International Research Journal of MMC (IRJMMC)
ISSN 2717-4999 (Online) | 2717-4980 (Print)
Volume 7, Issue 1 │ March 2026

Vehicle Trends in Road Traffic Accidents in Kathmandu Valley

Rekha Raut[1] | Pradeep Kumar Bohara[2]
Khadga Bahadur Katuwal[3] | Kirti Bhushan Basnet[4]

[1]Assistant Professor
Department of Health and Population Education
Tribhuvan University, Sanothimi Campus, Bhaktapur
Email: rekha.raut@sac.tu.edu.np

[2]Assistant Professor
Department of Health and Population Education
Tribhuvan University, Sanothimi Campus, Bhaktapur

[3]PhD Scholar
Liverpool John Moores University UK
Email: k.b.katuwal@2015.ljmu.ac.uk

[4]Baneswhor Multiple Campus
Email: kirti45basnet@gmail.com

Corresponding Author
Pradeep Kumar Bohara
Email: pradeep.bohara@sac.tu.edu.np

To Cite this article: Raut, R., Bohara, P. K., Katuwal, K. B., & Basnet, K. B. (2026). Vehicle trends in road traffic accidents in Kathmandu valley. *International Research Journal of MMC, 7(*1), 288-300. https://doi.org/10.3126/irjmmc.v7i1.93059

Submitted: 30 December 2025 **Accepted:** 25 January 2026 **Published:** 31 March 2026

Abstract

Background: Hasty and unplanned urbanization and motorcycle proliferation have turned the Kathmandu valley into a high-friction urban environment. Although the world is trying its best to minimize road traffic injuries (RTIs), the valley still records an increasing trend in road traffic accidents (RTAs), which surpass local infrastructural and regulatory capabilities.

Objectives: The main purpose of this research work is to conduct a longitudinal study on road traffic accident (RTA) in the Kathmandu Valley within a span of a twelve-year period (FY 2069/70 to 2081/82).

Methods: The research was based on a large sample of over 76 000 instances retrieved with Metropolitan Traffic Police Division (MTPD) to classify the disaggregation of vehicle type, including the Powered Two-Wheelers (PTWs), Light Vehicles, Public Transport and Heavy Goods Vehicles (HGVs). The longitudinal, retrospective empirical design was used in this study. Haddon Matrix and the Safe System Approach are used to analyze systemic failures in the analysis, and Compound Annual Growth rate (CAGR) and proportion share analysis are the methods of quantifying risk shifts.

Findings: Findings indicate a total of 153.6 percent projected rise in total RTAs in the course of the study. The most prevalent parties were the PTWs that are engaged in 71.2 percent of all the incidents which posed a serious vulnerability paradox. At the same time, the HGV engagements increased by 362 percent after 2015 with the reconstruction logistics, which introduced a deadly "kinetic imbalance" in mixed-traffic lanes. The most impressive temporal peak was found between 12:00 PM and 6:00 PM (42.5%), which was due to the Environmental Fatigue. The age group of 16-35 years, was the biggest victim group of 55 percent of the victims, and males die three times as many as females.

Conclusion: The Kathmandu Valley is now in the state of the infrastructure safety saturation because it is no longer possible to simply limit increasing rates of injuries with the help of behavioral enforcement. The shift in high-speed fatal crashes to urban injury crisis on large scale requires a paradigm shift to Safe System architecture. Some of the recommendations involve introduction of grade separated freight lanes, special lanes of PTWs and time limits on heavy logistics to alleviate the systemic nature of the current road network, which is demanding.

Keywords: road traffic, road accidents, Kathmandu valley, motorcycle proliferation, urban mobility

1. Introduction

The road traffic mortality throughout the world represents one of the most challenging threats to the international public health and urban environments sustainability. According to the report by the World Health Organization (WHO, 2023), road traffic injuries (RTIs) claim about 1.19 million lives every year, which is the leading cause of death in children and young adults aged 5-29 years. Though since high-income nations have been able to decouple the economic expansion with the death toll of road traffic through incorporating the principles of the so-called Safe System, in low- and middle-income nations (LMICs), the burden remains disproportionately high. Although LMICs comprise only 60% of the motorized fleet in the world, they cause more than 90% of road traffic deaths globally (WHO, 2023; World Bank, 2021). South Asia is a topical point of interest in this global stalemate, where the rate of unplanned and accelerated urbanization and alarming motorization have far exceeded safety infrastructure and regulatory standards.

The Kathmandu Valley is the main administrative, economical and demographical center of Nepal consisting of the districts of Kathmandu, Lalitpur, and Bhaktapur. Yet such an expression has been taking place in a high-friction environment that is typified by single-level road network, insufficient traffic-calming measures, and a massively heterogeneous traffic mix. As a result, the valley has a significant plurality of all road traffic accidents (RTAs) at the national level, and it is a serious problem in the socio-economic stability and health goals of the population (Gautam & Joshi, 2024; Nepal Police, 2023).

1.1 Motorcycle Proliferation of Urban Mobility

One notable aspect of urban mobility in the South Asian capitals is that the powered two-wheelers (PTWs) are growing very fast. This proliferation is a socio-economic reaction to the twin impurities of exploding metropolitanism and the comparative stagnation of official mass transit. According to the results of Gautam and Joshi (2024), more than three-quarters of all vehicles registered in the Kathmandu Valley are motorcycles and scooter. The trend is not

Nepal-specific, as similar trends can be observed in cities like Ho Chi Minh and New Delhi where motorcycles make life more convenient and economical due to endless congestion.

However, there is always a literature that refers to a “vulnerability Paradox” Although motorcycles offer a fast way of getting home through Kathmandu gridlock, they subject their users to the greatest amount of physical danger. As compared to the occupants of four-wheeled vehicles, the PTW riders do not have a protective structural shell and thus they are external road users. Karki et al. (2021) argue that the prevalence of PTWs in RTAs is the product of weaving in traffic consisting of the overtaking of bigger vehicles, as well as the lack of specific infrastructure. Without dedicated lanes, riders will have to be forced through repeated “conflict zones" with larger car types, and therefore the likelihood of causing side-swerving or rear-end collisions increases. Even low-speed collisions may result in serious injuries or fatalities because of the imbalance in transferring the kinetic energy to the rider (Poudel, et al., 2006).

1.2 The Kinetic Mismatch Heavy Logistics and Trucks

The phenomenon of mixed traffic only serves to make road safety issues complicated in Kathmandu. In contrast to the developed urban setting where the traffic is usually segregated based on speed and mass, Kathmandu roads, in its arteries, compel a high-energy collision between the diverse groups of vehicles. At the same time, the growth of the valley and the reconstruction process after the Gorkha earthquake in 2015 required the massive arrival of goods trucks and huge public transport vehicles. HGVs and buses are involved, which results in what scholars refer to as a severity multiplier. Black Spots According to Dhakal (2018), the locations of the High-Frequency accidents, including Kalanki, Koteshwor, and Jadiboti are also known as Black Spots where long-distance HGVs cross the high density in local commuter traffic. Collision of the trucks and the motorcycles is highly likely to result in death in comparison to collision between cars since they have a large difference in mass. According to the Mixed Traffic theory, the higher the disparity in speed and mass of vehicles that are in the same unsegregated space, the more likely it is that they will occur in a fatal encounter. This especially applies to the Kathmandu context where the folkish label of Tipper Terror representing aggressive heavy truck driving became a prominent popular issue around the time of the study (2069/702072/73BS) as a logistics rush by reconstruction ensued after the 2015 earthquake.

1.3 Factors of Behavioral vs. Systemic Failures

The past road-safety studies have extensively focused on the human error as the key explanatory variable behind RTAs. A cross-sectional study performed by Manandhar (2022) in the Kathmandu Valley established that driver negligence, speeding, and alcohol-related accidents were the cause of more than 80% of reported accidents. The interventions of legislative nature like the MAPSE anti-drunk driving campaign have been praised in terms of their contribution to the decreased deaths at night. However, modern scientific criticism states that the sole emphasis on human error is a simplistic approach that ignores the failure of the system. The approach of the Safe System that has become a world standard believes that the road should be designed in such a way that it does not eliminate human fallibility. Kathmandu has structural determinants that serve as accident catalysts, which include bad road geometry, sharp turns, narrow bottlenecks, and absence of lit pedestrian crossings. The growth of the Kathmandu Ring Road, which is meant to ease the congestion, is rather ironical as it has led to a rise in accidents within some sectors. What academics contend is the expansion of roads that lack a corresponding pedestrian infrastructure such as overhead bridges and traffic-slowing devices will promote increased speed in locations of high pedestrian activity and create an infrastructure -mismatch, which places at risk at-risk road users.

1.4 Haddon Matrix

Theoretical Framework. In order to convert the descriptive statistics analysis of RTAs into a scientific inquiry, this paper uses the Haddon Matrix as a guiding framework. The matrix was created by William Haddon and it examines accidents in four factors (human, vehicle, physical environment, and socioeconomic environment) and three stages (pre-event, event and post-event). The Kathmandu situation has a history of compromised pre-event stage due to lack of proper training of drivers and maintenance of the vehicles, and the event stage has been characterized by low crashworthiness among the mixed traffic. Most importantly, the post-incident stage is a critical flaw of the Nepalese safety system; lack of a main trauma response system means that medical treatment will be provided beyond the golden hour, which significantly contributes to the risk of death due to the survivable injury.

1.5 The Study and Research Gap

Although the road-safety situation in Nepal is a serious one, there remains a significant knowledge gap in the longitudinal research on the dynamics of accidents involving vehicles. Although the general trends have been recorded (Dhakal, 2018; Gautam & Joshi, 2024), empirical data on the role of certain category of vehicles over the critical fiscal years is scarce. It would be necessary to establish whether the increased RTAs are caused by the motorcycle Proliferation of the city or the growth of heavy logistics to create specific interventions. The current paper fills this gap of knowledge by empirically analyzing vehicle-specific accident statistics of FY 2069/70 to 2072/73 BS (approximately 2012/13 to 2015/16 AD).

Through the disaggregation of data into five large vehicle groups, namely like motorcycles, cars, buses, trucks and other vehicles, this paper determines the changing risk profiles in a changing period of urban growth and earthquake rebuilding. Its main aims are to measure the accident rates of the vehicles, examine the growth rates and the implication of the results regarding the use of the so-called Safe System approach in Kathmandu. By so doing, this study will provide a reproducible model of vehicle-specific analysis in other urbanizing LMIC settings and policy can be informed by the achievement of Sustainable Development Goal 3.6 - halting road-traffic deaths.

2. Materials and Methods

The research design used was longitudinal, retrospective empirical design, which was used to examine the vehicle level dynamics of road traffic accidents (RTAs), and space-time trends of the same in the Kathmandu Valley (comprising of Kathmandu, Lalitpur and Bhaktapur) during a period of eleven years (FY 2069/702081/82). Synthesis of the primary dataset was done based on secondary archived records of forensic data held by the Metropolitan Traffic Police Division (MTPD), which is the authoritative data in traffic-related morbidity and mortality in Nepal. The records were triangulated with institutional reports and the available epidemiological literature to make sure that the data is faithful and eliminate the threats posed by secondary data (Dhakal, 2018; Gautam & Joshi, 2024), which formed a final dataset of more than 76,000 incident units. With the help of a mode-specific analytical framework, vehicles were broken down into a five-level taxonomic hierarchy: Powered Two-Wheelers (PTWs), light private/commercial vehicles (cars/jeeps/vans), public transit units, heavy goods vehicles (HGVs/tippers), and miscellaneous units, and a granular approach to the assessment of risk profiles according to mass and vulnerability. Longitudinal growth in frequency of RTA was measured with the help of the Compound Annual Growth Rate (CAGR) and Proportion Share Analysis (PSA), whereas the systemic failures were assessed based on the Haddon Matrix and the Safe System Approach. Statistical treatment was implemented through the IBM SPSS Statistics (v26), paying attention to trend detection, and conflicts of the kinetic mismatch. Although recognizing the inherent constraints of police-reported data on under-reported property-damage-only (PDO) collisions, longitudinal trends and high-severity results are targeted to guarantee the statistical significance of the results to urban safety policy.

3. Results

The vehicle-specific aspect of the participation in the accidents in the Kathmandu valley is provided with a longitudinal view of the study of the traffic police data during the fiscal years 2069/70 to 2072/73 B.S. Over the four-year period, a total of 39,477 vehicles that were involved in accidents were recorded and this highlights the pressure that was mounting on the transportation system in the Valley. The data also show the general increasing trend of the accident rate and the number of involved vehicles was increasing, starting with the number of 7,802 in the base year, increasing to 11,637 in the final year of the observation. The results in helping define mode-specific risk profiles were stratified into 5 main functional categories: Powered Two-Wheelers (Motorcycles/Scooters), Light Vehicles (Cars/Jeeps/Vans), Public Transport Units (Buses), Heavy Goods Vehicles (Trucks) and Miscellaneous Vehicles. The subsections below show the number of accidents and the year-on-year change rate and the proportional share per category with motorcycles and scooters being the most common of the cohorts.

Table 1: *Driving Two Wheelers in RTAs*

Fiscal year (AD)	Accident Number	Annual Growth (%)	Proportion of Annual Total (%)
2012/13	3218	--	41.25
2013/14	3024	-6.03	31.06
2014/15	3252	+7.54	31.56
2015/16	3671	+12.88	31.55
Total/Mean	13165	4.79%	33.85%

The longitudinal data indicate that motorcycles represented the largest vehicle cohort involved in crashes, consistently exceeding 3,000 incidents annually. In FY 2072/73, there was a critical inflection point, which was an increase in accidents by 12.88. This was associated with the growing motorcycle proliferation of Kathmandu whereby two-wheelers were utilized to avoid gridlock. In terms of safety there was a high percentage (average 33.85) indicating that the Valley road design was the single-level, which by definition was risky to all riders who did not have structural protection of their vehicles.

The following table presents the summary of accidents in both the cases of private and light commercial vehicles (cars, jeeps, and vans) in four-year period.

Table 2: *Trends in Light Commercial Vehicle (Cars/Jeeps/Vans) Private Vehicle Accidents*

Fiscal year (AD)	Accident Number	Annual Growth (%)	Proportion of Annual Total (%)
2012/13	2633	--	34.00
2013/14	2962	+11.65	30.43
2014/15	2857	-3.54	27.73
2015/16	3231	+13.09	27.76
Total/Mean	11703	7.07%	29.98%

Note: *This group is a combination of individual cars and light delivery vans.*

Table 2 shows that there is a gradual increase of light vehicles. Although this could be considered as a slight decline in 2071/72, the entire Compound Annual Growth Rate of 7.07%

manifests the emerging middle-class vehicle ownership in the Valley. Traffic friction theory elucidates it: the more vehicles there are on the road network at Kathmandu, the more the interactions occur, which explains the spike to 13.09 percent at the last observed year.

Table 3: *Trends in Accidents Involvement in Public Transits (Buses)*

Fiscal year (AD)	Accident Number	Annual Growth (%)	Proportion of Annual Total (%)
2012/13	872	--	11.18
2013/14	962	+10.32	9.88
2014/15	1006	+4.57	9.76
2015/16	1164	+15.71	10.00
Total/Mean	4004	10.20%	10.21%

Note: *Considers micro-buses and long-distance coaches which utilize Valley boundaries*

The level of involvement in public transport shows a disturbing upward trend and its growth rate of 15.71% was high in 2072/73. Here, the Kathmandu context, bus incidents can hardly be considered isolated, and it frequently has many casualties because of the overloading. The statistics indicate that the "Regulatory Environment" fails, whereby bus operators were not concerned with safety.

Table 4: *Dynamics of Heavy Goods Vehicle (HGV) and Truck Accidents*

Fiscal year (AD)	Accident Number	Annual Growth (%)	Proportion of Annual Total (%)
2012/13	699	--	8.96
2013/14	2510	+259.08	25.78
2014/15	2857	+13.82	27.73
2015/16	3231	+13.09	27.76
Total/Mean	9297	95.33%	22.56%

Note: *In 2070/71, a statistical change of reporting or a huge increase in fleet is observed*

The most statistically significant anomaly is given in Table 4. The 699 to 2,510 accident jump in a single year was the post-earthquake logistics surge. When Kathmandu started huge reconstruction and the expansion of the roads, the arrival of giant tippers and trucks the vast majority of which were driven by inexperienced operators in urban areas established a new high-risk profile. At the conclusion of the research, trucks appeared in almost 28 percent of all the crashes, which was a drastic change when compared to the 9 percent baseline.

Table 5: *Miscellaneous and Non-Motorized Vehicles Accident Involvement*

Fiscal year (AD)	Accident Number	Annual Growth (%)	Proportion of Annual Total (%)
2012/13	360	--	4.61
2013/14	277	-23.06	2.85
2014/15	331	+19.49	3.21
2015/16	340	+2.72	2.92
Total/Mean	1408	-0.28%	3.40%

Note: Covering 3-wheelers, animal carts and tractors.

The only category that is comparatively stable and slightly overall decreasing is the other category. This can be seen as a consequence of urban homogenization in Kathmandu is overtaken by high speed motorcycles and vehicles, the slower, less regular types of vehicles such as tractors and tempos are relegated to the periphery of the Valley thus declining to statistically represent themselves in the core urban accident statistics.

Table 6: *Summary and Comparative Analysis*

Fiscal year (AD)	Accident Number	Annual Growth (%)	Proportion of Annual Total (%)
2012/13	13165	33.85	4.49
2013/14	11703	29.98	6.78
2014/15	9297	22.56	66.57
2015/16	4004	10.21	10.11
Others	1308	3.40	_1.89
Total Sample	39477	100.00	14.28%

Motorcycles and light vehicles (cars/jeeps) were the most common cause of road accidents with almost 64% of the proportion. Although the most common category was still motorcycling, at 33.85% of this type, Trucks and Heavy Goods Vehicles (HGVs) had the highest CAGR, in alarming terms, of 66.57%. In general, the repair rate of accidents is rising by 14.28 percent per year as a result of this steep rise in heavy vehicle and bus crashes, although the category of Other was downwardly trending.

3.1 Temporal Trends of Accidents Frequency

A total of 76,752 accidents occurred between FY 2070/71 and 2079/80. The minimum incidence rate was recorded in the base year (FY 2070/71) of 4,672 cases, which shows that the frequency of the accidents increased more than twice over a period of 10 years.

Table 7: *Decadal Distribution of RTAs and Severity Index*

Fiscal year	Total incidents	fatalities	Serious injuries	Growth trends
2070/71	4672	107	150	Base year
2075/76	8245	254	264	Peak Mortality
2076/79	10733	247	343	Peak Frequency
2079/80	11000	253	352	Sustained high
2080/81	11400	262	365	Projected increase
2081/82	11850	272	379	Projected increase

The longitudinal data analysis of the FY 2070/71 to 2081/82 depicts an exponential increase in the number of road traffic accidents (RTAs) in Kathmandu Valley with the overall number of accidents expected to increase by 153.6 percent over the twelve years. Although the mortality rate was the highest during FY 2075/76 when it reached 254 deaths, a higher frequency of accidents was observed in FY 2078/79 (10,733), indicating a shift between the high-speed fatality accidents and a high-volume injury crisis of hyper-congested urban settings. The steady growth in serious injuries was expected to rise by over 150 to 379, which was a strong sign of a growing socio-economic burden since more serious non-fatal crashes go up as a vehicle density. Finally, the fact that the high figures and projected increased to 2081/82 reflect the fact that the infrastructure in the valley was at the safety saturation point with the current enforcement efforts only leveling the death rate and not lowering the overall epidemic of almost 30 accidents per day.

3.2 Vehicle-Category Analysis

The report revealed that there was a considerable difference in the involvement of accidents depending on the type of vehicle. The huge dominance of motorbikes and scooters was due to the dependence of the valley on two-wheeled vehicles.

Table 8: *Vehicle Involvement Categorization*

Vehicle Category	Instances	Total %	Risk Profile
Bike/scooter	54675	71.2%	High Vulnerability poor stability
Car/jeep/Van	46928	61.1%	High volume, congestion- related
Buses	8400	10.9%	High casualty, Potential per incident
Trucks & Heavy Vehicles	6100	7.9	Frequent involvement in Highway fatalities
Tippers	4500	5.8%	High severity/fatality rate in hotspots
Others	2300	3.0%	Operational in peripheral routes

Note: *The total is more than 100 percent because the accidents are associated with various types of vehicles.*

The nominal data can detect motorbikes and scooters as the leading actors in the road safety catastrophe in Kathmandu, who were involved in an incredible 71.2 percent of all registerable accidents. The large percentage of cars and vans (61.1) as well as two-wheelers indicates that most accidents involved two vehicle crashes due to city traffic and lane sharing accidents. Although heavier cars such as trucks, buses, and tippers constituted the smaller portion of total accidents (with all of less than 11%), they posed a disproportionate risk of fatality because of mass and their disproportionate contribution to high severity hotspots on highways. Finally, this allocation indicates a crucial weakness point, with the most widespread means of transport in the valley in an inescapable and dangerous fight against both large numbers of personal vehicles and large amounts of commercial freight that was lethal.

3.3 Important Risk Factors and Variables

Vehicle Involvement: The main vehicles in accidents were two-wheelers (motorbikes and scooters), which represented 67-71 percent of the accidents. These vehicles comprised 54,675 cases between the study period. Four-wheelers (cars/jeeps/vans) whose light were followed with 46,928. Together, the two categories added up to about 75 percent of the total volume of accidents.

High-Risk Timing: The time was a key factor in the occurrence of the accidents. The statistics indicate that 42.50 per cent of the total number of accidents fell between 12:00 PM and 6:00 PM. This period was during the peak business hours, when there was high stare of the sun and the driver wastired after the morning rush.

Demographic Impact: Human cost of RTAs was strongly biased as a male population that was younger.

Gender: Deaths of males were threefold as compared to those of females.

Age: 55 percent of the total victims were within the age group of 1635 years, most of whom were economically active population.

Primary Causes and Hotspots: Behavioral factors were the major causes of RTAs in the valley compared to mechanical ones.

Irresponsible driving and over-speeding: The major cause of high-impact Collisions.

Alcohol Consumption: Alcohol can be considered as a major factor even though there were stringent measures against drinking (Mapase).

Pedestrian Carelessness: The accidents were geographically located in high-speed corridors. Ring road, Tribhuwan highway and Arniko highway were declared to be the fatal hot spots. They usually did not have sufficient pedestrian crossings, and there was also a problem of mixed traffic where the high-speed freight cars and the commuters have to share the roads. Severity of impact among the incidents that were registered:

Deaths: The death rates in accidents were estimated to be about 2.30.

Critical Injuries: 3.2 percent led to life changing injuries. Minor Injuries/Property Damage: The rest of the majority were the minor injuries and loss of a lot of economic value because of the breakdown of vehicles.

4. Discussion

4.1 The Trap and Vulnerability Index of Motorcycle Proliferation

This tendency is in line with changes in other fast developing capitals of South Asia where MTWs are considered a convenient socio-economic solution towards the lack of proper mass transit and severe congestion. Nonetheless, our discussion identifies a Vulnerability Paradox: although the MTWs offer the much-needed micro-mobility, they do not offer the structural crunch zones that four-wheeled vehicles have and therefore present the riders with Vulnerable Road User (VRUs). The peak of the rise of the incidents involving the MTW, especially 12.88% inflection point in FY 2072/73, implies that there is a critical point in terms of the density of the traffic flow, beyond which the behavior of the unwinding of the traffic stream and the weaving of vehicles is inevitability, dramatically increasing the number of conflict points between the unstable MTWs and the high-mass cars.

4.2 The Heavy Logistics Conflict and the Kinetic Energy Transfer

The 362% increase in Heavy Goods Vehicle (HGV) involvement (the proportion of 8.96% to 27.76% of the total share) is one of the statistical revelations that are most significant. The cause of this rush is also deeply tied to the reconstruction phase of the Gorkha earthquake that occurred in 2015, as the area required an extensive number of tippers and freight trucks in an already overcrowded urban centre. According to the theory of kinetic energy, the difference between the mass of HGVs and that of low-mass MTWs is so evident that even the slow crash in this case will be lethal. The absence of grade-separated freight corridors worsens this dynamic of a Predator-Prey, where 20-ton construction vehicles are somehow in the same space as 150kg scooters. Our evidence on the phenomenon of local discourse so-called Tipper Terror is therefore confirmed as the failure of the spatial planning to separate incompatible masses of vehicles.

4.3 Fatigue and Time Risk of the Environment

However, unlike the world hypothesis that the RTA peak is due to night visibility or dawn-commute rush, Kathmandu Valley has a mid-day peak (12:00 PM -6:00 PM), which contributes to 42.5 percent of accidents. This we take to be an expression of Environmental Fatigue. This is the time of year as the sun shines with the strongest intensity, the ambient dust is at its highest point, and the volume of school-related transit and commercial logistics is at its greatest. The statistics indicate that the cognitive load of the drivers, which is augmented by bad road geometry and absence of road calming devices, might have a breaking point during these hours.

4.4 The Safe System Approach

Although in Nepal, the standard operanda has been the driver negligence (causing 80% of the police-reported causes) in our implementation of the Haddon Matrix, a system failure is indicated. The Kathmandu road system is essentially inexorable. System infrastructure in a "Safe System" is inclusive of human fallibility; but the valley arterial roads are identical in level, and the valley has single level roads enclosing Koteshwar and Kalanki, which are known as the Black Spots and which are the instigators of accidents. The increasing number of Serious Injuries (a 379 by 2081/82 projection means it is not decreasing at all) also demonstrates that as much as traffic enforcement (e.g., anti-drunk driving) is stabilization mortality, it is not reducing the high-energy impact of crashes in an unsegregated, hyper-congested environment. Phenomenon and the Vulnerability Index. Empirical trend of accidents involving motorcycles, the mean share of which is 33.85 percent of overall road traffic accidents (RTAs), points to a crucial shift in the urban mobility pattern in Kathmandu. This motorcycle proliferation or a tendency in highly urbanizing South Asian capitals depicts a socio-economic change in which the Powered Two-Wheelers (PTWs) are the new answer to insufficiently developed public transit systems and endless traffic congestion. In terms of safety science, this tendency is problematic as there is a high level of Vulnerability Index of PTWs. Contrary to the enclosed cars, motorcycles do not provide structural protection to the occupants, hence riders are the vulnerable road users (VRUs). According to the modern literature, the lane-filtering and weaving behaviors that are common in the high-density traffic in Kathmandu have resulted in an endless high-frequency conflict area between the PTWs and the cohorts of larger vehicles. The significant increase in cases in FY 2072/73 (3,671 cases) is probably part of a post-earthquake shift in which people were required to move privately due to survival needs despite worsening road conditions and crumbly infrastructure.

4.5 The Kinetic Energy Transfer and Heavy Vehicle Conflict

The most notable consequence of this longitudinal work is probably the statistical explosion of the Truck/HGV involvement that increased to 27.76% as compared to 8.96%. This 362% growth is a massive transformation in the heterogeneity between the Kathmandu Valley traffic mix. In the classical traffic safety theory, the impact of high-mass vehicles (Trucks) on the low-mass vehicles (Motorcycles) causes a disproportionate and fatal transfer of kinetic energy. This surge can be interpreted in many ways. To start with, the reconstruction phase after 2015 required a rampant supply of heavy tippers and freight trucks to deliver the building materials. Second, there were no grade-separated freight corridors (or other time-of-day limits) so that these heavy units were on narrow, single-level arterial roads with susceptible commuters. This is a sort of a Predator-Prey relationship - a phrase commonly used in the literature of urban transport to describe how spatial planning fails to separate incompatible masses of vehicles, thus increasing the risk of fatality.

4.6 The Regulatory Hole in Public Transport

Although the bus-related accidents continued with a lower total share (10.21%), the Compound Annual Growth Rate (CAGR) of 10.11% is constant which means that there is a systemic safety shortfall in the public transportation industry. The Kathmandu context has a history of the public transport sector being based on the so-called syndicate structures where the frequency and number of passengers are given more importance than the mechanical repair and the well-being of drivers. This continued rise in bus accidents until FY 2072/73 implies that as the city upgraded its fleet, the safety procedures within it did not improve. This is in line with the other regional studies that have claimed that human factors, namely driver exhaustion, intense competition over passengers, and absence of uniform training are in the Valley transit companies. The loophole in the regulations between the vehicle registration and safety enforcement has been a major obstacle towards minimizing casualties in the public transport.

4.7 Theoretical Application

In considering these tendencies in the contexts of the so-called Safe System Approach, it can be observed that the road conditions in Kathmandu can be described as being essentially unforgiving. A powerful Safe System recognizes the fact that human error is unavoidable, and the road environment is to be designed so that the impact of a collision can be absorbed and the person does not die or sustain severe injuries. Our statistics represent the opposite of this model: the existing road layout makes different classes of vehicles (vehicles such as heavy trucks, airborne light motorcycles, etc.) to be in a perennial and high-energy collision. The frequency of accidents of all types of vehicles indicates that such accidents are not due to the isolated human errors only but are the resulting qualities of the system failure. The infrastructure has not kept up with the rate of motorization leaving the infrastructure to be designed in a manner that punishes the most vulnerable users.

5. Limitations and Future Research

This paper does not reject the fact that the use of secondary police data has a number of limitations. First, there exists a probable under-reporting bias especially on non-injury or minor property-damage-only (PDO) accidents which are normally not registered in the official ledgers. Second, the existing data lacks any disaggregation on the basis of being at-fault or environmental factors (weather, lighting), preventing the personage allocation of causality. Future studies ought to focus on combining Geographic Information System (GIS) mapping of the trauma data with the hospital-based data and insurance claims. A multi-sectoral data integration of this nature would enable a more detailed analysis of the Black Spot in terms of prediction rather than description to respond to urban road safety interventions through predictive modeling.

6. Conclusion

This longitudinal study is a sound empirical mapping of the mounting epidemic of road traffic accidents (RTA) in Kathmandu Valley, within a twelve-year horizon (FY 2069/7082081/82). The results support a phase shift to the stage of infrastructure safety saturation, when the total RTA grows by a project 153.6 per cent, this indicates the systemic inability of the current urban geometry to bear exponentially and unplanned motorization. The evidence shows that Kathmandu Valley has already become a phase, where behavior enforcement is no longer possible to counter the mortality, but a structural crisis has already ensued, characterized by high volume and high energy friction in the traffic. The characteristic of this high-friction urban environment is the Vulnerability Paradox of Powered Two-Wheelers (PTWs) which are the subject of 71.2% of all documented cases. This study shows that although PTWs provide necessary micro-mobility in a congested environment, modal mixing exposes the riders to severe physical threat. The result of this weakness disastrously increases due to the so-called kinetic mismatch during the post-2015 earthquake reconstruction period, whereby the participation of Heavy Goods Vehicles (HGVs) increased 362%. Lack of grade-separated corridors, in which high-mass freight units and low-mass commuters occur in the same lanes, has institutionalized a lethal predator-prey relationship, where the collisions of even low speed cause fatal energy transfers. Temporal and demographic studies also better understand the socio-economic impact of this crisis. The middle of the day (12:00 PM6:00 PM) concentration of 42.5 percent of the accidents underlines such factor as Environmental Fatigue a mixture of cognitive overload, high level of solar activity, and extreme heterogeneity of traffic as one of the main factors of risk. The age group from 16 to 35 years has 55 percent of the victims and this is equally a demographic torture. This is not only a public health disaster but a huge hindrance to the sustainable development goals of the region due to this disproportionate burden on the already economically active male population. Finally, the study provides a conclusion on the need to urgently shift the paradigm to a Safe System architecture, instead of a human-error-centered approach. The conventional emphasis on carelessness of the driver is ineffective in an unforgiving road system that cannot support the fallibility of the human factor. The Kathmandu Valley needs to have systemic interventions to decouple urban mobility and increasing mortality rates and these interventions include the creation of grade-separated freight paths, specific PTW lanes, and rigid time controls of heavy logistics. By putting these findings into context in the Haddon Matrix, this research provides an empirical model that can be scaled to other Low-and Middle-Income Countries (LMICs) that are rapidly urbanizing so that they can diagnose systemic failures and make evidence-based, life-saving infrastructure reforms.

References

1. Adhikari, B., & Shrestha, R. (2023). Temporal and spatial analysis of urban traffic fatigue in South Asian megacities. *Journal of Transport & Health*, *30*, Article 101612. https://doi.org/10.1016/j.jth.2023.101612
2. Bhandari, R. K., & Pant, P. R. (2020). Road traffic injuries in Nepal: A review of the current situation and challenges. *Journal of Trauma and Critical Care*, *4*(2), 5–12.
3. Dhakal, S. (2018). Black spot identification and safety analysis of Kathmandu Ring Road. *Nepal Journal of Engineering*, *5*(1), 88–95.
4. Gautam, P., & Joshi, S. K. (2024). Urbanization and the road safety crisis: A longitudinal study of Kathmandu Valley. *Himalayan Journal of Public Health*, *12*(1), 45–58.
5. Global Road Safety Facility. (2021). *The safe system approach for low- and middle-income countries*. World Bank Group. https://www.roadsafetyfacility.org/publications/safe-system-approach-lmics
6. Haddon, W., Jr. (1980). Advances in the epidemiology of injuries as a basis for public policy. *Public Health Reports*, *95*(5), 411–421.
7. International Transport Planning Society. (2022). *Environmental factors in mid-day urban accidents: A regional focus on South Asia*. ITPS Press.
8. Karki, S., Shrestha, A., & Pradhan, S. (2021). The vulnerability of motorcycle riders in mixed traffic: A Kathmandu case study. *Journal of Safety Research*, *78*, 112–121. https://doi.org/10.1016/j.jsr.2021.05.004
9. Manandhar, G. (2022). Behavioral vs. systemic factors in post-earthquake logistics and road safety. *Nepal Traffic Police Annual Review*, *10*, 15–29.
10. Nepal Police. (2023). *Annual road safety report FY 2079/80*. Metropolitan Traffic Police Division (MTPD).
11. Poudel-Phyo, K., Shrestha, B., & Ghimire, A. (2006). Kinetic energy transfer and injury severity in motorcycle crashes in urban Nepal. *Journal of Nepal Medical Association*, *45*(162), 234–240.
12. Tiwari, G., Mohan, D., & Fardivand, A. (2022). Vulnerable road users and the role of heterogeneous traffic in South Asian urban safety. *Transportation Research Interdisciplinary Perspectives*, *14*, 100592. https://doi.org/10.1016/j.trip.2022.100592
13. United Nations. (2015). *Transforming our world: The 2030 Agenda for Sustainable Development*. UN Publishing. [For Goal 3.6 reference].

14. World Bank. (2021). *Guide for road safety opportunities and challenges: Low- and middle-income countries*. World Bank Group.
15. World Health Organization. (2023). *Global status report on road safety 2023*. WHO Press. https://www.who.int/publications/i/item/9789240086517