crash experiences over the past three months. Riders reporting stunts, violations and using a motorcycle of 125-200 cc reported having received more fines in the last three months. These findings were confirmed in both univariate and multivariate binary logistic regression models. The study assessed the factor structure of a modified version MRBQ and the extracted factors associations with self-reported crash involvement. The factor structure revealed in the current study is consistent with MRBQ factor structures found in other countries. However, the support for a relationship between MRBQ factors and self-reported crashes was less significant. The findings suggest that if replicated by future studies, local policymakers are advised to focus on the five MRBQ factors while planning future interventions to achieve a reduction in the number of road crashes among motorcyclists.

1. Introduction

Every year, more than 1.2 million people lose their life due to a road traffic crash, making it one of the leading causes of death worldwide (WHO, 2018). Around 90% of the crashes occur in low and middle-income countries (LMIC) even though their contribution to the number of vehicles in the world is 54% (WHO, 2018). In India, road crashes are the sixth leading cause of death, causing immense socio-economic losses among the young-aged population of the country (WHO, 2018; Gururaj, 2014). The economic growth in India has contributed to a sharp increase in the motorization of transportation. This surge in motorization, coupled with the expansion of the road network, has brought with it the challenge of addressing adverse factors such as the increase in road crashes. The national crime records bureau of India indicated that around 150,785 people were killed, and 494,624 were injured due to road traffic injuries in 2016 (MoRTH: Annual report, 2019). There has been a fourfold increase in the number of road traffic crashes in India during the last four decades accompanied by 9.8 times increase in the fatalities associated with road crashes. Road traffic injuries place a massive burden on the healthcare sector in terms of hospitalization and rehabilitation (Gururaj, 2014). In a report published by the Government of India, 21.1 and 23.2% of fatal crash victims were in the age group of 18–25 years in 2016 and 2017, respectively (MoRTH: Annual report, 2019).

Motorized two-wheelers comprise 70% of the total vehicle population in India. In India, as per the Motor Vehicles act of 1988, applications for the provisional driving licence can be made from the age of 16 years. An applicant has to attain the age of 18 to start the licensing procedure for a geared motorcycle with an engine capacity of 100 cc or above. There is no doubt that riding a motorcycle is the most common mode of transportation in India and motorcyclists are vulnerable to road traffic injuries (RTIs), even more so because in case of a collision, their bodies are exposed directly to an obstacle or another vehicle (Gururaj, 2014). This vulnerability is reflected in the crash statistics from India, where motorcyclists account for a substantial share of crashes with 33.8% in 2016 and 33.9% in 2017, respectively (MoRTH: Annual report, 2019).

Young novice riders form a target group of interest due to two factors, i.e., experience and age (Robbins & Chapman, 2019). First, crash risk is higher for young drivers due to lack of experience, for instance, in comprehending, assessing and responding to hazards (Ross et al., 2014). Similar issues with experience could be at play for inexperienced motorcycle riders. Second, related to age, risky driving amongst young drivers has been theoretically explained by neurocognitive evidence that suggests an imbalance between the development of the social-affective brain and the cognitive control system during the transition period from child to adult (Ross et al., 2016). The brain's socio-emotional reward system shows early adolescent remodelling while the cognitive control system (e.g., inhibitory control, working memory, mental flexibility, and planning) matures more gradually, well into people's 20s. This maturational gap between both brain systems makes it difficult for youngsters to self-regulate impulsive responses, which is even more pronounced in males than in females. One explanation for this sex difference is that male road users, compared with female road users, prioritize the benefits of risk taking over the costs associated with it (Ross et al., 2016; Robbins & Chapman, 2019). Again, the same could be applied to young motorcycle riders as well. Young adult riders were indeed found to be prone to risk taking in response to highly social-affective situations such as the presence of a peer passenger or riding highly powered motorcycles (Mullin, 2000). Furthermore, in a case control study conducted by Mullin (2000) among motorcyclists, it was reported that there was a strong and consistent negative relationship between riders' age and their risk of moderate to fatal injuries (Ruikar, 2013).

Globally, road crashes have become the 8th leading cause of death worldwide for all age groups and the 1st leading cause of death among the young-aged population (WHO, 2018). Riders in the age range of 18–25 years contribute to 41.4% of India's total road crash victims (MoRTH: Annual report, 2019). Several studies conducted in India (Gururaj, 2014; Ruikar, 2013) have indicated the vulnerability of young riders for road crashes. In Udupi district, with the university town Manipal at its centre and where the current study took place, there were 787 crashes with motorcyclists in the first half of 2015, among which 41 school and college-going students (Udupi district police, 2015). Nearly 10% of all victims in traffic were in the age range of 18–25 years, and 33% of them were motorcycle users (Udupi district police, 2015). It should be noted that many of the road crashes cases in India are underreported due to less awareness about the reporting procedure or informal settlement of road crashes between the parties involved (Dandona et al., 2008).

Individual rider characteristics such as young age, male gender, low economic and social status, and risky behaviours such as speed violations, not obeying traffic laws, competing with other fellow riders are the key factors causing motorcycle crashes among young riders (Sexton et al., 2004; Lin & Kraus, 2009; Elliott et al., 2007). Risky rider behaviours may have different psychological motives because those behaviours might be intentional or nonintentional. Behaviours like not allowing enough time to stop at traffic lights, making inappropriate headway may result from inexperience and are hence considered as nonintentional behaviours (Lin & Kraus, 2009). Behaviours such as speeding, riding under the influence of alcohol, not wearing protective clothing are mostly conscious related decisions and thus might be considered intentional, although instances can be identified in which for example speeding is not intentional, for example because riders are not aware of the speed limit for a specific road section or do not regularly attend to the speedometer (Stephens et al., 2017, Sullman & Taylor, 2010). Also, a distinction is made in the literature between violations and errors, where the former originate from social and motivational factors such as operational procedures, codes of practices rules, and norms whereas the latter are the results from failures in information processing by the individual resulting in slips, lapses, and mistakes (Parker et al., 1995). To bring forward interventions aimed at reducing road crashes, the behaviours that are associated with crash risks among motorcyclists need to be thoroughly understood. To this end, Elliott et al. (2007) developed the motorcycle rider behaviour questionnaire (MRBQ) based on the driver behaviour questionnaire (DBQ) that has been widely used, for example to assess driver behaviour in relation to crash involvement among truck drivers Sullman and Taylor (2010) and car drivers Dimmer and Parker (1999) in different countries. Studies show that participants who have a higher score on the DBQ are more likely to be involved in crashes in the past as well as in the future (From Winter & Dodou, 2012; Gupta et al., 2021). The need for a tool that enhances the understanding of the involvement of human factors in motorcycle crashes led to the development of the MRBQ. Relevant items for motorcyclists were selected from the DBQ and also new items explicitly related to motorcycling were added to develop the MRBQ (Elliott et al., 2007). The MRBQ was developed along similar lines with DBQ to measure errors and violations in motorcycle riding behaviour. It also included a domain on the use of motorcycle protective equipment. Specifically, the MRBQ contains 43 items using six point Likert scales (1 = never, 2 = hardly ever, 3 = occasionally, 4 = quite often, 5 = frequently, and 6 = nearly all the time) that was developed to assess five aspects of risky motorcycle rider behaviour, i.e., violations (e.g., fail to notice or anticipate that another vehicle might pull out in front of you and have difficulty stopping), traffic errors (e.g., going quite wide from the corner of the road when negotiating a corner), control errors (e.g., did not notice or anticipate another vehicle coming in front of you and had difficulty to stop), stunts (e.g., intentionally do a wheel spin), and wearing protective equipment (e.g., use riding boots) (Elliott et al., 2007). The MRBQ study conducted in Turkey by Özkan et al. (2012), n = 451; respondent's mean age = 33.94 years; males = 100%) among commuting motorcyclists reported five-factor MRBQ structure. A similar factor structure was also reported in a study conducted by Stephens et al. (2017) in Queensland, Australia (n = 470, respondent's mean age = 35.4 years; males = 89%). Contrary to that a four-factor solution combining control error and traffic error was reported in another study conducted by Sakashita et al. (2014) in Victoria, Australia (n = 1302; respondent's mean age = 36.0 years; males = 79.2%) among novice riders (Sakashita et al., 2014). The study by Sunday (2010) in Nigeria among commuting motorcyclists also revealed a four-factor structure (n = 500; respondent's mean age = 27.0 years; males = 100%) (Sunday, 2010). The application of MRBQ lies in identifying behaviours that increases the likelihood of motorcycle crashes. For example, speed violations and control/traffic errors are the significant behavioural factors affecting motorcyclists' crash risk (Sunday, 2010). Nevertheless, performing stunts was the unique MRBQ factor that correlated with crash involvement among Australian motorcyclists in Queensland (Stephens et al., 2017). Similarly, this factor was the primary determinant of active crashes (i.e., hitting another road user or an obstacle) and traffic offences (related to parking, overtaking, speeding or other traffic violations) for Turkish riders (Özkan et al., 2012). To date, most of the MRBQ studies have been conducted in high-income countries like Australia and the United Kingdom (Stephens et al., 2017; Elliott et al., 2007; Sakashita et al., 2014) or in countries where motorcycling is used for adventure riding or pleasure-seeking as in Turkey (Özkan et al., 2012). It is important to investigate risky riding behaviour in LMICs like India where motorcycles are the primary mode of commuting (MoRTH: Annual report, 2019). To the best of our knowledge, the MRBQ has not been tested in India yet. Therefore, the current study aimed to examine the factor structure of a modified version MRBQ among young motorcycle riders for use in India. In addition, we assessed whether the extracted MRBQ factors were associated with self-reported crash involvement, violations and the number of fines paid to examine the MRBQ's potential in predicting risky riding behaviour among the young riders.

2. Method

2.1. Participants and procedure

Study participants were young motorcyclists in Manipal, a locality of Udupi city, which is situated at the southwest coast of India bordering the Arabian Sea in the province Karnataka. Manipal is an international university town that is home to 30,000 students from all corners of India and 60 countries across the world. It is one of the fastest-growing cities of India. The main eligibility criteria for study participation were that participants (1) should have a motorcycle of 100 cc or above, (2) either hold a motorcycle learners' licence or permanent licence, and (3) have been riding regularly for the past three years. The data collection period ranged from March to September 2018.

A convenience sampling technique was used in this study to recruit 300 young motorcyclists in the age range of 18–25 years from the regional transport office and various colleges in the city. Convenience sampling was chosen because participant recruitment was being subjected to the opening hours of the colleges and the regional transport office. The questionnaire was given to eligible participants in hard copy paper format and was filled out by the participants themselves after taking written informed consent from the participants. To maintain confidentiality and anonymity no names were recorded. The study was approved by the institutional ethical committee of Kasturba Medical College at Manipal Academy of Higher Education, Manipal, India (Reference number-09/2018). Since the study involved human participants, the data collection was performed in accordance with the principles of the Helsinki declaration.

2.2. Motorcycle rider behaviour questionnaire (MRBQ)

The modified MRBQ for use in India was piloted among ten motorcyclists in the age range of 18–25 years to check the suitability of the research instrument and to assess content validity. To this end, the original MRBQ questionnaire developed by Elliott et al. (2007) was first translated from English to Kannada (the local language) and then back-translated to English by another person who was fluent in both languages to check for correct translation. The questionnaire was well understood by the participants. However, the pilot study findings showed that seven out of ten participants were not using a helmet and used a mobile phone while driving, which confirms earlier research that suggests that motorcyclists use mobile phones while driving (Save life foundation, 2017). Also, inconsistent helmet usage is prevalent, especially in the coastal cities of Western India, because of the humid weather conditions (Sreedharan et al., 2010; Hassan et al., 2017). Therefore, it was decided to add questions about helmet use and mobile phone usage to the modified version of the MRBQ. It should be noted that the original MRBQ does not have any questions on helmet and mobile phone usage. Besides the MRBQ items, the questionnaire assessed motorcyclist's socio-demographics, motorcycle ownership details, crash involvement, and fines paid. The first component included information on socio-demographic variables such as age, gender, education, and occupation. For the details regarding their motorcycles and driving, participants provided information on the type of motorcycle and the average riding hours in a week. Participants were also asked to provide information on their crash history during the past three months, including severe crash injuries (1 = none, 2 = one, 3 = two or more), mild crash injury (1 = none, 2 = one, 3 = two or more), and near-crash experience (1 = none, 2 = one, 3 = two or more).

2.3 Data analysis

The data were entered and subsequently analysed using IBM's statistical package SPSS version 22. The factor structure of the MRBQ was determined using exploratory factor analysis with Principal Axis Factoring (PAF) and direct Oblimin method. The associations between MRBQ factors and crash-related outcomes were explored using univariate and multivariate binary logistic regression. The univariate analysis is relevant for determining possible targets for future intervention programmes, while the multivariate analysis provides information about the unique contribution of each factor in predicting crash experience and receiving fines while controlling for the other MRBQ factors and the overall variance explained (Crutzen, 2021). To this end, the outcome variables were recoded into a binary variable with no = 0, if no crash or near-crash involvement is reported or no fines have been paid, and yes =1, if participants reported one or more crash or near-crashes and fines paid. The cut off for p value was set at 0.05, and the odds ratio for each independent variable was calculated at a 95% confidence interval.

3. Results

3.1 Participant characteristics

Out of the 300 participants, 52.7% were in the age group of 18–20 years, followed by 32 and 15.3% in the age range of 21–23 and 24–25 years respectively (M = 20.91; SD = 2.06) (see Table 1). The majority of the respondents (93%) in the study were males, which is in line with observations that suggest there are fewer female than male riders overall, particularly on higher-powered non-moped/scooter type models (MoRTH: Annual report, 2019). Females usually ride a moped or a gearless scooter. Almost all (92.3%) participants were college students. Out of the 300 participants, 57.6% rode motorcycles with a power range between 125 cc to 200 cc, and 40.7% rode motorcycles between 100 cc to 125 cc. Just 1.7% % of the participants reported riding motorcycles with more than 500 cc. Weekly, 46.3% of the participants, rode less than 5 h, and 36.4 and 17.3% of them reported average hours of riding between 5 and 10 h and more than 10 h, respectively.

3.2 Crash experience

Table 1 also describes the crash experiences of study participants. The majority of the participants (74.7%) were not involved in any severe injury crashes over the past three months. However, 42.4% of the participants got one or more mild injuries, and 46.3%

experienced damage to some part of their motorcycle during the past three months. Out of the total participants, 47.3% experienced near-crash experience once or more over the past three months.

Table 1: Participant characteristics & crash experience

Age	% (n)	Mean	Standard deviation
18-20	52.7 (159)	20.91	2.06
21-23	32 (96)		
24-25	15.3 (45)		
Gender	**%(n)**		
Male	93 (279)		
Female	7 (21)		
Education	**%(n)**		
Illiterate	1.3 (4)		
SSLC	3.7 (11)		
Graduate	82.3 (247)		
Postgraduate	12.7 (38)		
Category	**%(n)**		
Student	92.3 (277)		
Employed	7 (21)		
Unemployed	0.7 (2)		
Type of Motorcycle	**%(n)**		
100cc-125cc	40.7(122)		
125cc-200cc	57.6 (173)		
More than 500cc	1.7 (5)		
Average hours of riding in a week			
Number	**%(n)**		
Less than 5 hours	46.3 (139)		
5-10 hours	36.4 (109)		
>10 hours	17.3 (52)		
The number of severe injury crashes they were involved in over the past three months			
Number	**%(n)**		
None	74.7 (224)		
One	17 (51)		
Two or more	8.3 (25)		
Light/mild injury crashes			

Age	% (n)	Mean	Standard deviation
Number	%(n)		
None	57.7 (173)		
One	36.7 (110)		
Two or more	5.7 (17)		
Material damage crash (Damage to some part of the motorcycle)			
Number	%(n)		
None	53.7 (161)		
One	35 (105)		
Two or more	11.3 (34)		
Near crash experience over the past three months			
Number	%(n)		
None	52.7 (158)		
One	34.3 (103)		
Two or more	13 (39)		

3.3 Factor analysis of the MRBQ

The factor analysis was performed to identify the optimal factor structure of the MRBQ in the Indian setting (see Table 2). The exploratory analysis of the MRBQ items revealed five factors (loading cut-off point = 0.3). The original five-factor names were retained for the present factors due to their similarity with previously reported factors (Elliott et al., 2007). Seven items loaded on factor 1'traffic errors' (α = .66), nine items loaded on factor 2 'control errors' (α = .69), nine items loaded on factor 3 'usage of protective equipment' (α = .82), two items loaded on factor 4 'stunts' (α = .79), and, finally nine items loaded on factor 5 'violations' (α = .80). The items with low factor loadings (<.30) were omitted from the model. Among the five identified factors, protective equipment, violations, and stunts have a good internal consistency of .82, .80, and .79, respectively. The total Cronbach's alpha of the MRBQ scale was .80, which indicates a good internal consistency and suggests that all the factors measure a common underlying theme (i.e., risky riding behaviour). The factor traffic errors explained the largest share of variance in the data (15%), while the other factors control errors, protective equipment, stunts, and violations accounted for 10, 6, 5, and 3% of the variance, respectively (Table 2). There were some differences among the factor loadings when comparing the original MRBQ context (Elliott et al., 2007) to the modified MRBQ in the Indian context (see Table 3). Two items ("driving in between two lanes of fastmoving traffic"; "go extremely fast towards a corner that you will feel scared"), which loaded onto the stunts factor for the UK participants, but loaded under traffic errors and control errors respectively among the Indian participants. Two items that were added to the original MRBQ to assess mobile phone usage ("talk on the mobile phone while riding," "texting and driving") while driving loaded onto the violations factor in the current study. Three items related to helmet usage ("use helmet while riding," "comfortable in using helmet" & "not using helmet while riding slowly") that were added to the original MRBQ were omitted from the model due to low factor loadings (<.30). Also, one item (engage in racing with other riders or drivers) loaded under violations in the current study, but loaded under stunts in the original study conducted by Elliott et al. (2007). Table 4 shows the correlations among the MRBQ factors. Traffic errors showed strong positive correlations with control errors, stunts, and violations, whereas it was weaker and negatively correlated with protective equipment. Strong positive correlations were further found for violations with control errors and stunts. Protective equipment showed moderate negative associations with control errors and stunts.

Table 2: Factor structure and loadings of the MRBQ items

Questions	1 Traffic errors	2 Control errors	3 Protective equipment	4 Stunts	5 Violations
1. Drive the vehicle so fast into a corner (or curve) until you feel that you might lose control	0.30				
2. When riding at the same speed as other traffic, when the traffic light indicates to stop, it becomes difficult to stop in time	0.44				
3. Going quite wide from the corner of the road when negotiating a corner	0.47				
4. Failing to notice a pedestrian waiting at a crossing when the lights have just turned red	0.52				
5. Failing to notice the pedestrians are crossing when turning onto a side street from the main road	0.43				
6. Attempting to overtake someone without noticing a right turn signal	0.38				
7. Driving in between two lanes of fast-moving traffic	0.37				
8. Go onto the main road in front of a vehicle that you did not notice or whose speed you had misjudged		0.30			

Questions	1 Traffic errors	2 Control errors	3 Protective equipment	4 Stunts	5 Violations
9. Did not notice or anticipate another vehicle coming in front of you and had difficulty to stop		0.39			
10. Being distracted or pre-occupied, you suddenly realize that the vehicle in front has slowed, and you have to apply the brake hard to avoid a collision		0.37			
11. Not noticing someone stepping out from a parked vehicle and it is too late for you to stop your vehicle to avoid collision with him		0.49			
12. Go extremely fast towards a corner that you will feel scared		0.34			
13. While waiting for your turn to turn left on the main road, you pay such close attention to the main traffic that you are almost about to hit a vehicle that is in your front		0.43			
14. Need to brake or back-off when negotiating a bend		0.39			
15. Skidding on wet road or manhole cover, road marking, etc.		0.52			
16. You go so close to the vehicle at the front that it becomes difficult to stop in an emergency		0.53			
17. Use motorcycle protective trousers (leather or non-leather)			0.69		
18. Use motorcycle boots			0.77		
19. Use motorcycle protective jacket (leather or non-leather)			0.83		
20. Use body armor/shock protectors (e.g., elbow, shoulder, knee)			0.78		
21. Bright/fluorescent stripes/ patches on your clothing			0.72		
22. Use Leather one-piece motorcycle suit			0.57		
23. Use Bright/fluorescent clothing			0.45		
24. Use motorcycle gloves			0.74		
25. Do you wear any motorcycle-specific protective clothing			0.69		
26. Attempt or done a wheelie				-0.37	
27. Intentionally doing a wheel spin				-0.42	

Questions	1 Traffic errors	2 Control errors	3 Protective equipment	4 Stunts	5 Violations
28. Exceed the speed limit in a motorway					--0.59
29. Exceed the speed limit on rural roads					-0.53
30. Exceed the speed limit in a residential road (Colony road)					0.41
31. Talk on the mobile phone while riding					0.75
32. Texting and driving					0.66
33. Ignore the speed limit at late night or early morning					-0.61
34. Going very fast in a country road					-0.67
35. Engage in racing with other riders or drivers					-0.45
36. Going fast from the traffic lights to defeat the driver/rider in front of you					-0.36
α	0.66	0.69	0.82	0.79	0.80
R^2	15%	10%	6%	5%	3%
Mean	2.02	2.26	5.07	1.49	2.24
SD	0.67	0.62	1.01	0.90	0.82

Table 3: Factor structure of the original MRBQ (Elliot et al., 2007) compared to the present study in the Indian context

Questions	Original MRBQ	Modified MRBQ
1. Drive the vehicle so fast into a corner (or curve) until you feel that you might lose control	Traffic errors	Traffic errors
2. When riding at the same speed as other traffic, when the traffic light indicates to stop, it becomes difficult to stop in time	Traffic errors	Traffic errors
3. Going quite wide from the corner of the road when negotiating a corner	Traffic errors	Traffic errors
4. Failing to notice a pedestrian waiting at a crossing when the lights have just turned red	Traffic errors	Traffic errors
5. Failing to notice the pedestrians are crossing when turning onto a side street from the main road	Traffic errors	Traffic errors
6. Attempting to overtake someone without noticing a right turn signal	Traffic errors	Traffic errors
7. Driving in between two lanes of fast-moving traffic	Stunts	Traffic errors

Questions	Original MRBQ	Modified MRBQ
8. Go onto the main road in front of a vehicle that you did not notice or whose speed you had misjudged	Control errors	Control errors
9. Did not notice or anticipate another vehicle coming in front of you and had difficulty to stop	Control errors	Control errors
10. Being distracted or pre-occupied, you suddenly realize that the vehicle in front has slowed, and you have to apply the brake hard to avoid a collision	Control errors	Control errors
11. Not noticing someone stepping out from a parked vehicle and it is too late for you to stop your vehicle to avoid collision with him	Control errors	Control errors
12. Go extremely fast towards a corner that you will feel scared	Stunts	Control errors
13. While waiting for your turn to turn left on the main road, you pay such close attention to the main traffic that you are almost about to hit a vehicle that is in your front	Control errors	Control errors
14. Need to brake or back-off when negotiating a bend	Control errors	Control errors
15. Skidding on wet road or manhole cover, road marking, etc.	Control errors	Control errors
16. You go so close to the vehicle at the front that it becomes difficult to stop in an emergency	Control errors	Control errors
17. Use motorcycle protective trousers (leather or non-leather)	Protective equipment	Protective equipment
18. Use motorcycle boots	Protective equipment	Protective equipment
19. Use motorcycle protective jacket (leather or non-leather)	Protective equipment	Protective equipment
20. Use body armor/shock protectors (e.g., elbow, shoulder, knee)	Protective equipment	Protective equipment
21. Bright/fluorescent stripes/patches on your clothing	Protective equipment	Protective equipment
22. Use Leather one-piece motorcycle suit	Protective equipment	Protective equipment
23. Use Bright/fluorescent clothing	Protective equipment	Protective equipment
24. Use motorcycle gloves	Protective equipment	Protective equipment
25. Do you wear any motorcycle-specific protective clothing	Protective equipment	Protective equipment
26. Attempt or done a wheelie	Stunts	Stunts
27. Intentionally doing a wheel spin	Stunts	Stunts
28. Exceed the speed limit in a motorway	Violations	Violations

Questions	Original MRBQ	Modified MRBQ
29. Exceed the speed limit on rural roads	Violations	Violations
30. Exceed the speed limit in a residential road (Colony road)	Violations	Violations
31. Talk on the mobile phone while riding	New addition	Violations
32. Texting and driving	New addition	Violations
33. Ignore the speed limit at late night or early morning	Violations	Violations
34. Going very fast in a country road	Violations	Violations
35. Engage in racing with other riders or drivers	Stunts	Violations
36. Going fast from the traffic lights to defeat the driver/rider in front of you	Violations	Violations

Table 4: Correlations between MRBQ factors

	Traffic errors	Control errors	Protective Equipment	Stunts	Violations
Traffic errors		0.65*	-0.25*	0.32*	0.45*
Control errors			-0.27*	0.23*	0.39*
Protective Equipment				-0.19*	-0.06
Stunts					0.46*
Violations					

*Note: *p < 0.05*

3.4 Factors associated with crash involvement in the last three months

Table 5 shows the results of the regression analysis for crash involvement in the last three months. There was no association between crash involvement and the type of motorcycle, (Wald (2, N = 300) = 2.81, p = .25), and average hours of riding in a week (Wald (2, N = 300) = 1.09, p = .58). The MRBQ stunt factor was dummy coded into less or equal to median and more than median. The factors traffic errors, control errors, violations, and protective equipment were categorized into lower, second, third, and upper quartile. No significant associations were found between the MRBQ factors and crash involvement in the last three months (stunts: (Wald (1, N = 300) = 3.30, p = .07); (traffic errors: (Wald (3, N = 300) = 2.81, p = .42); (control errors: (Wald (3, N = 300) = 3.69, p = .30); (violations: (Wald (3, N = 300) = 4.84, p = .18). There was a significant negative association between wearing protective equipment and severe crash involvement (Wald (3, N = 300) = 8.22, p = .04). Posthoc comparisons showed that participants who scored more in the second and third quartile were less likely to be involved in severe crashes. Multiple logistic regression was not performed in this case because only one variable (protective equipment) was statistically significant in the univariate analysis.

Table 5: Factors associated with severe crash injury over the past three months

Variable	**Crashed %**	**Not crashed %**	**OR**	**95% CI**	***p*-value**
		Type of motorcycle			
100cc-125cc	23.8	76.2	Referent		
125cc-200cc	25.4	74.6	0.91	(0.53-1.57)	0.74
More than 500cc	60	40	0.21	(0.03-1.31)	0.09
		Average hours of riding in a week			
< 5 hours	26.6	73.4	Referent		
5-10 hours	22	78	1.29	(0.71-2.32)	0.40
> 10 hours	15	37	0.89	(0.44-1.82)	0.76
		Stunts (MRBQ)			
Stunts	Yes	No	OR	95% CI	*p*-value
Less than or equal to median	46.8	53.2	Referent		
More than median	55.7	44.3	1.64	(0.96-2.83)	0.07
		Traffic errors (MRBQ)			
Traffic errors	Yes	No	OR	95% CI	*p*-value
Lower quartile	46.7%	53.3%	Referent		
Second quartile	47.1%	52.9%	0.63	(0.31-1.27)	0.19
Third quartile	55.2%	44.8%	1.09	(0.53-2.26)	0.81
Upper quartile	51.8%	48.2%	0.94	(0.43-2.05)	0.88
		Control errors (MRBQ)			
Control errors	Yes	No	OR	95% CI	*p*-value
Lower quartile	37.8%	62.2%	Referent		
Second quartile	53.3%	46.7%	1.42	(0.69-2.92)	0.35
Third quartile	58.1%	41.9%	1.32	(0.59-2.92)	0.5
Upper quartile	51.5%	48.5%	2.06	(0.98-4.36)	0.06
		Violations (MRBQ)			
Violations	Yes	No	OR	95% CI	*p*-value
Lower quartile	44.3%	55.7%	Referent		
Second quartile	42.9%	57.1%	0.86	(0.36-2.06)	0.73

Variable	**Crashed %**	**Not crashed %**	**OR**	**95% CI**	***p*-value**
Third quartile	51.9%	48.1%	1.75	(0.88-3.48)	0.11
Upper quartile	59.0%	41.0%	1.65	(0.76-3.58)	0.21
		Protective equipment (MRBQ)			
Protective equipment	Yes	No	OR	95% CI	*p*-value
Lower quartile	36.7%	63.3%	Referent		
Second quartile	19.0%	81.0%	0.41	(0.19-0.88)	0.02*
Third quartile	19.6%	80.4%	0.42	(0.21-0.83)	0.01*
Upper quartile	26.2%	73.8%	0.61	(0.29-1.27)	0.19

*Note: *p < 0.05*

3.5 Factors associated with near-crash experience over the past three months

Table 6 shows the results of the regression analysis for near-crash experience over the past three months. There was no association between near-crash experience and the type of motorcycles (Wald (2, N = 300) = 1.45, p = .48), No significant associations were found for traffic errors (Wald (3, N = 300) = 3.18, p = .37) and wearing protective equipment (Wald (3, N = 300) = 4.16, p = .25) with near-crash experiences. However, stunts, control errors, violations and average hours of riding in a week (5–10 h) showed a significant association with near-crash experiences (stunts: Wald (1, N = 300) = 8.79, p = .01) (control errors: (Wald (3, N = 300) = 6.67, p = .04) (violations: Wald (3, N = 300) = 12.49, p = .01) (Average hours of riding in a week: Wald (2, N = 300) =6.22, p = .04). Posthoc comparisons showed that participants scoring in the third and upper quartile on violations were more likely to be involved in near-crash experiences over the past three months as well as those performing more stunts. Multiple logistic regression included those sociodemographic variables and MRBQ factors that showed significant univariate associations with near-crash involvement, namely average hours of riding, stunts, control error, violation and protective equipment. Among these, stunts (Wald (1, N = 300) = 7.42, p = 0.04) and violations (Wald (3, N = 300) = 10.54, p = 0.04) showed unique significant associations with near-crash involvement (see Table 6).

Table 6: Factors associated with near-crash experience over the past three months

Variable	Crashed %	Not crashed %	OR (crude)	95% CI (crude)	*p*-value (crude)	OR (adj)	95% CI (adj)	*p*-value (adj)
		Type of motorcycle						
100cc-125cc	23.8%	76.2%	Referent					
125cc-200cc	25.4%	74.6%	1.15	(0.19-7.14)	0.88	-	-	-

Variable	Crashed %	Not crashed %	OR (crude)	95% CI (crude)	p-value (crude)	OR (adj)	95% CI (adj)	p-value (adj)
More than 500cc	60%	40%	1.51	(0.25-9.31)	0.65	-	-	-
	Average hours of riding in a week							
< 5 hours	26.6%	73.4%	Referent					
5-10 hours	22%	78%	1.81	(1.08-2.98)	0.02*	1.65	(0.95-2.85)	0.07
> 10 hours	28.8%	71.2%	1.78	(0.94-3.39)	0.07	1.52	(0.76-3.01)	0.24
		Stunts (MRBQ)						
Stunts	Yes	No	OR	95% CI	p-value	OR (adj)	95% CI (adj)	p-value (adj)
Less than or equal to median	41.4%	58.6%	Referent					
More than median	59.8%	40.2%	**2.11**	(1.29-3.45)	**0.01***	**1.74**	**(1.03-2.44)**	**0.04***
		Traffic errors (MRBQ)						
Traffic errors	Yes	No	OR	95% CI	p-value	OR (adj)	95% CI (adj)	p-value (adj)
Lower quartile	48%	52%	Referent					
Second quartile	46.1%	53.9%	0.93	(0.51-1.68)	0.8	-	-	-
-	55.2%	44.8%	1.34	(0.69-2.59)	0.39	-	-	-
Upper quartile	39.3%	60.7%	0.7	(0.35-1.41))	0.32	-	-	-
		Control errors (MRBQ)						
Control errors	Yes	No	OR	95% CI	p-value	OR (adj)	95% CI (adj)	p-value (adj)
Lower quartile	39%	61%	Referent					
Second quartile	53.3%	46.7%	1.78	(0.97-3.28)	0.06	0.76	(0.39-1.47)	0.41)
Third quartile	56.5%	43.5%	2.02	(1.04-3.96)	0.04*	0.66	(0.32-1.37)	0.27
Upper quartile	40.9%	59.1%	1.08	(0.56-2.10)	0.82	1.75	(0.81-3.75)	0.15
		Violations (MRBQ)						
Violations	Yes	No	OR	95% CI	p-value	OR (adj)	95% CI (adj)	p-value (adj)
Lower quartile	36.7%	63.3%	Referent					

Variable	Crashed %	Not crashed %	OR (crude)	95% CI (crude)	*p*-value (crude)	OR (adj)	95% CI (adj)	*p*-value (adj)
Second quartile	35.7%	64.3%	0.96	(0.47-1.95)	0.91	1.21	(0.57-2.56)	0.63
Third quartile	53.8%	46.2%	**2.01**	(1.11-3.66)	**0.02***	0.57	(0.3-1.07)	0.08
Upper quartile	60.7%	39.3%	**2.66**	(1.34-5.29)	**0.01***	**2.08**	**(1.08-4.68)**	**0.03***
	Protective equipment (MRBQ)							
Protective equipment	Yes	No	OR	95% CI	*p*-value	OR (adj)	95% CI (adj)	*p*-value (adj)
Lower quartile	44.3%	55.7%	Referent					
Second quartile	52.4%	47.6%	0.72	(0.37-1.40)	0.34	0.78	(0.38-1.62)	0.51
Third quartile	59.8%	40.2%	**0.53**	(0.29-0.98)	**0.04***	0.55	(0.29-1.06)	0.07
Upper quartile	52.5%	47.5%	0.72	(0.37-1.41)	0.72	0.85	(0.4-1.81)	0.68

*Note: *significant at p < .05*

3.6 Fines paid due to traffic violations in the last three months

Table 7 shows the results of the regression analysis for fines paid due to a traffic violation in the last three months. There was no association between fines paid and average hours of riding in a week (Wald (2, N = 300) = 2.56, p = .28). There was a significant association between type of motorcycles (125 cc–200 cc) and fines paid (Wald (2, N = 300) = 5.81, p = .01). Posthoc comparisons showed that those riding a motorcycle of 125 cc– 200 cc were more likely to have paid a fine in the last three months than those with lighter motorcycles. This difference was not found among those with heavier motorcycles. No significant associations were found between wearing protective equipment and fines paid (protective equipment: Wald (3, N = 300) = 2.61, p = .46).

Table 7: Factors associated with fines paid for traffic violation in the last three months

Variable	Paid %	Not Paid %	OR	95% CI	*p*-value	OR (adj)	95% CI (adj)	*p*-value (adj)
	Type of motorcycle							
100cc-125cc	28.7%	71.3%	Referent					
125cc-200cc	41.0%	59.0%	**1.73**	1.05-2.84	**0.03***	**1.53**	**(1.10-2.59)**	**0.01***
More than 500cc	60.0%	40.0%	0.27	0.04-1.67	0.16	2.17	(0.32-14.92)	0.43

Variable	Paid %	Not Paid %	OR	95% CI	p-value	OR (adj)	95% CI (adj)	p-value (adj)
Average hours of riding in a week								
< 5 hours	31.7%	68.3%	Referent					
5-10 hours	39.4%	60.6%	1.59	0.82-3.05	0.17	-	-	-
> 10 hours	42.3%	57.7%	1.12	0.56-2.20	0.73	-	-	-
Stunts (MRBQ)								
Stunts	**Yes**	**No**	**OR**	**95% CI**	**p-value**	**OR (adj)**	**95% CI (adj)**	**p-value (adj)**
Less than or equal to median	22.2%	77.8%	Referent					
More than median	32%	68%	**1.65**	(1.01-2.72)	**0.04***	**1.16**	**(1.02-2.04)**	**0.03***
Traffic errors (MRBQ)								
Traffic errors	**Yes**	**No**	**OR**	**95% CI**	**p-value**	**OR (adj)**	**95% CI (adj)**	**p-value (adj)**
Lower quartile	28%	72%	Referent					
Second quartile	19.6%	80.4%	0.79	(0.42-1.51)	0.48	1.58	(0.80-3.13)	0.19
Third quartile	29.9%	70.1%	1.19	(0.6-2.37)	0.62	1.24	(0.57-2.69)	0.58
Upper quartile	26.8%	73.2%	**2.31**	(1.13-4.70))	**0.02***	1.24	(0.51-3.00)	0.61
Control errors (MRBQ)								
Control errors	**Yes**	**No**	**OR**	**95% CI**	**p-value**	**OR (adj)**	**95% CI (adj)**	**p-value (adj)**
Lower quartile	19.5%	80.5%	Referent	.				
Second quartile	25.6%	74.4%	**1.97**	(1.02-3.81)	**0.04***	1.72	(0.84-3.50)	0.14
Third quartile	24.2%	75.8%	1.7	(0.83-3.52)	0.15	1.37	(0.62-3.01)	0.44
Upper quartile	33.3%	66.7%	**2.92**	(1.45-5.86)	**0.01***	1.96	(0.83-4.65)	0.13
Violations (MRBQ)								
Violations	**Yes**	**No**	**OR**	**95% CI**	**p-value**	**OR (adj)**	**95% CI (adj)**	**p-value (adj)**
Lower quartile	25.3%	74.7%	Referent					
Second quartile	30.4%	69.7%	1.29	(0.6-2.76)	0.51	1.10	(0.49-2.44)	0.81
Third quartile	42.3%	57%	**2.16**	(1.14-4.10)	**0.02***	1.71	(0.85-3.41)	0.13
Upper quartile	45.9%	54.1%	**2.5**	(1.22-5.11)	**0.01***	**1.47**	**(1.26-3.36)**	**0.03***
Protective equipment (MRBQ)								
Protective equipment	**Yes**	**No**	**OR**	**95% CI**	**p-value**	**OR (adj)**	**95% CI (adj)**	**p-value (adj)**
Lower quartile	36.7%	63.3%	Referent					
Second quartile	19%	81%	0.62	(0.31-1.23)	0.17	-	-	-
Third quartile	19.6%	80.4%	0.65	(0.35-1.2)	0.17	-	-	-
Upper quartile	26.2%	73.8%	0.8	(0.4-1.59)	0.52	-	-	-

*Note: *p < 0.05*

4. Discussion

The present study aimed to determine the most appropriate factor structure of the modified version of the MRBQ among the motorcyclists in Manipal, India, and secondly, to assess which MRBQ factors are associated with self-reported crash involvement and violations.

4.1 The MRBQ factor structure

The exploratory factor analysis for the MRBQ questionnaire revealed a 36-item five-factor solution, namely traffic errors, control errors, stunts, protective equipment, and violations. The five-factor structure that emerged out of the current study was similar to the factor structure in studies conducted in Australia, the UK, and Turkey, respectively (Stephens et al., 2017; Elliott et al., 2007; Özkan et al., 2012). Out of the five identified factors, protective equipment, violations, and stunts, reported a good internal consistency. Traffic errors contained seven items, control errors and protective equipment nine items each, stunts contained two items, and violations had nine items. The items added to assess mobile phone usage behaviour while riding got loaded under the violations factor. A significant proportion of the participants talk (25.3%) and text (34.8%) on their mobile phones while riding. Globally, these findings are consistent with the studies conducted in Mexico and Vietnam. The study results in Mexico showed that the prevalence of mobile phone usage was high among motorcyclists of all age groups (Pérez-Núñez et al., 2013). Similar results were also reported in Vietnam, where high mobile phone usage was reported among young motorcyclists (Truong et al., 2018). From the Indian perspective, these results align with studies conducted by Save LIFE Vodafone Foundation and in Kerala, India that reported high usage of mobile phones among young riders while riding (Save life foundation, 2017; Hassan et al., 2017). The three items related to helmet usage (i.e., use helmet while riding, comfortable in using helmet, and not using helmet while riding slowly) added in first instance to the original MRBQ were omitted from the model due to low factor loadings. Wearing a helmet is mandatory in India for two-wheelers. However, studies conducted by Hassan et al. (2017) and Sreedharan et al. (2010) reported low helmet usage in settings similar to the current study setting (Hassan et al., 2017; Sreedharan et al., 2010). This is in line with a study conducted among Iranian motorcyclists where it was reported that 67% of the motorcyclists do not use helmet while riding (Zamani-Alavijeh et al., 2011). In a study conducted by Fletcher et al. (2019) in Jamaica, low helmet usage (29.4%) was reported among young motorcyclists. This is consistent with the findings of a study conducted in Ghana, where 34.2% of the respondents use a helmet while riding (Ackaah &

Afukaar, 2010). Furthermore, in our pilot study seven out of ten respondents reported not to use a helmet while riding or only very inconsistently, which was the reason for adding the three items on helmet usage ("use helmet while riding," "comfortable in using helmet" & "not using helmet while riding slowly") to the original MRBQ. However, in our main study, 89% of the respondents reported that they use a helmet while riding at all times and also feel comfortable using the helmet. Maybe because of reasons related to socially desirable answering, but respondents were very positive about helmet usage. As a result, the variation in this variable was low, which may have resulted in the low contribution of the items to the explanation of the factor protective equipment and their non-significance in the predictions of crash experience. Overall, the item loadings for the traffic errors factor were consistent with MRBQ studies conducted in Australia, the UK and Nigeria (Stephens et al., 2017; Elliott et al., 2007; Sunday, 2010), except for the item "driving in between two lanes of fast-moving traffic", which originally loaded onto the stunts factor in the study conducted by Elliott et al. (2007) but in the current study, loaded under traffic errors. Riding in between two lanes of fast-moving traffic is considered dangerous on Indian roads and the offender can be booked under the reckless driving act (Road Safety in India: Status Report 2017). It could therefore be argued that the young respondents rated this item similar to other errors due to lack of experience (Sreeharshika & Jothula, 2021). The two items loading onto the stunts factor in the present study confirmed the findings from the previous study conducted by Elliott et al. (2007). However, the items "driving in between two lanes of fast-moving traffic," "go extremely fast towards a corner that you feel scared" and "engage in racing with other riders or drivers", which were loaded onto stunts factor in the study conducted by Elliott et al. (2007), were loaded under traffic errors, control errors and violations, respectively, in the present study. Similar to the study conducted by Save life foundation on distracted riding this can be attributed to the fact that the study respondents would have rated these items similar to other errors items due to lack of awareness regarding its danger or distracted riding which warrants further exploration. For the control error factor, it was evident that item loadings onto this factor covered behaviours that were likely to be non-intentional (e.g., "skid on a wet manhole cover") and related to speeding, careless riding, and inattentiveness (e.g., "You go so close to the vehicle at the front that it becomes difficult to stop in an emergency"). The findings of the present study confirmed the findings from the previous study conducted by Elliott et al. (2007). Lastly, in the current study, a factor related to protective equipment emerged from the data. Most of the participants have rarely used any form of protective equipment during motorcycle riding. This suggests that in India, motorcycle riders hardly use protective equipment during their day-to-day commutation.

4.2 Correlates of crash experiences

Performing stunts was positively associated with self-reported near-crash experiences over the past three months. Riders who reported attempting or have done a wheelie and intentionally spinning the wheel had more chance of getting involved in near-crash experiences. These findings were similar to findings reported by the studies conducted (Stephens et al., 2017; Özkan et al., 2012) in Australia and Turkey. The results also align with previous studies that identified stunts behaviour as the cause of crash involvement in both police reports (Sakashita et al., 2014) and self-reported incidences of crashes (Stephens et al., 2017). Beside performing stunts, riders who reported violations also had more risk of getting involved in recent near-crash experiences, which aligns with previous studies highlighting the positive association between violations and recent near-crash experiences (Stephens et al., 2017; Elliott et al., 2007; Özkan et al., 2012). In the current study, type of motorcycle, stunts and violations were positively associated with fines paid because of committing traffic violations in the last three months. Riders using motorcycles (125-200 cc), performing stunts and reporting frequent violations are more likely to pay fines compared to the riders who reported using of low-powered motorcycles, not performing stunts and committing traffic violations. These results align with previous studies' findings (Stephens et al., 2017; Elliott et al., 2007) conducted in Australia and the United Kingdom, where it was reported that performing stunts and committing traffic violations was associated with paying fines. In the Southeast Asian context, this finding is similar to a study conducted in Indonesia, which reported that young aged motorcyclists are more prone to violating traffic rules and paying fines (Susilo et al., 2015). In a study conducted by Dandona et al. (2006) in Hyderabad, India, it was found that more than one-fourth of the respondents have been penalized by traffic police for violating traffic rules. There was no association between stunts, traffic error, control error and violations with severe crash injury in the last three months. This resembles the findings of a study by Stephens et al. (2017) in Victoria, Australia, where no significant association was found between traffic error, control error and violations with severe crash injury. However, the study by Stephens et al. reported that stunts behaviour had a significant association with severe crash injury. In the present study among all the MRBQ factors, only wearing protective equipment was (negatively) associated with severe crash involvement. This corresponds to findings reported by De Rome et al. (2011) in a study conducted in the Australian Capital Territory and Erdogan et al. (2013) in Turkey. In both the studies, it was reported that using protective equipment significantly reduces the risk of injury in crash involvement. For the present study, performing stunts was not directly associated with severe crash involvement; given its association with near-crashes, there is likely to be an indirect association between stunts behaviour and crash risk. This finding is suggestive of further investigation.

5. Practical implications

As mentioned in the above, the current modified version of MRBQ can be a suitable version of MRBQ that can be used in other settings of India. The modified MRBQ can be an effective tool to investigate risky riding behaviour among at-risk young motorcyclists in India to target for intervention. The present study shows that performing stunts and reporting traffic violations were the two MRBQ factors positively associated with recent near-crash experiences among young motorcyclists. In case these findings are replicated in future research, it is thus recommended for the local policymakers to initiate targeted interventions that focus on the predictors of risky driving to reduce crash and injury rates. The current study's findings have also generated evidence for the local authorities about the importance of strict law enforcement for traffic violations. In addition, the findings of the current study may be of value for decision-makers to implement strict regulations for motorcyclists riding underage or without a proper valid licence because unless the licensing procedure in India is regulated and closely monitored, the quality of the rider will be questionable (Gupta et al., 2021; Mridula et al., 2018).

6. Limitations and future research

The focus of the study was very specific both in terms of place (i.e., Manipal) and age (i.e., young riders). Therefore, the results of this study do not simply generalize to other places and age groups. The present study needs further replication using a larger population and broader age group involvement to come to a more generalizable overview of the factor structure of the MRBQ in the Indian context. Nevertheless, internationally, the young rider population is a very important focus in traffic safety research. The other main limitation of the study was the fact that we made use of self-reported data, which could have promoted socially desirable responses (Sakashita et al., 2014; Bener et al., 2008). The key findings that emerged out of the study were that stunts and violations were the two MRBQ factors positively associated with recent near-crash experiences, which require further exploration in explicitly investigating these factors for near-crash involvement in a broader population, and why no associations were found with severe crash involvement although that may have been caused by the lower number of participants that experienced a severe crash.

7. Conclusion

In this study, the factor structure of a modified version MRBQ and the extracted factor's associations with self-reported crash involvement were assessed. Five factors, namely traffic errors, control errors, violations, stunts, and protective equipment, emerged from the modified MRBQ scale. The factor structure revealed in the current study is consistent with MRBQ factor structures found in other countries (Stephens et al., 2017; Elliott et al., 2007; Özkan et al., 2012). To the best of our knowledge, the MRBQ has not been tested in India yet. The current study contributes to the existing literature and knowledge regarding the understanding of risky motorcycle rider behaviour among young motorcyclists in India. However, the use of a convenience sample warrants further studies using the modified version of MRBQ in other settings of India to support more general use of the MRBQ in the wider Indian context to understand and evaluate motorcyclists 'risky behaviour. If replicated by future studies, local policymakers are advised to focus on these findings while identifying risky riding behaviours and the subsequent planning of behavioural, infrastructural and policy interventions to achieve a reduction in the number of road crashes among motorcyclists.

Chapter 4

A Focus Group Study to Explore Risky Ridership among Young Motorcyclists in Manipal, India

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Abstract

Road crash injuries have emerged as a significant public health issue in many low and middle-income countries in recent years. In India, motorized two-wheelers comprise 70% of the vehicle population and are considered the most vulnerable road users. Road crash injury is common among the young-aged population leading to premature deaths. It is essential to understand risky riding behaviours to develop accurate, evidence-based risk reduction programmes that fit the target population's characteristics and the intervention setting. The current study aims to improve the understanding of the typical characteristics of motorcycle crashes among young riders in India, primarily focusing on the prevalence and role of risky riding behaviours. Five focus group discussions with eight to ten participants in each group (N = 35) were conducted in Manipal, in the Karnataka state of Southwestern India. A thematic analysis was completed using MAXQDA software to identify, analyze, and report on themes within the data. Speeding, riding under the influence of alcohol, and the poor maintenance of motorcycles were indicated as leading causes of crashes. Furthermore, using mobile phones while riding, violations of the traffic rules, and helmet non-use were identified as other risky behaviours among young riders. Future research can be taken up in other settings for the target population. Generational awareness with the involvement of young riders, government authorities, university officials, and the Regional Transport Office can be initiated. Engaging young riders, government authorities, university officials, and the Regional Transport Office through behavioural interventions such as persuasive communication techniques, an active experimental approach (such as the use of a simulator) and regulating the licensing procedure can reduce the number of road crashes.

1. Introduction

Roads are the primary source of connectivity for any country, which secures socioeconomic and logistical planning (Pal et al., 2019). Motorization has improved the lives of millions of people worldwide. However, the advantages have been accompanied by a substantial cost (Gopalakrishnan, 2012). The higher density of road networks has given rise to global public health concerns, such as air pollution and increased morbidity and mortality through road traffic crashes. Road crashes have emerged as the latest Public Health challenge in Asia and Africa's low and middle-income countries (LMICs). LMICs contribute to 92% of the road traffic injuries (RTIs) associated with mortality. The economic cost involved in RTIs with a traumatic outcome varies between 1% and

2% of the total national product in LMICs, causing 1.35 million deaths and 50 million injuries every year worldwide (WHO, 2018; Chauhan et al., 2017). Road crashes in India kill almost 150,000 people annually, accounting for nearly 11% of the crash-related deaths in the world. It is expected that the total number of deaths related to RTIs will cross the 250,000 mark by 2025 (Singh, 2017). Motorcycles are one of the conventional and affordable means of transportation in LMICs. Motorcycle-related injury is common and causes premature deaths with high costs for society, especially when it concerns the young population in the productive age group (Pal et al., 2019; Hung et al., 2006). With an estimated 37 million motorcycles, India is home to one of the world's largest numbers of motorcycle users. With the exponential increase in motorcycle use in the last twenty years, road crashes involving motorcyclists have emerged as India's latest Public Health challenge (MoRTH: Annual report, 2019). Globally, one-fourth of all road crashes are among motorcyclists. What is even more concerning, however, is that in the South-East Asian and the Western Pacific regions, most deaths are among riders of motorized two and three-wheelers, who represent 43% and 36% of all deaths, respectively (WHO, 2018). It is noteworthy to mention that death rates due to road crashes among motorcyclists exceed the global average in India. Motorcyclists accounted for 30.9% of India's total fatal road crashes in 2017 (Bhalla et al., 2016). In India, motorists between 18 and 25 years-of-age are more susceptible to road crashes than any other road user category, contributing to 50% of the total crash-related deaths (MoRTH: Annual report, 2019; Bhalla et al., 2016), and accounting for 41.4% of India's total road crash victims (MoRTH: Annual report, 2019). Several studies in India have reported the vulnerability of young riders to road crashes (Bhalla et al., 2016; Ruikar, 2013). Reasons for this increased vulnerability in young riders resemble those for young car drivers. In a study by Robbins and Chapman (2019), it was reported that young people are more prone to crashes due to two factors—experience and age. Firstly, crash risk is higher for young drivers due to a lack of experience, for instance, in comprehending, assessing and responding to hazards (Robbins & Chapman, 2019; Ross et al., 2014). Similarly, experience issues could be at play for inexperienced motorcycle riders. Secondly, age-related, risky driving among young drivers has been theoretically explained by neurocognitive evidence that suggests an imbalance between the development of the social–affective brain and the cognitive control system during the transition period from childhood to adulthood (Ross et al., 2016). The brain's socio-emotional reward system shows early adolescent remodelling, while the cognitive control system (e.g., inhibitory control, working memory, mental flexibility, and planning) matures more gradually well into peoples' 20s. This maturational gap between both brain systems makes it difficult for youngsters to self-regulate impulsive responses, which is even more profound in males than in females. A possible explanation for this sex difference is that male road users, compared with female road users, prioritize the benefits of risk-taking over the costs associated with it (Robbins & Chapman, 2019; Ross et al., 2016). Applied to risky motorcycle riding, young adult riders are more vulnerable for risk-taking in response to highly social–affective situations, such as the presence of a peer passenger or riding a highly powered motorcycles (Mullin, 2000). This current study reports on a focus group study among young riders that aimed to understand the typical characteristics of motorcycle crashes. The next section is a literature review, firstly summarizing studies where a self-report instrument (i.e., the Motorcycle Rider Behaviour Questionnaire (MRBQ) has been used to associate risky ridership with several safety-indicators (e.g., crash involvement, number of violations and traffic fines). This is followed by an overview of motorcyclist crash causation with respect to three main contributory factors: human factors, vehicle factors, and environmental factors.

2. Literature Review

2.1. Risky Riding and Motorcyclist Safety: The MRBQ

According to (Elliott et al., 2007), it is important to understand how rider behaviour is related to crash risk to develop effective road safety interventions. Taking the typology behind the Driver Behaviour Questionnaire (DBQ) (Elliott et al., 2007; Reason et al., 1990) as a conceptual starting point, Elliott et al. (2007) proposed a new self-reported tool for measuring motorcyclists' behaviour named the Motorcycle Rider Behaviour Questionnaire (MRBQ). The MRBQ is a five factor tool differentiating between traffic errors (e.g., failing to notice or anticipate that another vehicle might pull out in front of you and have difficulty stopping), control errors (e.g., running wide when going round a corner), speed violations (e.g., exceeding the speed limit on rural roads), stunts (e.g., engaging in racing with other riders or drivers), and the use of protective equipment (e.g., using motorcycle gloves). The authors found that the MRBQ was able to predict crash risk for motorcyclists. More in detail, based on a sample of 8666 UK motorcyclists, they established that traffic errors were the main predictors of crash risk, and that for crashes in which respondents accepted some degree of blame, control errors and speed violations were also significant predictors (Elliott et al., 2007). Since then, the MRBQ has been used in several cultural and geographical settings (e.g., Trung Bui et al. (2020) in Vietnam; Motevalian et al. (2019) in Iran; Sunday (2010) in Nigeria;

Özkan et al. (2012) in Turkey; Sakashita et al. (2014); Stephens et al. (2017) in Australia; Sumit et al. (2021) in India; Topolšek and Dragan (2016) in Slovenia; Uttra et al. (2020) in Thailand. Even though across these different studies, the MRBQ was a significant correlate of safety-related indicators such as crash involvement, the more specific MRBQ-factors significantly correlating with safety-related indicators investigated varied, and the psychometric properties of the MRBQ were inconsistent. For example, Sunday (2010) studied commercial motorcyclists in Nigeria and found major differences between the British motorcyclists' factor structure and their Nigerian counterparts. Insufficient internal consistency and predictive validity were reported in the study by Sakashita et al. (2014) in Victoria, Australia. Moreover, the study by Nguyen et al. (2022) mentioned: "from a conceptual point of view, the MRBQ is sometimes capturing behaviours that are less suited to the particular context under study, while vice versa, the MRBQ is sometimes missing behaviours that are particularly relevant to a specific geographic or cultural region" (Nguyen et al. (2022) p. 3), which was acknowledged in other studies, such as the ones by Özkan et al. (2012), Uttra et al. (2020) and by Sumit et al. (2021). For instance, Sumit et al. (2021) added items to the original MRBQ related to mobile phone use while riding because this behaviour frequently occurs in the Indian context. In terms of factor structure and predictive validity, the authors found that the five-factor structure extracted in previous studies replicated quite well in an Indian sample of 300 young motorcycle riders (age 18–25 years), and that performance of stunts and commission of violations were the two MRBQ-factors that were positively associated with self-reported near-crash experiences. In addition, the performance of stunts, commission of violations, and use of a motorcycle of 125–200 cc were associated with an increased number of traffic fines. Furthermore, Uttra et al. (2020) presented 26 indicators that composed the motorcycle rider behaviour of Thai people. These were separated into four factors, namely traffic error, control error, stunts, and safety equipment. Unlike previous studies, the support for a relationship between the MRBQ and self-reported crash involvement was less significant. In summary, aside from some exploratory work (e.g., Hassan et al., 2017; Setty et al., 2020; Sharma et al., 2014; Shruthi et al., 2019; Sumit et al., 2021), not much is currently known about the occurrence of risky motorcyclist riding behaviours in India. Also, the focus of these studies was almost exclusively on speeding or mobile phone use, while previous work conducted in the same or neighbouring regions (i.e., South-East Asia and the Pacific) found evidence for the occurrence of multiple additional forms of risky riding, such as wrong lane use, illegal U-turns, intentional right-of-way violations, turn signal neglect, red-light running, riding in pair or a group, and alcohol-impaired riding (e.g., Nguyen et al., 2022). It remains unclear whether these manifestations of risky riding also apply to the Indian context. Furthermore, more advanced insight into the underlying psychological mechanisms that guide risky ridership among Indian motorcyclists is lacking, nor is it known what typical risk-prone circumstances trigger risky riding behaviours in India. As for the socio-cognitive determinants of risky riding, some work is available for mobile phone use (e.g., Nguyen et al., 2020; Nguyen-Phuoc et al., 2020; Truong et al., 2019), speeding (e.g., Chorlton et al., 2012; Elliott, 2010), the use of personal protective equipment and safety helmets (e.g., Ali et al., 2011; Bachani et al., 2012; Brijs et al., 2014; Norris & Myers, 2013), and a (non-) compliance to the traffic code and rules (e.g., Susilo et al., 2015), but none of these studies apply to the Indian context, and most of this work is based on cross-sectional surveys where the Theory of Planned Behaviour was used as the supportive theoretical framework while additional determinants may play a role as well (see, for instance, the studies by Özkan et al. (2012) and by Nguyen et al. (2020). Qualitative research techniques would be a perfect complement to such structured survey studies to uncover and learn more about the deeper-situated motives behind risky riding behaviour. Unfortunately, such qualitative studies on risky motorcycle riding are rather scarce. To the best of our knowledge, besides the work by Bazargan-Hejazi et al. (2013), Huth et al. (2014), and Nguyen et al. (2022), no qualitative research on risky motorcycle riding is available. Undoubtedly, there is a clear need for qualitative research, particularly when a more in-depth understanding of what drives risky riding is still missing.

2.2 Motorcyclist Crash Causation

Overall, the occurrence of road traffic crashes can be primarily attributed to three contributory factors: (1) human factors, (2) vehicle factors, (3) environmental factors. Out of these, human factors are the dominant causative factor (Haddon, 1980). Several previous studies have demonstrated that the major cause of crash is related to the human factor (e.g., Lin & Kraus, 2009; Özkan et al., 2012). Furthermore, in a study conducted by Yousif et al. (2020), it was revealed that more than half of road crashes are due to human factors. It is also essential to understand the role of environmental infrastructural factors, such as road condition, road design, and traffic volume, which are some of the predominant environmental factors causing road crashes (Gopalakrishnan, 2012; Hassan et al., 2017; Shruthi et al., 2019). Finally, certain vehicle-related factors such as poorly maintained lighting systems and worn-out tyres can be attributed to road crashes (Gopalakrishnan, 2012; Haddon, 1980). With respect to environmental factors, weather conditions have been identified as an important risk-increasing environmental factor. Weather affects road surface conditions and the motorist's visibility, thereby increasing the chances of mishaps. Adverse weather conditions such as heavy rain, thick fog, and hailstorms make riding riskier as visibility reduces and road surfaces slippery (WHO, 2018; Singh, 2017; Bhalla et al., 2016; Ruikar, 2013). Contrary to that, the annual report published by the Ministry of Road Transport and Highways, Government of India, (MoRTH; Annual report, 2019), signals that almost 34^{th} of crashes among motorcyclists occur under sunny/clear weather. Nevertheless, the same report mentioned that crashes under adverse weather conditions such as rain, fog, and hail/sleet accounted for 17.3% of the total road crashes in India. Furthermore, in an a-depth Chinese crash data study conducted by Wang et al. (2021), it was reported that poor visibility is one of the major contributors to road traffic crashes. Also, in a study by Aupetit et al. (2016) to identify the risky situations of novice motorcyclists on real roads, 13 incident scenarios were identified among novice motorcyclists, among which loss of control due to wind or a slippery road. A second environmental factor relates to roads being in unacceptable conditions in many parts of India (Pal et al., 2019; Bhalla et al., 2016). Roads are not always built with a proper long-term vision in terms of country planning and urban development, so they often cannot accommodate the quickly rising number of vehicles (Pal et al., 2019). Undoubtedly, bad roads are also a significant crash risk among motorcyclists (WHO, 2018; Singh, 2017; MoRTH: Annual report, 2019; Konlan et al., 2020). Konlan et al. (2020) for example, reported that bad roads account for 23.3% of road crashes among motorcyclists. Furthermore, motorcyclists are prone to road crashes due to poor geometric and cross-sectional road design. As a two-wheeled vehicle, a motorcycle is more dependent than other vehicles on a solid, high friction road surface to maintain control. In addition, the critical surface area where the tyre meets the roadway is smaller on a motorcycle than on any other highway vehicle, and those points of contact are essential for the motorcyclist's stability, maneuvering, and braking. Poorly designed intersections and curves, pavement defects, and dangerous bridge joints increase the crash risk among motorcyclists (Singh, 2017; MoRTH: Annual report, 2019; Jain et al., 2009). As for vehicle-related factors, most studies have identified poorly maintained brakes, lighting and worn-out tyres as risk factors for road crashes among motorcyclists (Pal et al., 2019; Gopalakrishnan, 2012; Pervez et al., 2021). Additionally, missing, or loose parts such as bolts, cotter pins, or nuts can cause a motorcycle to wobble, making steering difficult and increasing the chance of a crash. Turn signals are another important part of motorcycle maintenance that is often neglected. When turn signals are not working, other drivers will not know the motorcyclists' intentions while turning, increasing crash risk (Shaker et al., 2014; Hagan et al., 2021; Oxley et al., 2013). As for human factors, speeding is probably the commonest behavioural factor reported across different studies among motorcyclists (Gopalakrishnan, 2012; Sharma et al., 2014; Chen & Chen, 2011; Paris & Broucke, 2008). Some studies, such as the ones conducted by Chen and Chen (2011) in Taiwan and Paris and Broucke (2008) in Belgium, have explained speeding with the help of the Theory of Planned Behaviour. For instance, in their study, Paris and Broucke (2008) reported that self-reported speeding was predicted by intention and perceived behavioural control. They also demonstrated the validity of the Theory of Planned Behaviour to predict self-reported speeding behaviour. Chen and Chen (2011) reported that perceived enjoyment and concentration seem to positively impact riders' speeding behaviour. Furthermore, they affirmed individual factors, such as personality traits and experience, to reflect differences in speeding behaviour. A study conducted in Bangalore, India by Sharma et al. (2014) to determine the inclination to speed and its correlates indicated that the propensity towards speeding was more commonly observed among young male riders. Furthermore, it distinguished different elements correlating with the speeding inclination among young riders, such as state of passion, sensation seeking, risk-taking, and rule-breaking. Another common human factor observed among riders is mobile phone usage while riding. An observation study conducted in Mysore, India by Setty et al. (2020) found that 50% of the observed riders use mobile phones while riding. No difference was observed in the proportion of mobile phone usage during the daytime or across various days of the week. A multi-city nationwide survey was conducted to understand the utilization patterns, its effects, and the perception of mobile phone usage among road users across India. Although 94% of the respondents believed that the use of a mobile phone while riding is risky, 47% of them receive calls while riding, and 60% do not stop riding before answering calls (Save LIFE Foundation, 2017). Riding under the influence of alcohol has also been identified as one of the major causes of crashes among young riders in India. This has been reflected by MoRTH; Annual report (2019) and with several previously conducted studies (Gopalakrishnan, 2012; Dash et al., 2019). For instance, Gopalakrishnan (2012) mentioned that in LMICs like India, between 33% and 69% of fatally injured drivers and between 8% and 29% of non-fatally injured drivers were under the influence of alcohol before their crash. Noteworthy to mention, fatal crashes are more prevalent on weekends among young riders due to riding under the influence of alcohol (WHO, 2018). Wrong lane use is one another commonly observed traffic violation in India. For instance, it was reported in MoRTH; Annual report (2019), that driving on the wrong side accounted for 6% of fatal road crashes. Furthermore, red-light running has been observed as a common problem among young motorcyclists in India (Bhosale et al., 2017). Empirical evidence with other Southeast Asian countries has also indicated the commonly observed practice of red-light running among young motorcyclists. For example, Abdul Manan et al. (2020) observed that the average rate of red-light running violations was between 3.6% and 22% based on a field survey at 27 intersections in Malaysia. Finally, tailgating is also one of the commonly observed risky riding behaviours among young Indian riders (Pal et al., 2019). Moreover, in the Southeast Asian context, Trung Bui et al. (2020) in their Motorcycle Rider Behaviour Questionnaire (MRBQ) study, obtained a mean value of 2.67 on tailgating items among 2254 motorcyclists in Vietnam, which meant that they committed this behaviour on an occasional basis. Apart from the above-mentioned human factors, other human factors can also impede driving and can cause crashes. For instance, in a systematic review conducted in LMICs by Piyasena et al. (2021) a positive association between vision impairment and traffic crashes in LMICs was reported.

3. Objectives

The overall aim of the current study is to improve the understanding of typical characteristics of motorcycle crashes among young riders in Manipal, India, primarily focusing on the prevalence and role of risky riding behaviours. Two more specific objectives are proposed. Firstly, to assess the dangers associated with risky riding behaviours and associated underlying motives among young riders in Manipal. Secondly, to identify road infrastructural and environmental factors associated with increased motorcyclist crash risk and their suggestions for improving rider safety. The findings from the current study will provide valuable leads for designing risk reduction programmes targeting young Indian motorcycle riders to motivate them to follow safe riding practices. This study contributes to the current literature in three different ways. Firstly, there is the geographical setting. To the best of our knowledge, this is the first study into the underlying motives of risky ridership among Indian motorcyclists. Even though there are studies available addressing the Indian context, these studies mainly focus on crash risk or the prevalence of risky rider behaviours, not on the underlying determinants of risky ridership. Secondly, this study adds to previous qualitative studies on motorcyclist safety. We found only three studies where in-depth interviews and/or focus groups were the method used to collect data. In two out of these three studies, the focus of data collection differed from our study. The study by Huth et al. (2014), for instance, was primarily interested in uncovering the risks motorcyclists associate with operating a motorcycle. The study by Bazargan-Hejazi et al. (2013) was focused primarily on how motorcyclists cope with the dissonance between personal demonstration of risky motorcycle riding behaviours on the one hand, and the personally held beliefs related to the dangers associated with those risky rider behaviours on the other hand. Different from those two studies, our study put more emphasis on the underlying motives of risky motorcycle riding. Left aside the study by Nguyen et al. (2022), qualitative work focussing on the determinants of risky motorcycle riding behaviour is non-existent. That study, however, was not conducted in India, but in Vietnam. Thirdly, different from previous work, our study captured the opinions of motorcyclists in terms of what they themselves believed to be effective or ineffective safety promoting countermeasures. In our opinion, it is valuable to know how motorcyclists evaluate countermeasures that are targeted to improve their safety. Practitioners, as well as policymakers, could learn valuable lessons from that.

4. Methodology

4.1. Semi-Structured Focus Group Discussion

Focus group discussion (FGDs) is a widely used method in qualitative research. A small group of participants is consulted to understand their perspectives, practice, attitude, and behaviour on a specific topic or an issue. FGDs have been defined as a "carefully planned discussion designed to obtain perceptions on a defined area of interest in a permissive, nonthreatening environment" (Krueger & Casey, 2014). The interaction within the group and guidance provided by the moderator stimulates comprehensive discussions to get an in-depth understanding of the underlying attitudes and behaviours towards a highlighted topic. FGDs can serve four different purposes (1) to describe and understand an issue; (2) for planning to achieve a set of goals; (3) to tweak the execution of the investigation; and (4) to analyze and plan out policy decisions on what was revealed during an investigation (Morgan et al., 1998). Considering the proposed research question in our study, the purposes of the FGD in this particular study is to understand the issue under investigation and to achieve a set of goals for future intervention development. In total, five FGDs were conducted (i.e., one with both males and females together and two each for males and females separately) with 8–10 participants in each of them. Heterogeneity in FGDs can serve to uncover deeper insights into what is being studied. In the current study, one of the five FGDs was heterogeneous based on the participant's gender to get varied, in-depth information on typical characteristics of motorcycle crashes among young riders and supplement the findings of the homogenous FGDs. This is in line with recommendations from

Grønkjær et al. (1970). Apart from the participants, there were two more people in all FGDs: the moderator and one person for taking notes and recording the session. The first author of this article acted as the moderator. He underwent some in-house training procedures to get familiarized with moderating FGDs, in which he was acquainted with key steps to organize, conduct and moderate FGDs. An in-depth interview guide was prepared for the FGDs encompassing the primary areas of interest that were deduced from the current trends of riding practices among the young-aged population that will provide insights into the thought process of the young riders and how they perceive the practice of risky conduct while riding their motorcycles. The discussion guide intended to prompt thoughts and personal opinions and guide the conversation among participants to identify factors associated with risky riding behaviours. More in detail, the interview guide was designed to elicit discussion among the participants about their views on the leading causes of road crashes, existing environmental hazards, and suggestions from them on how to improve rider safety. All the FGDs started with an opening question, and then sub-questions were optionally asked to guide the participants closer towards the research objectives. The discussions were facilitated in such a manner that new topics could freely emerge (Krueger & Casey, 2014).

4.2. Participants

The participants included were in the age range of 18 to 25 years, and residing in the university town of Manipal. Manipal is situated at the Southwest coast of India, bordering the Arabian Sea in the state of Karnataka. Manipal is home to the Manipal Academy of Higher Education (MAHE), and it hosts approximately 30,000 young students from all across India and 60 countries all over the world. The principal researcher visited college canteens, common youth hangouts points, motorcycle repair shops, youth clubs to identify eligible participants based on the inclusion criteria. The purpose of the study was explained to eligible participants and 35 agreed to participate in the FGDs. The participants were not provided with any incentive. To further investigate the issue of sample size, previous studies were consulted, where it was indicated that the ideal number of participants for qualitative research should be around 20 to 30 (e.g., Creswell, 2022; Morse, 2000; Patton, 2022). Morse (2000), for instance, proposed that a sample size of 30 participants is a good working number for qualitative studies based on interviewing techniques. During the focus group discussions, it was carefully monitored whether all participants received the opportunity to formulate ideas (instead of the group discussions being monopolized by the more responsive participants, and some people rather staying in the background), and whether no new themes, sub-themes or codes emerged, and participants indicated themselves they could not think of anything new to add to what was already said before suggesting that data saturation within each group discussion was reached (Saunders et al., 2017).

Table 1 shows further details of the age and gender break-up of the study participants.

Table 1: Participant characteristics.

Age	% (n)	Mean	Standard Deviation
18–20	20 (7)	22.2	2.12
21–23	45.6 (16)		
24–25	34.4 (12)		
Gender	**% (n)**		
Male	51.4 (18)		
Female	48.6 (17)		
Years of riding	**% (n)**		
<1 year	22.86 (8)		
1 to 3 years	48.57 (17)		
3 to 5 years	28.57 (10)		
Riding hours in a week	**% (n)**		
1 to 5 h	57.14 (20)		
6 to 10 h	25.71 (9)		
>10 h	17.15 (6)		
Type of motorcycle	**% (n)**		
100 cc to 125 cc	77.14 (27)		
125 cc to 200 cc	20 (7)		
>500 cc	2.86 (1)		

4.3. Procedure

The study was approved by the institutional ethical committee of Kasturba Medical College at Manipal Academy of Higher Education (reference: KMC IEC-09/2018). Written informed consent was obtained from the participants at the beginning of the FGDs. The purpose of the study was explained to all the participants. Participants were told their names would not be mentioned to maintain confidentiality and anonymity. In total, five FGDs were conducted, and on average, lasted for 80–90 min. Participants were sensitized about the outcomes of the study. The moderator explained the objectives before each FGD, and participants were informed that the result of the FGDs would be used to generate evidence for understanding risky riding behaviours and for the improvement of rider safety in the city. Group members were encouraged to communicate with one another, exchange ideas and share experiences, and to maintain a cordial atmosphere in the group. Participants were reminded at a regular interval not to hesitate to put their opinion across. A specific flow was followed during the discussion to encapsulate the research themes from the FGDs groups. Furthermore, one of the team members was delegated for taking notes and facilitating the recording of the session. It was clearly observed that the number of focus group discussions conducted was sufficient in the sense that saturation point was reached and no new ideas emerging anymore. The discussions were audio-recorded.

4.4. Thematic Analysis

The FGDs were conducted in English and Kannada. The data collected was processed according to the protocol proposed by Braun & Clarke (2006), (Figure 1). Familiarization with data included listening to the recordings and processing the notes taken during the discussions. Transcripts were thoroughly read to gain familiarity with the data content and to detect meaningful topics across the transcripts. Proper grammar and spell-check of the transcripts were done before subjecting the transcript to the MAXQDA software for thematic analysis. More in detail, thematic analysis is based on the identification of patterns through careful reading of the data and a thematic structuring into categories (e.g., Fuller, 2008; Rice & Ezzy, 1999). In thematic analysis, patterns are identified in a bottom-up procedure. The method is data-driven and goes beyond semantic content, focussing on the latent level information, i.e., underlying ideas and concepts. The method is based on researcher judgement rather than on quantifiable measures (Braun & Clarke, 2006). Themes consist of patterned responses related to the research questions and are not subject to a prevalence threshold. As for the MAXQDA software, firstly, a thorough reading of the entire data was performed. Then the interesting and essential features of the data were coded related to the study's objectives. Colour coding was given to the verbatims, which gave a similar kind of information, and also to the text providing information other than the study objectives were highlighted. The software has an option of code memo where the meaning of code and the context can be written, which helps determine which category the code belongs to. Once the entire document was coded, it was exported to a Word document. Then, to categorize the codes, the coder compared the codes to decide which categorization is more appropriate for the group of similar context codes. The number of repetitions of the codes in the Word document determines the significance of the information, leading to answering the research question. Subsequently, categories were created with the few codes that have specific qualities in common. Finally, categories and coding matrix were analyzed and summarized into groups and four main themes were derived from it (Kuckartz & Radiker, 2020). Noteworthy to mention, the principal researcher himself (first author) was the coder and he got first familiarized with the thematic analysis protocol proposed by Braun and Clarke (2006) and also, he got acquainted himself with the MAXQDA software in order to do the coding.

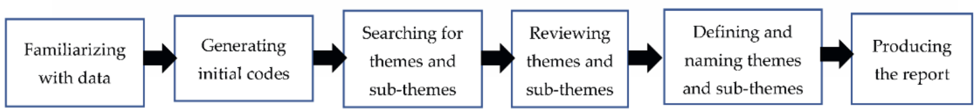

Figure 1- Stepwise data analysis protocol. Source-Braun & Clarke (2006).

5.Results

Table 2 gives an overview of the different themes derived from the FGDs, highlighting the most important sub-themes and related codes. Also, for each of these codes, the number of associated quotes is indicated.

Table 2: Themes, codes and quotes

Category	Codes	Associated Quotes
Theme 1: Risky behaviours considered as safety critical		
1. Reasons for speeding	Thrill-seeking	12
	Late for college	4
	Empty roads	2
	Show-offs	8
	Age factor	9
	Influenced by movies	3
	Competition/racing	6
	Overtakes	7
	Peer pressure	6
2. Ignorance in servicing motorcycles	Using 2nd hand bikes	2
	Save pocket money	3
	Using rented bikes	2
3. Drink and drive culture	Loss of coordination	5
	Loss of judgment	5
Theme 2: Risky behaviours observed among young riders		
1. Use of gadgets while riding	Cell phone addiction	11
	Listening to music	4
	Checking itinerary	6
	Making pictures & videos	5

Category	Codes	Associated Quotes
	Time saving	5
2. Helmet non-use	Spoiled hairstyle	8
	Humid climate	5
	Helmet theft	7
	Streamlined vision	3
	Discomfort	3
	Pillion riders don't use a helmet	4
3. Under-aged riding	Lack of parental supervision	3
	No valid licence	1
	Lack of proper training	2
	Access to motorcycles without a licence	7
Theme 3: Environmental factors for crashes		
1. Climatic and road conditions	Heavy rain	5
	Vertical curvature	3
	Potholes	3
	Irregular horizontal alignments	3
2. Absence of basic safety infrastructure	No streetlights	6
	No signboards	4
	No speed breaks	3
	No cameras	6
	No barricades	5
3. System accountability	Inadequate training & examination	4
	Limited accessibility to RTO *	2
	Long-standing queues in RTO *	2
	Corruption	1
	Licensing fraud	3
	Increase in private vehicles	6
Theme 4: Suggestions for crash reduction		
1. Education & awareness activities	Alcohol limitation in pubs	3
	Promote public transport	6
	Stakeholder synergy	4
	Promote physically active travelling	6
	Promote cycling	2
2. Equipment & technologies	Put traffic barricades	3
	Speed breaker	3
	Traffic signals	5

Category	Codes	Associated Quotes
	Signboards	4
	Advancement in technology	3
	Improve road conditions	6
	Install cameras	5
	Cover potholes	2
3. Strict enforcement	Heavy penalties	7
	Increase checking on weekends	9
	Frequent random checks	4

* RTO-Regional Transport office.

The thematic analysis revealed four themes with multiple categories (Figure 2). The first theme explored the risky behaviours considered as safety-critical causing road crashes among young riders. The second theme was about risky riding behaviours observed among young riders, comprising the use of mobile phones while riding and non-usage of a helmet. The third theme covered details related to risks arising from environmental conditions and road infrastructure. The last theme comprised suggestions for the reduction of crashes and the improvement of road safety.

5.1. Theme 1: Risky Behaviours Considered as Safety-Critical

Participants reported that speeding, poorly maintained motorcycles, and riding under the influence of alcohol are the main factors for road crashes among young riders.

5.1.1. Speeding

Participants felt that speeding and racing propensities while riding motorcycles was commonly seen among young riders. Young riders were said to be enthusiastic about the thrill of chasing exercises while being ignorant of the adverse consequences of speeding. Further discussion revealed that additional reasons for speeding were being in a hurry (e.g., getting late to reach a destination such as a college), and competition among friends:

"The speed thrills, so the young riders like to indulge in speeding. It is like a racing thing for them. In that state of mind, they think that they can speed and are not much bothered about road conditions, and they just do not care about the effects of road crashes." (P3, Male)

Figure 2- Overview of themes, sub-themes and codes

Furthermore, participants reported that empty roads and sports bikes provoke them to indulge in show-offs, dangerous overtaking, and the performance of stunts. Moreover, participants identified seeking attention from their peers, flaunting their expensive bikes, and demonstrating judgement and control while riding as supplementary motives for speeding:

"I think one of the reasons for speeding is to show off to others the power of their bikes. I know that boys tend to buy bikes based on their speed and capacity of it. So just because they own a good bike, they indulge in speeding." (P1, Female)

Speeding, however, was not exclusively associated with thrill-seeking and adventurousness. For instance, it was mentioned that when stressed or undergoing mishaps in their personal life, young riders often choose to go for a long ride as a kind of coping mechanism to appease themselves with the situation. The increased danger resulting from that, is riders being less concentrated on the road, and thus less attentive for sudden hazards requiring immediate corrective action. Finally, escape from traffic police checkpoints was mentioned as a reason to speed. More specifically, young riders not possessing the essential documents for their vehicle or without a proper licence tend to raise the speed to get rid of the checking procedures:

"A person can also ride a bike because of some sort of external distress. Moreover, that is the time like they want to escape the problem that they are facing. And because of which, they generally take their bikes for a long ride. Furthermore, this could account for road crashes among them, as they are not very much concentrating on the road because they are thinking about their problem and at the same time riding the vehicle." (P16, Male)

"I have seen many people, when there is checking by police, then they suddenly increase their speed and they try to run away from that site, especially in Manipal. Once, I have witnessed it at syndicate circle, my friend was riding without a helmet, and the moment he saw the police check post, he increased the speed and ran away from there." (P4, Female)

5.1.2. Alcohol Impairment

The majority of the participants reported that riding under the influence of alcohol is the primary reason for crashes among the youth population in Manipal. Participants felt that alcohol impairment reduces a person's thinking and reasoning abilities, leading to erroneous judgments and even loss of neuro-muscular coordination. Consumption of alcohol and subsequent decisions to ride back home after weekend parties was said to have become almost a culture among youths in Manipal:

"There is a pub culture in Manipal. Many people go to these places and get intoxicated. The thing is that cognitive abilities are badly affected after drinking. The rider cannot control the vehicle, which can cause road crash. Furthermore, I believe that this is the major cause of crashes in Manipal." (P28, Male)

"The major reason is drunk and drive. Because whenever we take alcohol, it completely affects muscular coordination of our body." (P9, Male)

5.1.3. Poorly Maintained Motorcycles

Most participants drew attention towards the use of second-hand motorcycles by the young-aged population in Manipal. Youngsters come from different parts of India and abroad to Manipal to study. As such, they reside only temporarily in Manipal, which is why they prefer to purchase a second-hand bike. After completion of their studies, these bikes are resold to newly incoming arrivals. Currently, there is no official authority regulating and monitoring the sale and safety of such second-hand motorcycles. Poorly maintained motorcycles were considered to be jeopardizing the safety of young riders in Manipal:

"The young students prefer to buy second-hand bikes instead of buying a new proper vehicle because they are cheaper. So, there is no regulating body to keep a check on it. Now they do not maintain the second-hand bikes, and it is prone to crashes." (P6, Male)

"Vehicle condition is one of the reasons for road crashes. Most of the students in Manipal are from other states of India and abroad. So, they prefer second-hand bikes during their course of stay. They will sell their bikes and will go from here. Now the new students prefer buying these second-hand vehicles which are not in good condition. This causes a problem later. So, I believe the vehicle condition is important for safe riding." (P34, Female)

According to some of the participants, saving pocket money is one of the primary reasons for not getting a vehicle properly serviced. Students prefer to keep their limited pocket money for other expenses rather than spending it on regular motorbike servicing. Additionally, a lot of youngsters are ignorant about the importance of getting their motorcycles regularly inspected. Those who service their vehicle only get the minimum essentials checked (e.g., brakes and engine oil), while the rest is skipped. Spoilt headlights, taillights and even indicators are usually not replaced, which by itself already is a road safety violation. Interestingly, some participants also mentioned that many rental firms provide motorcycles that are not adequately serviced with poorly maintained brakes:

"Look, pocket money is limited for young students, and that is the reason they do not go for timely service of their bikes. They have to pay the house rent, mess bill, and many other expenses. Thereby very little is left for the maintenance of the bikes. So, they will mainly sometimes go for a brake check or changing of the engine oil. Moreover, I have seen my friends having a bike without a taillight and indicator. Now it becomes difficult for the riders behind to make out where exactly he is turning. In many instances, he has almost experienced very close crash situations." (P13, Female)

"*Also, many students here rent a bike for the day-to-day commutation. The rented bikes are not adequately serviced and maintained. I had rented a bike, and it did not have a proper brake system, and whenever I used to come down, it was challenging for me to control the bike.*" (P4, Female)

5.2. Theme 2: Risky Behaviours Observed among Young Riders

5.2.1. Use of Mobile Phone while Riding

Participants discussed the use of mobile phones while riding among the youths. Young riders were said to attend phone calls with only one hand available to balance the motorbike. Timesaving was believed to be an important underlying motive. In addition, listening to high-volume music while riding with the earplugs in for enjoyment was another reason for using the mobile phone while riding. Furthermore, youngsters were said to browse google maps for visiting specific addresses. These behaviours were perceived as dangerous since they create a distraction and decrease riders' situation awareness. Finally, some of the participants mentioned the use of a mobile phone to take pictures and make videos while riding as a common trend among the young-aged riders:

"*So, they probably feel that the phone call is important, and it has to be attended without wasting time. They feel that both riding the bike and talking on the phone can be done at the same time. They do not have the patience to stop and then take the call. We see young riders listening to music in high volume and riding because they do not want to drive alone, they need some company, and music gives them that company on a long ride.*" (P7, Male)

"*They use mobile phones to access google maps while they are driving in an unfamiliar area. Sometimes they also listen to music while riding. They cannot hear the honking from the other vehicles. So, most of the attention is on the phone and not on the roads. This eventually leads to crashes.*" (P13, Female)

"*Many times, it happens that while riding a bike, the person sitting behind tends to make a video of them going till their destination using a mobile phone camera, which results in the driver's distraction as he/she tends to look into the video quite often. This distraction leads to crashes.*" (P33, Male)

5.2.2. Helmet Non-Use

Most participants felt that non-use of helmets was related to the fact that it spoils hairstyle. Discomfort due to extreme humidity was another motive for not using a safety helmet. Few participants also mentioned that sometimes young riders simply tend to forget wearing a helmet, for instance, when being in a hurry. Furthermore, helmet weight and obstructed field of view were mentioned as possible reasons for not using it:

"*Young riders do not prefer wearing helmets because they think that it is not cool. Alternatively, also it just damages their hairstyles. Also, wearing a helmet produces a lot of heat, mainly in the summer season. It causes discomfort.*" (P11, Female)

"*I can say sometimes they are in a hurry, and they forget to take their helmet sometimes because of the weather. It is too humid.*" (P29, Female)

"*I also think helmets cause much physical disturbance, and it is heavy on the head, and it is very suffocating. That is why the preference is low.*" (P3, Male)

"*Young riders do not choose to wear a helmet because of the streamlined vision they get after wearing the helmet. They consider they cannot see the whole 280-degree vision, which might cause some problems to see if anyone is coming from behind.*" (P7, Male)

Interestingly, participants also mentioned helmet theft as another reason for riding without a helmet. More specifically, carrying a helmet without secure methods to store the helmet once reaching the destination was considered as an important barrier for wearing helmets. It is common practice among young riders to hang their helmet on the rear-view mirror while parking, often resulting in the helmet being robbed. Some participants also reported that, since most young riders only reside for a limited period of time as a student in Manipal, there is almost no motivation to buy a helmet. Additionally, most rental companies offer motorcycles without the inclusion of a helmet. Many youngsters simply do not see a point in investing in it and believe they can safely manage the riding task without wearing a safety helmet. The non-use of safety helmets among pillion passengers was also raised as an important safety issue:

"*If you have a moped or a scooter, you can easily put the helmet near the footrest or the deck. Nevertheless, carrying a helmet on motorcycles is difficult. Also, if you put your helmet in the rear mirror, there are high chances of it being stolen. This all reason just demotivates young riders to use a helmet.*" (P2, Female)

"*Many of us have seen that on one bike, there are three, four people going altogether. So, I think it is challenging to manage the motorcycle, and sometimes they lose their balance, which can lead to crash. Moreover, the pillion does not use a helmet.*" (P1, Female)

"*Since in Manipal, young student riders usually buy second-hand bikes, and the mentality is why to buy helmets also. No one is interested in buying helmets. Because it is like you will not be using it after two years. I have seen that the rental agencies do not provide helmet to their customers.*" (P7, Male)

5.2.3. Access to Motorcycles

Many of the participants referred to the accessibility to motorcycles at an early age being much easier today as another important safety issue. Parents provide their children with sports bikes and do not follow up on how they ride or whether they use a helmet. Access to motorcycles is seen even before reaching the rightful age to obtain a valid motorcycle licence. The lack of parental supervision is especially problematic among resident students who are away from home:

"*The accessibility to bikes has increased tremendously since the past decade. Now the condition is that even after passing class 10th, parents are giving motorcycles to their son and daughter. So, the culture has changed. The parents seem to have completely surrendered in front of their kid's demand.*" (P17, Female)

"*There is no parental guidance to look over riding behaviours. The young student riders who are not staying with their parents have a sense of freedom and often indulge in rebel riding. These days, students are not telling everything to their parents. Therefore, the parents are not aware of what their child is doing when they are in some other town for education.*" (P35, Male)

Related to ease of access, most participants reported that youngsters often start riding motorcycles without proper initial training, for instance, from an officially recognized driving school. Consequently, they lack basic knowledge of safe riding practices and are allowed to ride even without obtaining a valid licence:

"*Some young students have access to motorcycles even if they do not have a licence. I have seen them riding without any proper training and licence. They somehow manage to escape the checkpoints by paying some money. Yes, they are not trained; they just have a bit of knowledge about riding a bike and other safety measures. This finally leads to crashes.*" (P3, Male)

5.3. Theme 3: Environmental Factors

Environmental factors have emerged as an essential issue. Participants identified and discussed specific climatic and road conditions, the absence of basic safety infrastructure, and system accountability.

5.3.1. Climatic and Road Conditions

Almost all participants claimed that the number of crashes increases during the rainy season. Especially during the monsoon season, dilapidated roads and potholes get filled with rainwater, creating slippery surface conditions. This, in turn, increases the difficulty of the riding task and puts pressure on riders' vehicle control skills:

"*It is probably more during the rainy season because the roads are repaired inadequately before the rainy season, and again it has been damaged during the rainy season. Furthermore, again, the cycle goes on.*" (P14, Male)

"*If there are potholes on the road, the vehicles cannot be adequately balanced on the road. So, they tend to lose our balance and fall. Moreover, if they are at high speed, then they will not be able to maintain the balance. Moreover, even in the rainy season, the holes get filled with water. So, they cannot judge if it is a hole or plane.*" (P4, Female)

Participants also mentioned that Manipal has a hilly and uneven terrain. Straight roads are relatively scarce in the city and its outskirts. Sharp bends, sudden downhills, and robust curves sometimes make riding conditions challenging and require riders to be cautious and mindful when riding on these roads. Correspondingly a rider stated:

"*Manipal is a hilly terrain, and there are a lot of blind curves and narrow roads. Additionally, there are a lot of remote roads and blind curves, so these all conditions make riding risky and are one of the reasons for crashes.*" (P1, Female)

5.3.2. Absence of Basic Safety Infrastructure

Participants reported the lack of basic road safety infrastructure in as another safety obstacle. According to them, it is essential to have at least the basic safety infrastructure such as streetlights, signboards, and traffic calming measures such as speed breakers and barricades to minimize the occurrence of crashes. Many of the participants claimed that they had not witnessed adequate safety infrastructure in Manipal. Furthermore, riding at night in the outskirts of the city was considered difficult due to low visibility as there are no streetlights. As one rider commented:

"*The streets of Manipal are not well lighted. Like the area beyond the KFC and Udupi roads, there are hardly any streetlights. Construction is happening in the entire stretch, and movement of heavy traffic makes the road dangerous for riding.*" (P6, Male)

Many participants highlighted that signboards were also missing on substantial parts of the local road network. Road maintenance work zones were mentioned as one illustrative example of how road signs were sometimes removed without being properly replaced afterward. The absence of traffic calming measures was deemed particularly problematic since speeding is one of the predominant risky behaviours among young riders:

"*There are no signboards on the town roads. Now because of road construction, the signboards have been misplaced here and there. This creates confusion and sometimes crashes.*" (P2, Female)

"*They are overconfident about their driving skills. There are not many speed breakers on Manipal roads, so controlling the speed becomes difficult. So, they go freely with high speed.*" (P12, Male)

5.3.3. Accountability of Regulating & Enforcement System

Participants also explicitly raised the loopholes in the existing regulating system and enforcement authorities as an important issue. For example, many participants felt that prospective young riders were trained inadequately and that they lack basic theoretical knowledge on the syllabus of road safety and traffic rules. Another point raised, was the lenient nature of the authorities in issuing a licence for a two-wheeler. Furthermore, they mentioned that usually, the Regional Transport Office (RTO) is located far from the city and requires some travel time, prompting licence-seekers to go through an agent and obtain a licence without any training or examination. This is illustrated by statements as:

"*There is no government body, or there is no one to educate us like what should be the traffic rules and regulations and what should be the ideal traffic behaviour. Even when we go to the RTO to get the licence, they hardly take any examination kind of thing, or they hardly teach us something about the traffic signals and rules, what are the hand signals should be, and what should be the indicator manners.*" (P4, Female)

"*The RTO like in most of the cities are not located in the main city and sometimes very far off area which you have to travel. You have to travel and so avoid that people just opt to sit at home and get the licence by other possible means. Furthermore, I think that is also one of the major reasons like nobody wants to stand in a queue.*" (P11, Female)

"*There has been an upsurge in the number of vehicles due to improvement in the purchasing power from the past few years. The RTO officers are very lenient when it comes to clearing the new licence and vehicle. The process involved should be fair and free from corruption.*" (P3, Male)

5.4. Theme 4: Suggestions for Crash Reduction

Participants also reflected on possible crash reduction measures. Emerging suggestions related to education and awareness-raising initiatives, use of supportive equipment and technology, enforcement policy, and road infrastructure. Most participants stressed the importance of stakeholder synergy for such countermeasures to be effective.

5.4.1. Education and Awareness Activities

Many respondents observed impaired riding to be common among young riders in Manipal. Proposed countermeasures were to have bar/pub owners play a more upfront role in the prevention of riding under the influence of alcohol. For instance, information, education, and communication materials could be displayed making the point that riding under alcohol impairment can be fatal. Furthermore, a limit on the amount of alcohol served could be imposed. Additionally, participants thought bar/pub authorities could be provided with breath analyzers to test customers' BAC-level before leaving the bar/pub. Some participants suggested that youngsters should use public transport (e.g., taxi or city bus) instead of their own vehicle to visit bars/pubs and return home:

"*There should be a restriction on the amount of liquor served to young student riders in pubs/bars. This restriction can reduce toxication and can prevent crashes. The bar security guards should be given a breath analyzer, and they can test for those who are coming out of bars, so if the alcohol level is more than the permissible limit, that person should not be allowed to drive. They can display digital IEC (Information, education and communication) material in a pub/bar. It should have messages on it like 'Do not mix and drive.*" (P35, Male)

"*One of the major problems in Manipal was drinking and driving. So, the solution is that the bars and pubs wherever the young student riders go for drinking and other activity, they can have a rule that they cannot come with their vehicles. Instead, they can make an auto stand near the bar or pub so that after getting drunk, they can go by auto to their home.*" (P9, Male)

Some participants argued in favour of more active involvement of university authorities in promoting road safety. Universities could, for instance, provide students with shuttle bus services to decrease the number of private vehicles. Security officials could be given the authority to conduct random checks for rash driving, possession of the required documents, and helmet use at the gates:

"*They should start campus shuttle bus service within the campus so that the number of vehicles will be restricted during the peak hours. This will avoid the morning rush and will decrease the number of crashes.*" (P6, Male)

"*I feel that even university security guards should start conducting random checks at various points on the campus, particularly at the entry and exit. They can also see to it whether the students are using helmets, have a valid driving licence, bike papers, and all. This will keep the young student riders on their toes, and they will behave properly.*" (P29, Female)

Some participants suggested the need for collaborative awareness-raising activities between the university and the traffic unit of the police department, such as orientation sessions for university students to sensitize them about the traffic rules and previous crashes in the city, recruitment of student volunteers from the university by the local police traffic unit, authorizing them for random checks on campus and in pubs:

"*The police department can collaborate with students and can issue them temporary cards authorizing to volunteer traffic control and random checks. The volunteering students can also visit pubs and bars on the weekend and sensitize the youths not to drive after consuming alcohol.*" (P2, Female)

"*Inspectors will take a class on traffic rules regulations and other possibilities of crashes and how you need to behave on the roads. Moreover, sir, like a collaboration with the college and Regional Transport Office, can be done, and they can come to college to teach us about safe riding practices. The students should be sensitized in the beginning by Regional Transport Office and traffic police about the prevailing traffic conditions in Manipal and some safety measures.*" (P16, Male)

5.4.2. Equipment and Technology

One of the valuable suggestions emerging from the FGDs was to encourage coordinated efforts between the engineering college and the traffic department to come up with advanced technology to reduce traffic violations and identify the violators. Additionally, inter-college competitions and hackathons to promote innovations and further technical development were proposed. Some participants proposed the installation of speed sensors to monitor speed and identify speed limit violations:

"*I did not see any speed control systems in Manipal. So, I think they can use a little more technology to have control over speed. Inputs can be taken from the engineering college to initiate some kind of speed tracking intervention. There should be inter-college collaboration within the university to promote creativity.*" (P16, Male)

"*I would just like to add that engineering college students should be involved in designing certain technology which can reduce crashes. There can be some kind of a hackathon where all can participate and come out with some creativity, and the winner should be rewarded.*" (P3, Male)

To reduce the number of crashes, one of the participants suggested implementing innovations such as sensitive alarms. The alarm can alert the vehicle owner if any part of the vehicle is damaged or non-functional. Like the car, the car does not start if the seatbelt is not used. As stated by a rider:

"*Nowadays, many vehicles are coming out that if you do not put a seatbelt on the vehicle, it will not start. So, similarly, if such technology can come into bikes that if engine oil is in not proper, if backlight or indicators are not functioning, then the vehicle should not start. So, if such technology can be* *incorporated into bikes, I think I know it will be expensive, but it will surely help in reducing crashes.*" (P18, Male)

Some of the participants felt the need to improve the road safety infrastructure of the city to reduce the number of crashes. Participants strongly recommended immediate fixation of the non-functional road safety equipment, i.e., traffic signals, streetlights, traffic barricades, signboards, and speed breakers. Installation should be done according to the junctions, peak hours, traffic status, and crash-prone zones. One of the participants pointed out the urgency to fix up the potholes as it becomes dangerous during the prolonged monsoon seasons. Participants deplored the approach of the authorities in fixing the potholes temporarily and were of the opinion to fix it permanently. See statement as:

"*They can put speed breakers near the junction; if not, they can install zigzag traffic barricades, and exactly how they have done on the campus roads.*" (P4, Female)

"*The authorities should at least take initiatives to install traffic lights near the busy junction and crash-prone areas. So, just by keeping traffic signals or giving proper light will not reduce the accidents.*" (P3, Male)

"*Road condition should be improved; there are potholes on the road. During the rainy season, the road condition is bad, which needs to be permanently repaired". The authorities just do some temporary patchwork before the onset of the rainy season. It should be repaired permanently.*" (P16, Male)

5.4.3. Strict Enforcement

For law and enforcement, many participants were of the view that the existing traffic rules should be enforced more strictly. Few of them suggested imposing hefty fines in case of any violations. Furthermore, it was also opined that the authenticity of the bike rental agencies should be verified on a regular interval:

"*Penalizing should be more stricter.*" (P23, Female)

"*I think the young student riders should be charged with heavy penalties when they are not wearing their helmets. Furthermore, I think the government should regularly check the authenticity of various bike rental agencies in the town.*" (P27, Male)

According to some of the participants, there can be surprise random checkpoints for the proper implementation of traffic rules. The offenders should be fined heavily to discourage them from committing the same offense in the future. Random checkpoints should be continuously maintained to thwart any escape plot by the young riders. Furthermore, extra traffic policemen can permanently be deputed at those random checkpoints to ensure efficacy. Correspondingly a rider stated:

"*On weekends, there should be a strict vigil, and traffic police should do a thorough checking of drivers, and strict action should be taken if found guilty.*" (P30, Male)

"*There should be random checkpoints, not fixed checkpoints, as the youths are aware of the fixed checkpoints and will try to avoid that route. Also, it would be better if they could have more traffic policemen deployed at the checkpoints.*" (P13, Female)

Many of the participants deplored the dishonest and fraudulent behaviour of some people in authority. According to them, the enforcement authorities should be honest in implementing the laws among the young riders. Stringent enforcement of laws will discourage young riders from committing violations. Furthermore, the release of fake driving documents can be curbed and will prevent crashes:

"*If corruption can be reduced, crashes will automatically come down as people with a bogus driving licence cannot ride anymore. Strict law enforcement can also be ensured.*"(P26, Male)

6. Discussion

The overall aim of this paper was to improve the understanding of typical characteristics of motorcycle crashes among young riders in Manipal (India), primarily focusing on the prevalence and role of risky riding behaviours. For that purpose, a qualitative study design was implemented, including five focus group discussions among a sample of young riders. The present study responds to the need for a better understanding of the determinants of road crashes among young riders as they represent a high-risk group. The main factors derived from the FGDs responsible for road crashes are risky riding practices and gaps in the infrastructure of the city. The most prevalent risky riding practices mentioned were speeding, alcohol-impaired riding, use of the mobile phone while riding, not wearing a helmet, and improper maintenance of motorcycles. This is in line with several studies conducted in India and other countries (Pal et al., 2019; Hassan et al., 2017; Huth et al., 2014; Sharma et al., 2014; Lucidi et al., 2019). Huth et al. (2014) and Lucidi et al. (2019) have identified the above-mentioned riding behaviours as commonly observed in their respective study settings. Also, this is in line with the data retrieved from the local authorities (personal communication, 5 May 2019), which showed that these riding practices were the leading causes of fatal road crashes from

2008–2018. It is worth noting that there is scarce empirical evidence in the Indian context regarding improper maintenance of motorcycles and road crashes. For instance, Pal et al. (2019) do mention that improper maintenance of motorcycles is a crash-causative factor, but it does not elaborate further on how it causes crashes. This warrants further investigation. Speeding the vehicle beyond the lawful limit is the most commonly reported risky riding behaviour among the young riders, which is similar to findings of several previous studies (Pal et al., 2019; Singh, 2017; Ruikar, 2013; Sharma et al., 2014; Dash et al., 2019). The report published by the Ministry of Road Transport and Highways, which stated that over-speeding is the leading cause of fatal road crashes, accounting for 71.1% of the total crash (MoRTH: Annual report, 2019). The tendency for speeding can be explained by citing the work of Sharma et al. (2014) in Bangalore, where "liking for chasing and competing", "sense of power and control," and "relief from anger" were identified as the main correlates. Looking at it from a psychosocial perspective by using the Theory of Planned Behaviour, speeding behaviour is strongly predicted by negative social norms and attitudes towards respecting speed limits (Chen & Chen, 2011). Furthermore, the tendency to speed also aligns with the findings of some studies conducted in low-and middle-income countries (Oltaye et al., 2021). For instance, Oltaye et al. (2021) in Ethiopia and Konlan et al. (2020) in Ghana reported speeding as one of the main causes of crashes among motorcyclists. Discussing it further in the context of a developed country, in a study conducted by Dubos et al. (2016) in France, speeding was identified as the major cause of fatal road crashes among motorcyclists. The study pointed out that heavy motorcyclists were involved in 62% of fatal crashes. It was argued by Dubos et al. (2016), heavy motorcyclists tend to run over the speed limit by a higher margin. Interestingly, speeding behaviour may not always be intentional. Unintentional speeding may occur due to reasons including a lack of awareness of the current speed limit/travelling speed and not paying regular attention to the speedometer on the vehicle (Etika et al., 2021). As for the use of a helmet, the current study revealed that youths are self-fixated with their appearances and peer praise, which prompts them to post their pictures and videos on social media. Many participants responded that they prefer not to wear a helmet as it is uncomfortable due to the humid climate and also opined that it ruins hairstyle. One of the other possible reasons for low helmet usage can be due to lack of awareness about the protective efficacy of helmet (Dubos et al., 2016). Few also mentioned that using a helmet restricts vision while riding and that the weight of the helmet makes them feel suffocated. Comparable findings have been reported for young adult motorcyclists in Cambodia (Brijs et al., 2014). In another study conducted by Faryabi et al. (2014), it was reported that the heavy weight of the helmet, followed by a feeling of heat, neck pain, feeling of suffocation, and limitation of head and neck movements were the main reasons for not wearing helmet among Iranian motorcyclists. Additionally, young riders do not prefer to wear a helmet when they go out for short distances, which may be indicative of their unawareness of the importance of using protective equipment. This is similar to findings reported in other studies conducted in Taiwan and India (Hung et al., 2006; Jain et al., 2009). Participants in the present study also highlighted the practice of using mobile phones while riding. Riders or pillion passengers are commonly observed recording videos and capturing pictures to post them on social media. Furthermore, they browse the internet for google maps, access social media, and attend calls. This aligns with the findings of the study conducted by Bates et al. (2014) in Oman. Studies conducted in other regions of the India by the Save LIFE Vodafone Foundation (2017) and by Hassan et al. (2017) also reported high usage of mobile phones for various activities among young riders while riding. Overall, and in line with what was reported still recently by Nguyen et al. (2022) for Vietnam, quotes provided by the FGD participants regarding the motives underlying risky rider behaviour seem to suggest that risky ridership can best be understood as a dual process phenomenon, similar to what has been reported for car drivers (Ross et al., 2016). In a study conducted by Widyanti et al. (2020) among Indonesian motorcyclists, results showed that the prevalence of mobile phone usage among Indonesian motorcyclists was as high as 75%. It was argued that factors such as age, education, and marital status affect mobile phone usage among Indonesian motorcyclists. Interestingly, fines did not influence the use of mobile phones during motorcycling amongst them. Risky rider behaviour can be explained as volitionally controlled, resulting from a conscious judgement of the pros and cons, the cost and benefits related to a specific behaviour (e.g., speeding or alcohol-impaired riding). On the other hand, risky behaviour can be the outcome of a reactive decision-making pathway where risk-conducive contextual circumstances (e.g., the presence of peers, the lack of safe alternatives to travel back home after having drunk) trigger an unintentional willingness to take risks (Nguyen et al., 2022). Alcohol-impaired riding was also identified as risky behaviour. The culture of weekend celebration and riding after getting drunk in bars/pubs was mentioned by many of the participants as an important crash causative factor. This is also similar to what (Romero et al., 2019) found in Brazil. It is obvious that alcohol can affect most of the abilities and skills needed for safe riding. It can affect attention, motor skills, and decision-making. Noteworthy to mention, the current evidence shows that degradation of riding performance due to alcohol impairment can occur at a BAC-level 0.05 or even less than that. Although most of the study participants opined that riding under the influence of alcohol is dangerous, there are two major concerns that can well explain why riding under the influence of alcohol remains one of the major causes of road crashes. Alonso et al. (2015) mentioned that riders are prone to neglect the "objective risk" of operating a vehicle under the influence of alcohol, as every time they don't encounter a crash. This prompts them to believe that there is no risk involved in riding under the influence of alcohol, which further reinforces the behaviour. This can also somewhat be explained in a study conducted by Bazargan-Hejazi et al. (2013) in Iran. Iranian motorcyclists were clustered into different groups based on specific cognitive dissonances and consonances associated with risky riding. This resulted in the identification of four groups, i.e., risk managers, risk utilizers, risk calculators, and risk-takers. Two of these profiles (i.e., risk managers and risk utilizers) somehow reflect the answers provided by participants in our study. Furthermore, looking it from the perspective of the Health Belief Model (Becker, 1974), people usually will not change their existing behaviours unless they think such action is necessary. Interestingly, there is enough empirical evidence to suggest that many road users are unaware about the required information regarding the effects of alcohol on personal functioning (Potard et al., 2018; Dionne et al., 2007). Furthermore, there is a common assumption regarding the actions one can take to nullify the impact of alcohol before driving (for e.g., taking a cold shower, having mint, drinking coffee (Alonso et al., 2015). As stated by the protection motivation theory, adopting a preventive behaviour is not only dependent on a threat appraisal process (perceived severity) and the perceived probability that one can be more susceptible to the harm (perceived susceptibility) caused by that threat, but also on a coping appraisal process (Rippetoe & Rogers, 1987). Important to mention is that an individual's gender is a key factor that affects their riding behaviour. In a study conducted by Uttra, Laddawan, et al. (2020), it was reported that gender significantly affects the motorcycle riding behaviour. For instance, the main factors that influenced motorcycle riding behaviour were the attitude based on health motivation and perceived behaviour control. For females, attitude based on health motivation is more impactful as compared to males. Speeding behaviour can also be explained in terms dual-process theory. Jongen et al. (2011) was among the first to provide evidence for a dual process theory of risky riding by showing that a momentary reward leads to speeding among young riders, while cognitive control interacted with driving performance (i.e., lower inhibitory control related to increased lane-keeping variability). Nevertheless, they were not able to include a full test of a dual process theory of risky driving, which included the component of cognitive control and a socio-reward context as stated by Lambert et al. (2014).

Additionally, the study reveals seeking adventure and thrill as primary reasons young riders indulge in speeding, besides seeking peer attention, getting late to reach the destination, racing with fellow riders, and influencing movies. Stress was another reason given by the participants, which aligns with what was found in studies conducted by Kohli (2013) in India and Romero et al. (2019) in Brazil. The current study suggests that ego plays an essential role in shaping the behaviour of young riders. This reflects the findings obtained by Romero et al. (2019): personality traits including impulsivity, ego, and violence contributed to a significant share of road crashes among young Brazilian riders. Moreover, youths are careless when it comes to the regular and proper maintenance of their motorcycles. They set aside their pocket money for other expenses and do not get their motorcycles regularly serviced. Previous studies have reported an increased risk of road crashes if motorcycles are not adequately maintained (Annadurai et al., 2015). The importance of environmental factors (i.e., climate and road infrastructure) emerged as another major theme from the current FGDs. This aligns with the study conducted by Huth et al. (2014). Climatological conditions such as extreme rainfall and humidity worsen road conditions, especially during the monsoon season. This, in turn, increases crash risk (Jain et al., 2009; Tetali et al., 2013). The discussion revealed the non-functioning of the basic road safety infrastructure in the city, making riders vulnerable to crashes, which reflects findings reported in another qualitative study where a broad selection of road safety stakeholders (e.g., government officials, subject experts, road traffic injury victims, trauma surgeons, medical interns, nurses and taxi drivers) were consulted for their perceptions of road safety in Hyderabad, India (Tetali et al., 2013). Participants were critical of the local authorities in maintaining the basic road safety infrastructure and the loopholes in issuing a licence for a two-wheeler. The participants narrated their experiences in the RTO to justify their claims. It has been argued in other studies as well that the screening procedure in issuing a licence should be strictly followed to curtail the presence of unskilled riders on the road (Ramos et al., 2008). As for ways to improve the road safety of younger riders, participants suggested conducting awareness programmes through the coordinated effort of public bodies, educational institutions, and the traffic department (Tetali et al., 2013). Additionally, authorization of student volunteers to monitor other youths if they are abiding by the traffic laws in and around the city was proposed. Walking and cycling could be promoted by creating a separate lane for the cyclist and via the construction of subways for pedestrians. Some of the participants felt the need to improve public transport facilities outside bars/pubs to minimize the risk of crashes due to alcohol impairment (Ramos et al., 2008). Bar/pub authorities could take up the responsibility of setting limits on serving liquor to the youths. Furthermore, information, education, and communication materials could be displayed on the premises for creating awareness. The potential for such on-site interventions has been demonstrated for instance, in Europe. To illustrate, the EU-funded project Focus on Alcohol Safe Environments focused on available evidence for the success of five intervention areas aimed at preventing alcohol-related harm in drinking environments, i.e., (1) training of responsible servers and staff, (2) reduction of underage access to alcohol, (3) policing and enforcement, (4) brief interventions in drinking establishments (e.g., offering of incentives for designated drivers), and (5) community-based multi-component programmes. Although results were mixed across these five areas, the clearest evidence for success came from community-based programmes that combine a range of coordinated measures implemented through string multi-agency partnership. The Swedish STAD-project (Stockholm Prevents Alcohol and Drug Problems) serves as a good practice example. A range of measures were implemented, including responsible beverage service training, community mobilization, and increased enforcement, resulting in a reduction of the number of crimes by 29% in the intervention area in a cost-effective way. Most of the participants suggested the improvement and proper maintenance of the current road safety infrastructure in the city, which aligns with the findings of several previous studies (Pal et al., 2019; Gopalakrishnan, 2012; Huth et al., 2014; Jain et al., 2009; Tamakloe et al., 2022). Intradepartmental coordination to decide on the hot spots in the city to install traffic barricades, cameras, speed breakers, signboards, and signals can be initiated. Furthermore, it was opined that events such as hackathons could be conducted in the colleges, encouraging youth to come up with creative solutions to prevent road crashes. As a good practice illustration of that, in a hackathon organized by the Germany based Bosch group in Bangalore, some engineering students developed a prototype of an ultrasonic sensor that can alert a rider about speeding vehicles nearby (Arya, 2020). Even though a legislative framework for traffic violations is available, it was revealed that these regulations are not always properly enforced in the city. Participants stressed the fact that young riders of higher socio-economic status often commit traffic violations as they feel that they can afford penalties and escape. A heavier penalty system should be implemented to discourage riders from committing violations (Ramos et al., 2008). Furthermore, it was also suggested to increase the number of random surprise checkpoints in various zones of the city. Curbing the malpractices concerning the issuing of riding licences and enforcement by reforms can play a significant role in preventing road crashes among young riders (Tetali et al., 2013).

7. Practical Implications

Based on the study results, several tentative recommendations are proposed. As a countermeasure, there is a need to rectify the erroneous assumptions to prevent the negative effects of alcohol, so that riders do not continue to falsely believe that they can adequately deal with alcohol and continue driving while intoxicated. Furthermore, certain techniques for behavioural change, such as persuasive communication techniques targeting on skills including self-assessment, self-anticipation, and self-actualization, are suitable to influence the volitional pathway towards risky ridership behaviour (Nguyen et al., 2022). The authorities should also think about improving the safety systems to make the riding environment safer. Important to mention here is the concept of "safe system approach". The Safe System is based on well-established safety principles—of known tolerance of the human body to crash forces, speed thresholds for managing crash impact energies to survivable levels, and the capacities of vehicles and forgiving infrastructure to reduce crash impact energy transfers to humans. Additionally, the Safe System approach—a core feature of the WHO Decade of Action for Road Safety recognizes that road transport is complex and places safety at its core. It states that humans, vehicles, and the road infrastructure must interact in a cohesive way to ensure a high level of safety (WHO: Safety Report, 2020). Hence, it is recommended to improve the safety system. Adequate lighting systems are required to improve visibility, particularly during the daytime (Yousif et al., 2020). It is interesting to note that, as per the Government of India guidelines, all new motorcycles, and scooters that came into the market need to feature "Automatic Headlight On" (AHO) from 1 April 2017 onwards. AHO is mandated to improve visibility during day and at dawn and dusk (Vijayraghvan, 2016). One important point which can be raised here is what about those vehicles which came out before 1 April 2017 and are currently in use. The local authorities can organize programmes to raise awareness about the utility of AHO among the young riders and strategies to incorporate it in the older vehicles. Nevertheless, in a middle-income country such as India with a predominantly youth population dependent on the pocket received from their parents, it would be financially tasking for them to exchange their old running vehicles or pay for AHO to incorporate it. A multi-sectoral approach by engaging all the relevant stakeholders and behavioural interventions, such as persuasive communication techniques, and an active experimental approach, such as the use of a simulator and regulating the licensing procedure, can bring a reduction in the number of road crashes. Although the participants were aware of the dangers of speeding and riding under the influence of alcohol, they were not well informed by a correct understanding of the exact reasons why speeding and riding under the influence of alcohol increases crash risk. It is recommended to have an active experimental approach, such as a simulator, where riders personally experience the impact of speeding to better assess the relationship between speeding and crash risk (Kolb, 1983). For instance, the Automobile Association of Upper India is non-profit organization based in New Delhi and conducts driving stimulator experiments (Aaui, 2020). This can even be implemented at the licensing procedure to sensitize future riders. Furthermore, the current study's findings suggest that decision-makers should implement strict regulations for those riding underage or without a proper valid licence. It is noteworthy to mention that until and unless licensing procedures in India are regulated and closely monitored, the quality of the rider will be questioned (Gupta et al., 2021). The current study's findings have also generated evidence for the local authorities about the importance of strict law enforcement for any acts of traffic violations. Possible hazards for riders created by potholes and bad roads need to be taken into consideration. The local authorities should immediately focus on immediate fixation to neutralize any possible threats for the riders. Fixing the infrastructural issues with advanced road engineering under a coordinated multi-sectoral effort will end up in a more significant commitment to reducing road crashes (Opoku, 2019). It is noteworthy to mention that the study findings have international significance, particularly in LMICs. For instance, as indicated by Oltaye et al. (2021) in Ethiopia and Konlan et al. (2020) in Ghana, speeding is identified as the main cause of road crashes. Therefore, the findings from the current study will provide impetus to the researchers in other LMICs and assess the underlying motives for risky riding behaviours using an in-depth approach. Furthermore, the study has highlighted the importance of road safety infrastructure, which largely remains neglected in LMICs (Heydari et al., 2019). More importantly, behaviours such as speeding have been identified as the crash causation among motorcyclists in high-income countries as well (Dubos et al., 2016). It can therefore be recommended for policymakers in those countries to initiate targeted interventions that focus on the predictors of risky riding to reduce crash and injury rates.

8. Limitations and Future Research

Inevitably, there are certain limitations to studies such as this one. Firstly, the study had a qualitative research design, and its findings first need to be further validated in larger samples. Even though exploratory in nature, the inputs provided by the participants generate important leads for the design of (quantitative) follow-up studies where more structured surveys can be used to verify the opinions collected during the FGDs.

Secondly, few FGDs were conducted in Kannada and were then translated to English. Although the principal investigator was fluent in both languages, some information might have been missed or not properly interpreted during the translation process. Thirdly, Manipal is a cosmopolitan university town with a sizeable student population, which implies it is demographically different than other Indian cities and therefore the study only recruited young students as participants. Correspondingly, one should be cautious in generalizing the findings of this study to other Indian regions and other young riders as well. Lastly, the data analysis was done alone by the principal investigator himself and inter-reliability checks while coding the data was missed. There is a need for future research in several domains. As mentioned, study had a qualitative research design, and its findings first need to be further validated in larger samples. A cross-sectional survey research can be taken up in other settings of India to further validate the findings of the current study. Also, the study did not record information to what extent the participants themselves perform the risky riding behaviours. Furthermore, the study highlighted that participant might not consider this type of behaviour as dangerous as speeding, ignorance in servicing motorcycles, and drink-drive culture. Whether these speculations are valid or not is an issue that warrants further exploration.

9. Conclusions

In the current study, characteristics of motorcycle crashes among young riders were investigated, primarily focusing on the prevalence and role of risky riding behaviours. To the best of our knowledge, a focused group study exploring the perspectives of young riders on risky riding behaviour has not been conducted in India before. The main factors derived from the FGDs responsible for road crashes are risky riding practices and gaps in the infrastructure of the city. The most prevalent risky riding practices mentioned were speeding, alcohol-impaired riding (Nguyen et al., 2022; Huth et al., 2014), use of the mobile phone while riding, not wearing a helmet, and improper maintenance of motorcycles. Given the recent upsurge in the number of road crashes, there is an urgent need for targeted interventions to bring about behavioural change among the young riders. Multi-sectoral coordination by engaging the young riders, government authorities, university officials and RTO, behavioural interventions, such as persuasive communication techniques, active experimental approaches such as the use of a simulator, and regulating the licensing procedure can reduce the number of road crashes. Fixing the infrastructural issues with advanced road engineering will end up in a more significant commitment to reducing road crashes.

Chapter 5

A qualitative study to explore traffic police personnel perceptions towards road safety behaviour in young riders in Manipal, India

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Chapter 6

A quantitative analysis of the psychosocial determinants of risky riding behaviour among young motorized two-wheelers riders in Manipal, India

Chapter 7

General Discussion

Impact of this dissertation

My doctoral dissertation attempts to understand risky riding behaviour and explore its psychosocial determinants among young motorized two-wheeler riders. In this section, implications for future research and interventions are discussed. Given the paucity of evidence on the underlying evidence on psychological determinants of risky riding behaviours in India, the findings of this dissertation will serve as baseline data for future studies. Furthermore, the findings of this dissertation highlight the importance of the utilization of crash data at the local level for any kind of meaningful localized interventions. Nevertheless, it must be noted that awareness related to crash data utilization is seemingly low in India. Also, the crash data findings of the dissertation can be replicated in other cities in India for evidence generation and subsequent intervention. The findings also provide impetus for researchers working in this field to consider helmet and mobile phone usage behaviour and incorporate these two components in the MRBQ to further use it in other settings in India using a larger population and broader age group involvement. This will help to come to a more generalizable overview of the factor structure of the MRBQ in the Indian context.

The findings of this dissertation also provide the first hands-on information regarding the perspective of the traffic police personnel to understand the risky riding behaviour among young riders and plan out targeted interventions. The aforementioned interventions are necessary as the enforcement authorities are the key stakeholders in ensuring the sustainability of any targeted intervention programmes. The findings of this dissertation are of interest to both practitioners and policymakers. For instance, the practitioners can engage young riders for behavioural change programmes like behaviour change communication and persuasive communication programmes targeting speeding and mobile phone usage behaviour with support from government authorities, university officials, and the regional transport office. For the policymakers, the dissertation outlines the importance of strict licensing procedures, MTWs safe systems, road safety information database, strict law enforcement and road infrastructure improvement to achieve "vision zero".

The findings of this dissertation also consider the perspective of the target population, i.e., young riders, to further explore the underlying causes of risky riding behaviour. They opined that intradepartmental coordination to decide on the crash hot spots in the city to install barricades, cameras, speed breakers, signboards, and signals is the need of the hour. Furthermore, it was suggested that events like hackathons could be conducted in the colleges to encourage the youths to develop creative solutions to prevent road crashes. These findings can provide essential leads for such initiatives at the local level and in other parts of India. The results of this dissertation can be extrapolated in organizing much intensive mass campaign to sensitize the riders to safe riding practices. Future research should use the Intervention Mapping approach to develop a theory-based intervention to increase awareness about safe riding practices. Intervention Mapping is a protocol for systematic theory-and evidence-based behaviour change planning to form an ecological approach to assess and intervene in health problems and promote community participation (Bartholomew Eldredge et al., 2016). The Intervention Mapping protocol can inform the development, implementation and evaluation of interventions. Noteworthy, Intervention Mapping technique can be used in other settings to identify, modify or create new interventions that will comprehensively tackle road crashes. To the best of our knowledge, Intervention Mapping approach has not been used in India to study road crashes and design intervention programmes. Our current research provides the impetus for road safety researchers and programme managers to utilize the Intervention Mapping approach as a starting point for future targeted interventions.

Publications in this dissertation

1. Sumit, K., Ross, V., Brijs, K., Wets, G., & Ruiter, R. A. C. (2021). Risky motorcycle riding behaviour among young riders in Manipal, India. BMC Public Health, 21(1). https://doi.org/10.1186/s12889-021-11899-y
2. Sumit, K., Ross, V., Ruiter, R. A. C., Polders, E., Wets, G., & Brijs, K. (2022). An Exploration of Characteristics and Time Series Forecast of Fatal Road Crashes in Manipal, India. Sustainability, 14(5), 2851. https://doi.org/10.3390/su14052851
3. Sumit, K., Brijs, K., Ross, V., Wets, G., & Ruiter, R. A. C. (2022). A focus group study to explore risky ridership among young motorcyclists in Manipal, India. Safety (Basel, Switzerland), 8(2), 40. https://doi.org/10.3390/safety8020040

Conference presentation

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2. Kumar Sumit, Veerle Ross, Robert. A.C. Ruiter, Kris Brijs, Geert Wets. A qualitative study to explore traffic police personnel perception related to road safety among the young riders in Manipal, India. 65th Annual National Conference of Indian Public Health Association – IPHACON, 23rd -26th September 2021, JIPMER, Pondicherry, India.

3. Kumar Sumit, Kris Brijs, Veerle Ross, Geert Wets, Robert. A.C. Ruiter. A Focus Group Study to Explore Risky Ridership among Young Motorcyclists in Manipal, India. 2nd World Conference on Public Health 2021, 26th - 27th November 2021.
4. Kumar Sumit, Kris Brijs, Veerle Ross, Geert Wets, Rob Ruiter. A quantitative analysis of the psychosocial determinants of risky riding behaviour among young motorized two-wheelers riders in Manipal, India. ISTEC, Hasselt University, Belgium. 20th October, 2022.

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Author's Resume

Kumar Sumit was born on 16th October 1985. He received a Bachelor's degree in dental surgery in 2010 from Rajiv Gandhi University of Health Sciences, Bangalore. In 2014, he completed a Master's in Public Health from Manipal University. He has been teaching public health students at the Master's level since November 2014. Currently, he is working as faculty in the public health programme at Prasanna School of Public Health, Manipal Academy of Higher Education. He has been the recipient of the prestigious Erasmus ICM grant and has experience of teaching global health students at Tampere University, Finland.

In collaboration with Hasselt University, he commenced the PhD programme at the University of Maastricht in 2017. Also, in 2018 he has been to Oxford University to attend the "Global challenges in Transport" course. A passionate teacher, he also has a strong interest in road safety research and is keen on bringing some changes at the local level.

Summary

Road traffic crashes have emerged as the new public health threat in India and many other developing countries. With a population of nearly 1.37 billion people, India now faces the worst-ever road congestion in most cities and towns, and Indian roads have become more vulnerable to road crashes. Young MTWs riders are more vulnerable to road crashes due to a lack of experience in comprehending, assessing and responding to hazards. Young riders in the age range of 18-25 years contribute to more than half of total fatal crashes. The current research was based in the Indian university town of Manipal with a sizeable young student population in this age range. Manipal is home to the Manipal Academy of Higher Education (MAHE), and it hosts approximately 30,000 young students from all across India and 60 countries all over the world. The overall aim of this dissertation is to understand the risky riding behaviour among young MTWs in Manipal, Karnataka, India. A comprehensive understanding of these factors is necessary, given that little is known about risky riding behaviour and its psychological implications in India. Furthermore, the resulting information can inform interventions to promote less risky or safer riding among young MTWs in Manipal and similar settings.

To better understand the characteristics of fatal road crashes in Manipal from 2008–2018, in chapter 2, we used the data on fatal crashes retrieved from the office of the Superintendent of police. Also, we forecasted crashes by time series analysis prediction from 2019-2025. The analysis indicates an increase in crashes in the last few years. The analysis revealed that most fatal crashes are due to head-on collision followed by rear-end collision. The current chapter highlighted the involvement of motorcyclists in a fatal crashes much more than any other vehicle. Speeding the vehicle beyond the lawful limit is the most common cause of fatal crashes in more than 90% of cases. Crashes are more common on Saturday evenings, primarily due to riding under the influence of alcohol after weekend parties and get together. For the distribution of fatal crashes according to the types of roads, the study reported that the highest proportion of fatal crashes has occurred on National Highways, followed by State Highways and other roads. As for the distribution of fatal crashes depending upon local weather conditions, most fatal crashes were found to occur during heavy rains followed by light rain. For the distribution of fatal crashes per vehicular defect, defective brakes, worn-out tyres, and defective lighting systems contribute to more than half of the total share of fatal crashes.

Chapter 3 was a cross-sectional study which focused on the factor structure of a modified version of MRBQ. Furthermore, it assessed whether the extracted MRBQ factors were associated with self-reported crash involvement and the number of fines

paid to examine the MRBQ's potential in predicting risky riding behaviour. The exploratory factor analysis for the MRBQ questionnaire revealed a 36-item five-factor solution: traffic errors, control errors, stunts, protective equipment, and violations. Riders who reported violations and performing stunts also had more risk of getting involved in recent near-crash experiences. No positive associations were found for the other two factors (traffic and control errors) with near-crash involvement. Riders reporting frequent traffic errors, violations, and control errors had twice the odds of paying fines compared to those who reported low traffic, violations, and control errors.

Further, in Chapter 4, we focused on the perspectives of young riders in practising risky riding behaviours. From the FGD's held, significant factors have been derived which determine the dangerous riding ideas the youngsters are involved. Indicators for these risky riding practices were speeding, drinking and driving, using mobile phones while riding, not wearing a helmet, and improper maintenance of motorbikes. Furthermore, the indicators for the infrastructural factors were non-functional traffic signals, streetlights, barricades, signboards, and speed breakers. The participants enumerated several reasons why a rider speeds up while riding. For example, the participants gave different reasons for speeding, such as rushing for essential purposes, looking for peer consideration, getting late to arrive at the destination, hustling with individual riders and the impact of films. However, the primary reason for indulging in speeding activity was thrill-seeking. Moreover, participants were critical of the local authorities in maintaining the basic road safety infrastructure and the existing loopholes. As for ways to improve the road safety of younger riders, participants suggested conducting awareness programmes through the coordinated effort of public bodies, educational institutions, and the traffic department. Additionally, the authorization of student volunteers to monitor other youths if they abide by traffic laws in and around the city was proposed.

In Chapter 5, we did a qualitative study to understand the traffic police personnel's perceptions of the risky riding behaviour of young riders in the city. Five themes were derived from the data collected (1) Current traffic scenario in the city, (2) Common practices observed among the young riders, (3) Determinants of crashes observed among the young riders, (4) Strategies to improve road safety in the city, and (5) Proposals suggested by the traffic police personnel. The traffic scenario has changed drastically for Manipal. The reason is that the number of occupants in the city has expanded on the grounds of job security and educational purposes, which has added to an increment in the number of vehicles in the city. Nevertheless, the city has seen a hefty traffic load during the morning and evening hours and at the end of the week. It was reported that young female riders adhered better to traffic rules and well-being when contrasted with young male riders. This chapter highlights the young riders' lack of adherence to traffic rules and vague reasons for not abiding by the traffic rules or approaching the traffic police to convince them. Talking and texting on mobile phones while riding is a common behaviour among young riders reported by the majority of traffic police personnel. The chapter also points out the city's most crash-prone areas, i.e., the railway bridges used for road transportation connecting the cities. It was recommended to improvise the city's road safety measures by considering the target population group. Establishing a coordination committee that can locally organize awareness programmes for road safety and proper traffic police personnel training could improve road safety and reduce crash fatalities.

Finally, in Chapter 6, we did a cross-sectional study to identify the psychosocial determinants of risky riding behaviour in young, motorized two-wheeler riders guided by the empirical literature and the TPB. The result of the study indicated that speeding behaviour had a significant positive correlation with all its psychosocial determinants. Furthermore, the results stated that the riders believe that mobile phone usage while riding is normal and less risky than performing stunts on the road. It was observed that mobile phone usage behaviour had a significant positive correlation with all its psychosocial determinants except for habits and past behaviour. Moreover, there is a strong significance between the participants' behavioural intention, PBC, normative beliefs, barriers, and attitudes toward using mobile phones behaviour. The participants in the study clearly understand the benefits associated with helmet usage and have a positive attitude toward following the rule of helmet usage. Riders' perceived benefits and attitudes are considered to be the strong predicting factors for helmet usage. Furthermore, subjective norm was found to be positively associated with helmet usage. Policymakers and strategy planners should be encouraged to consider these valuable leads to design future interventions aiming toward controlling risky riding behaviours among young riders in India. Behavioural change programmes like behaviour change communication and persuasive communication programmes targeting speeding and mobile phone usage behaviour can be initiated with the involvement of young riders and support from government authorities, university officials, and the regional transport office.

In the general discussion in Chapter 7, the main findings are summarized and discussed. Finally, the following recommendations of the findings are proposed:

1. **Academic recommendations-** (a) Future research on collecting detailed information on crash configuration to support in-depth research, (b) MRBQ research with the incorporation of helmet and mobile phone usage behaviour in

other settings in India using a larger population and broader age group involvement, (c) research on what extent the young riders themselves performed the risky riding behaviours.

2. **Practical recommendations**- (a) the practitioners should engage young riders for behavioural change programmes like behaviour change communication and persuasive communication programmes targeting speeding and mobile phone usage behaviour, (b) software manufacturers should research and develop applications for mobile phones to minimize the direct usage of mobile phone while riding, (c) it is recommended to have an active experimental approach, such as a simulator, where riders personally experience the impact of speeding to better assess the relationship between speeding and crash risk.
3. **Policy approaches for licensing procedure-** (a) policymakers should implement strict regulations for those riding underage or without a proper valid licence, (b) graduated driving licence programmes for better driving skills.
4. **Policy approaches for MTWs safe systems-** It is recommended for the policymakers to implement and sustain the concept of "safe system approach" like advanced rider assistance systems (ARAS) such as anti-lock braking systems (ABS), assist and slipper clutches (A&S clutch), adaptive cruise controls (ACC).
5. **Policy approaches for a Road Safety Information Database-** It is mandatory to have Road Safety Information Database in a country like India. Although, due to the ongoing COVID-19 pandemic, the entire focus of the government has shifted towards it, the government and policymakers should still take cognizance of it and implement National Road Safety Information System sooner.
6. **Policy approaches for strict law enforcement-** Policymakers must take appropriate measures to assist the enforcement authorities to strengthen and improve the quality of enforcement in order to ensure effective and uniform implementation of traffic laws. For instance, establishing and strengthening highway patrolling on National and State Highways in cooperation with State Governments.
7. **Policy approaches for road infrastructure improvements-** It is necessary to improve the existing road safety infrastructure in India to achieve "vision zero" for the MTW riders in India. The policymakers should focus on immediate fixation to neutralize any possible threats for the riders. Fixing the infrastructural issues with advanced road engineering under a coordinated multi-sectoral effort will result in a more significant commitment to reducing road crashes.

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