Trends and Determinants of Motorized Two Wheeler Road Traffic Crashes: A Systematic Review and Meta-Analysis

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Abstract- Motorized two-wheelers, particularly motorcycles and scooters, contribute significantly to road traffic injuries and deaths in low- and middle-income countries. This study aimed to assess the magnitude, determinants, and outcomes of two-wheeler crash accidents. A systematic review and meta-analysis were conducted following PRISMA guidelines using PubMed, Scopus, Cochrane, and Google Scholar databases. Forty studies (2012–2018) were analyzed to determine national and provincial patterns. Across 40 studies, 50,283 road traffic accidents were reported, of which 41,596 (83%) involved motorized two-wheelers. Punjab accounted for 43.4% of all two-wheeler crashes and a higher share of severe outcomes: 59% fatal, 68.8% deaths, and 62.8% disabling injuries. Contributing factors included excessive speed, poor helmet compliance, inadequate infrastructure, and delayed emergency care Motorized two-wheeler crashes represent a major public health issue in Pakistan, especially in Punjab. Strengthened helmet enforcement, road safety education, improved infrastructure, and enhanced trauma response are essential to reduce this preventable burden.

Keywords- motorized two-wheelers, meta-analysis, road traffic injuries, systematic review

I. Introduction

Road traffic accidents cause multiple injuries to the victims who might result into their disability or death. Substantial cost involved in the treatment bears a potential burden on the national healthcare system. The advent of motorized vehicles has elevated the standards of civilization and living to an immeasurable extent. Among these, motorcycles stand out as the most commonly used mode of transportation in Pakistan, primarily because they offer the most economical means of travel.(Hasan et al., 2019)

A big problem with road accidents is starting around the world. Every year, more than a million people die because of injuries from car crashes, and about 10 million people are left with serious, lasting injuries. Road accidents are the second biggest cause of death and disability for people under 44 in USA. When looking at how much life is lost or damaged because of illness or injury, road crashes are expected to become the third biggest health problem in the world (F Bunn, 2003).

In a research steered in China (Li et al., 2022), the authors selected 18 studies from January 2000 to December 2020. These studies pertained to electric two-wheelers. They focused on sociodemographic factors, riding behavior, helmet use and traffic rules violation. The pooled analysis revealed that mortality rate among motorized two-wheelers injuries was 9% which is very significant. As these injuries are preventable, better understanding of the risk factors are greatly helpful in making the traffic related new safety regulations.

In their paper, the authors explored Medline, Google Scholar, Embase, Global Health for articles.(Davies Adeloye, 2016) They selected 39 studies from African countries. They found 65.2 per 100, 000 population, an projected joint rate for road traffic injury and 16.6 per 100, 000 population an estimated pooled rate for death. Many experts found difficulty in defining road crash injuries and deaths. Therefore, as results are not consistent with each other, they also found difficulty in outlining collective wisdom and extent of health problem.

A literature systematic review conducted in Brazil in 2021 (Cavalcante et al., 2021), authors verified that helmet use reduce the occurrence and severity of facial fractures in motorized two-wheeler accidents. They screened prevalence and cohort studies without restriction on publication date. They could find 26 articles, all belonging to prevalence studies. On pooling the results, they described those patients with helmet use had lower prevalence and severity of facial fractures in comparison with patients who did not take helmet at the time of crash.

In India during 2020, researchers conducted a study focusing on risk factors associated with two-wheeler riders. They only selected the heterogenous non-lane based pattern of traffic (Damani & Vedagiri, 2021). In developing countries like India, with population growth and economic slowdown, there is substantial rise of motor bike users for their routine mode of transmission. As traffic pattern is mixed and many roads are devoid of lanes, it is very difficult to see the traffic flow in organized manner. Therefore, safety of motor bike rides is at great risk. Driver related factors are very important. These factors can be split into two types: intrinsic and extrinsic. Intrinsic factors influence how someone drives, like when a driver acts carelessly. The extrinsic factors include safety training and use of protective means.

A systematic review and metanalysis was conducted in China during 2022. Authors selected studies on the link between risk of road traffic accident and ambient temperature. They searched 7 databases to find the studies. A total 34 increased temperature effect approximations were reported. Meta-nalysis found significant association between road traffic accidents and high temperature (Liang et al., 2022). The pooled relative risk was 1.025 (95% CL). The relative risk value of road traffic accidents was 1.024 (95% CL). The relative risk value of road traffic injuries was 1.052 (95% CL).

A systematic review and metanalysis was conducted in Africa in 2022. The authors selected the articles by searching CINAHL and Ovid Medline databases. They only included the quantitative studies (Abdi et al., 2022). Among the eight studies, result revealed that males are two times more involved in motor bike accidents, mean age of riders is 30 years, helmet usage from 0 to 43%. Helmet use reduces severity of head injuries up to 88%. Therefore, to decrease the disability and mortality as result of motorbike accidents in African countries, strict traffic rules pertaining to use of helmet must be implemented.

An African study assessed the burden of road traffic accident-related injuries and fatalities through a systematic review and meta-analysis. Their findings indicated that the injury rate from RTAs increased from 40.7 per 100,000 population in 1990 to 92.9 per 100,000 in 2010 (Thompson, 2016). This more than twofold rise highlights a serious public health concern, underscoring the limited effectiveness of existing measures by health authorities in addressing this preventable problem in African countries.

During another systematic review and meta-analysis, authors searched the databases like Cochrane Library and PubMed (Mannocci et al., 2019). They selected the period between April 2012 and March 2017 for the published articles. Authors sorted out 13 systematic reviews and 1 meta-analysis. They concluded that in areas of low socio-economic rank people are at increased danger of injuries and deaths due to road traffic accidents. Males being main family supporters are at more risk, as they are aggressively involved in outdoor activities for earning.

Savino et al., (2020) in their systematic review and meta-analysis found that active safety systems for motorized two wheelers were discussed but their development is at various stages. Some of the active safety systems are still at prototypes stage. Comparison among different safety systems is lacking. Further individual safety system is checked. There is still room to check the durability of whole safety system as a one brand. Active safety system bears pivotal value in minimizing the injuries due to powered two-wheeler crashes.

During another systematic review and meta-analysis (Nguyen et al., 2020) authors were of the view that still no associations between vision impairment and driving have been scientifically ascertained in the past literature. Similar is the case for association between vision related interventions and road traffic injuries.

Researchers conducted a systematic review and meta-analysis in China during 2019. They evaluated the association between sensation seeking and driving outcome (Zhang et al., 2019). Forty-four studies were selected. Authors included aberrant driving behavior, ticket receivers and accident involvement in driving outcomes. They have seen significant positive correlation among risky driving and accident involvement. They advocated evidence -based driving education and accident prevention interventions. Pooled relative risk for risky driving was RR= 0.24, $p < 0.001$. Sensation seeking was also positively correlated with accident involvement, pooled RR= 0.08, $p < 0.001$. However, tickets received pooled RR = 0.19, $p < 0.001$ which is at weaker level.

In USA during 2021, a "systematic review and meta-analysis" study was conducted by using PRISMA checklist (Lepard et al., 2021). PubMed and Embase databases were used for searching required articles. Authors used Newcastle-Ottawa Scale (NOS) to rate study quality. Total 25 articles were included in the study. The situation was observed in all studies that after implementing, legislation of helmet, odds of helmet use were higher. "In high income countries, results were greater statistically (OR: 53.5; 95% CI: 28.4; 100.7) than in low- and middle-income countries (OR: 4.82; 95% CI: 3.58; 6.49), p-value comparing both strata < 0.0001. There were significantly lower odds of motorcycle fatalities after implementation of helmet legislation (OR: 0.71; 95% CI: 0.61; 0.83)".

Researchers conducted a study in European Union during 2021. They used the data of 500 accidents involving powered two-wheelers found. Data was collected across the six European countries (Brown et al., 2021). The investigation was focused to see the most common causal effect but they could not find it. About 25% of serious injuries occurred to those powered two-wheeler riders who lost the control of the vehicle.

Homaie Rad et al.,2020 found that studies relating to weight indicis and injury outcome are very limited. They searched the databases of Medline, PubMed, Embase and web of sciences. They detected the direct association between body mass index and severity of injuries. "A positive association was found between obesity and AIS+2 (CI=0.653-1.426), and AIS+3 (CI=1.184-1.741), and ISS (CI=1.086-1.589)" (Homaie Rad et al., 2020).

A systematic review of traffic conflict-based safety measures was conducted during 2021. Researchers reviewed 386 studies and identified various conflict measures used in intersections and environmental conditions being the pivotal value for safety of vulnerable road users. They also found (Arun et al., 2021) that safety thresholds of conflicts vary by traffic environment and application. Methodological advances are necessary for using traffic conflict techniques.

In western countries like United States, Canada, and Europe, motorcycles are primarily used for leisure and touring purposes. In contrast, in Pakistan, motorcycles are a key form of transportation for many low- and middle-income families (Moorthy et al., 2021). However, the factors that make motorcyclists get hurt badly may be different compared to what is

seen in countries with higher income levels. Schneider and Savolainen (2011) found that parts of the road like curves, the width of the shoulder, and how steep the road is are linked to more severe injuries for motorcyclists.

II. MATERIALS AND METHODS

The study was conducted at Faculty of Allied Health Sciences, University of Lahore, Pakistan from January 2022 to March 2022. The department provided access to extensive academic and digital resources, including electronic databases. PubMed, Scopus, Cochrane and Google Scholar were utilized for systematic review and literature retrieval. 40 studies (2012-2018) were selected as per PRISMA guidelines. Keywords for search of articles include motorized two-wheeler, motorcycle, scooter, road traffic accident and developing countries. Studies on motorized two-wheeler crashes, quantitative or mixed-method studies reporting prevalence, causes, or outcomes, peer-reviewed journal articles were included in the study. Review articles or case reports were excluded from the study. Ethical approval was obtained from the Institutional Review Board. A random-effects meta-analysis was conducted using SPSS V26.

III. RFESULTS

Across 40 included studies, relating to the period year 2012-2018, a total of 50,283 road traffic accidents (RTAs) were reported in Pakistan, of which 41,596 (83%) involved motorized two-wheelers (Table 1). In Punjab, 21,317 RTAs were reported, of which 18,054 (85%) involved motorized two-wheelers.

Table 1
Distribution of Motorized Two-Wheeler RTAs, Fatalities, and Injuries in Pakistan and Punjab

Metric	Pakistan	Punjab	Punjab as % of Pakistan
RTAs involving motorized two-wheelers	41,596	18,054	43.4%
Fatal accidents	20,892 (51%)	12,339 (68%)	59.0%
Deaths	19,544 (47%)	13,452 (74%)	68.8%
Disabling injuries	12,034 (29%)	7,554 (42%)	62.8%

When focusing on two-wheeler RTAs: The meta-analysis indicates that Punjab is overrepresented in both the frequency and severity of motorized two-wheeler RTAs in Pakistan. While it accounts for less than half of the total reported two-wheeler RTAs. It contributes well over half of the fatal accidents, deaths, and disabling injuries. Statistics of Road traffic accidents exclusively related to Lahore were infrequent in these articles. Lahore being the capital of Punjab represent more glimpse picture out of these statistics of road traffic accident of Punjab. This pattern suggests possible differences in traffic safety enforcement, helmet use compliance, emergency response times, and road infrastructure between Punjab and other regions.

IV. DISCUSSION

This study comprehensively examined the burden and determinants of road traffic crash accidents involving motorized two-wheelers through a systematic review and meta-analysis. The systematic review synthesized evidence from 40 studies (2012–2018), documenting 50,283 road traffic accidents, of which 41,596 (83%) involved motorized two-wheelers. At the provincial level, Punjab accounted for 21,317 total RTAs, with 18,054 (85%) related to two-wheelers. Although Punjab represented 43.4% of national two-wheeler RTAs, it contributed a disproportionately high share of severe outcomes: 59.0% of fatal crashes, 68.8% of deaths, and 62.8% of disabling injuries. This pattern indicates that the province's challenge lies not only in frequency but also in severity. Several factors appear to underlie this disparity, including dense urban traffic, inconsistent enforcement of helmet laws, weak safety culture among riders and passengers, and inadequate road infrastructure and post-crash emergency response. In particular, the absence of city-specific data from Lahore, despite its status as the provincial capital and traffic hub, points to significant underreporting and the need for dedicated local surveillance.

V. CONCLUSION

This study highlights the substantial and growing burden of motorized two-wheeler–related road traffic accidents in Pakistan, with Punjab and particularly Lahore emerging as a critical hotspot for both crash frequency and injury severity. The systematic review and supporting local data reveal that motorcycles and scooters account for the vast majority of traffic injuries and deaths, underscoring their high vulnerability on urban roads. Contributing factors include inadequate enforcement of helmet and speed regulations, congested mixed-traffic conditions, poor road infrastructure, and delayed post-crash care.

The findings emphasize the urgent need for evidence-based, targeted interventions such as consistent helmet enforcement, rider education, improved road design and lighting, and strengthened trauma response systems. Establishing a city-specific surveillance framework and applying predictive modeling can further enhance prevention and policy planning. Without decisive action, the disproportionate toll of two-wheeler crashes on public health,

productivity, and socioeconomic stability in Pakistan is likely to persist.

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