KEC Conference 2024
ISSN: 3021-940X (Print) DOI: https://doi.org/10.3126/injet.v1i2.66715

Road Traffic Accident Data Visualization: A case study of Bhaktapur

Susmita Aryal[1,2], Swostika Dhakal[2, *]

[1]*Nagdhunga Tunnel Construction Project, Hazama Ando Corporation, Basundole, Chandragiri, Kathmandu, Nepal, aryalsusmita1999@gmail.com*
[2,*] *Khwopa College of Engineering, Libali, Bhaktapur,Nepal, swostikadhakal.001@gmail.com*

Abstract

This study focuses on multiple dynamics of road safety. It utilizes a dataset comprising recorded road traffic accidents (RTAs) in Bhaktapur to reveal the patterns, contributing factors, and demographic associations by data visualization. The research uncovers distinct high-risk locations as Thimi, Radhe Radhe, and Sallaghari. Demographic insights and gender-based disparities are observed. The study examines the prevalent modes of transportation involved in RTA. Findings show the addressing of identified issues which can be used for taking actions based on its results.

Keywords: Road Traffic Accident, Data Visualization, Hotspot

1. Introduction

Transportation facilitates quick and uninterrupted movement of people and goods (Aziz, et al., 2013; Santoso & Tjahjono, 2020; Leuhery, 2020; Rafiq, et al., 2021). Crash incidents, however, are frequently caused by neglect of traffic rules and bad road conditions (Ali, et al., 2021). These crashes cause damage to the community, and other commodities involved and cost human lives (Zhang, et al., 2014). Road traffic accidents (RTAs) ca n happen anytime, anywhere, and are now the leading cause of death worldwide. Various factors can be an influencing factor, including the time of day, traffic volume, gender, age, vehicle type, road geometry, environmental factors, human psychology, and vehicle occupancy (Blincoe, et al., 2002; Alaloul, et al., 2021; Alaloul, et al., 2021) .

The (World Health Organization, 2023) report highlights the expected 1.19 million road accident deaths annually. This corresponds to a rate of 15 road traffic fatalities per 100,000 population. Based on 2019 data, these incidents now rank as the primary cause of death for individuals between the ages of 5-29 and the 12th leading cause of death in the world when all ages are considered. Pedestrians, cyclists, and motorcyclists, especially those residing in developing nations, bear a higher amount of this burden (Ioannis, et al., 2023). The Southeast Asia Region has the largest death toll in terms of absolute numbers, accounting for 330,222 deaths or 28% of the global burden (World Health Organization, 2023). The majority of these deaths occurring in undeveloped countries (16%) and in developing countries (74%) makes traffic accident mortality not only a public health problem but also a socio-economic development issue (World Health Organization, 2023). Furthermore, the socio-economic cost of road accidents is classified as the most significant among all other human activities. The first step is to realize that driving is the riskiest daily activity that poses a risk to life and physical integrity (Ioannis, et al., 2023).

According to the Global Burden of Disease (GBD) 2016, RTIs are the leading cause of death among people aged 15 to 49 years (Global Burden of Disease Collaborative Network, 2017) (Oliveiraa, et al., 2021). In 2017, RTIs resulted in 296,686 potential lives lost due to premature deaths, making up 36% of the total injury-related disability-adjusted life years (DALYs) (Gutierrez-Osorio & Pedraza, 2020). Road traffic fatalities in Nepal is 7.96 persons per 10000 vehicles and 9.05 persons per 100000 populations in 2018/19. These numbers

*Corresponding Author

have been in increasing trend, indicating, no improvement in road traffic safety (Ojha, 2021). The number of crashes has risen significantly from 8,484 crashes in the fiscal year 2012/13 to 24,537 by 2021/22, which is 11.2% annual growth in road crashes. If this continues, the rate of fatalities may worsen in the future (Tiwari & Luitel, 2023) and so is the socio-economic burden. In the past few years, the Government of Nepal has formulated various policies targeting road safety concerns. Additionally, the Department of Roads (DoR) has made road safety a top priority to enhance safety in transportation. Furthermore, UN General Assembly Resolution 74/299 aims to reduce road accidents and fatalities by 50% by the year 2030 (World Health Organization; United Nations Regional Commissions, 2021).

As per (Ojha, 2021), after widening the road in Kathmandu-Bhaktapur, there was a rise in accidents, but they decreased in the following years. Carelessness, overspeeding, defective vehicles, drunk driving, and overtaking are major contributors to road accidents. Additionally, factors like age, gender, vehicle type (especially motorcycles), human behavior, and time played a significant role in causing accidents. The majority of traffic road accident data from Nepal Police mostly focuses on driver's mistakes and negligence such as overloading, overspeeding, and overtaking (Thapa, 2013). However, they rarely include other environmental factors, road conditions, and vehicle conditions that may be the cause of RTA (Khadka, et al., 2022). Moreover, police data are reliable only for fatal crashes and are found to be incomplete and poorly recorded for minor and damage-only crashes (Khadka, et al., 2022). The difference between the reported fatalities and WHO estimates suggests that injuries are probably being underreported, as the available data lack detail and aren't suitable for in-depth crash analysis (The World Bank, 2020).

The number of crashes is observed to be high because of the large vehicle proportion and confinement of all services to the valley (Rizal & Tiwari, 2023). Despite the increasing population and traffic flow connecting the BP Highway and tourist areas within the valley, there hasn't been a specific visualization or presentation of road accident data for the Araniko highway stretch at Bhaktapur. While some researchers have looked into road safety on the Suryabinayak-Kathmandu road after lane additions, similar research hasn't been conducted in Bhaktapur district yet. This paper aims to visualize the data to reveal the status of vehicle crashes in Bhaktapur. Thus, the recommendations can be made based on the outcome of the study.

2. Methodology

To analyze and visualize the road accident data, we first acquired the data. The available data was then plotted in ArcGIS to locate accidents on the map. The data was used for visualization according to the number of accidents, location, age groups involved, fatalities, time of the accident, and type of vehicle involved.

Figure 1. Work Flowchart

2.1 Study Area

The Araniko Highway is a two-lane single-carriageway road (Suryabinayak-Kodari) and a four-lane dual-carriageway (Suryabinayak- Kathmandu) with a mix of diverse vehicle types. The highway caters to a significant part of Nepal's freight and passenger traffic and links Kathmandu, the capital of Nepal. A 10 km stretch of Araniko highway lying in Bhaktapur district (Thimi-Palanse) and its feeder road in this region was selected. Maps and photographs are shown in Figure 2 and Figure 3.

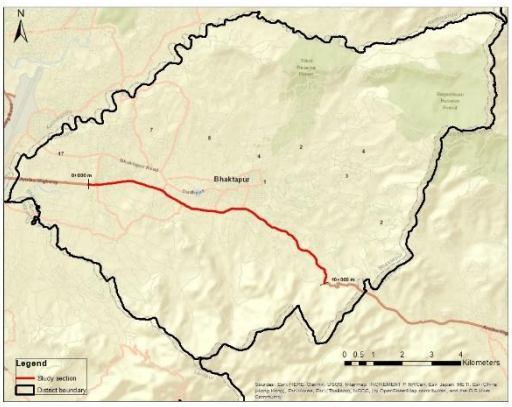

Figure 2. Map of the Study area: Bhaktapur

Figure 3. Section of the study area (Source: Naya Nepal News)

2.2 Data Collection

The Kathmandu Valley Traffic Police Office, Ramshahpath, Kathmandu granted permission to acquire the RTA data. The command was then transferred to the Traffic Police Office, Chundevi, Bhaktapur. The local office provided data for fiscal year 078/079 B.S. of the Bhaktapur district mainly concentrated on Highways containing 214 RTAs. The accident data contains driver information, accident information, and the location of an accident. Record of accidents/crashes were found to be recorded in two ways:

- Summarized data in soft copy format (Table 1)
- Handwritten hardcopy format with details of the incident (Figure 4)

Table 1. Sample of Summarized data

S.N.	Date	Time	Location	Age of driver	Gender of driver	Vehicle involved	Type of vehicle fault	Reason of accident	Fatalities	Injuries	Remarks
1.	078/04/09	19:00	Sallaghari	25	M	Car/Tipper	Private	Overspeed	0	1	Non-Fatal
2.	078/04/10	19:00	Thimi	25	F	Motorbike	Private	Overspeed	0	2	Non-Fatal
3.	078/04/26	19:00	Radhe Radhe	24	M	Motorbike	Private	Overspeed	2	1	Fatal
4.	078/05/01	12:00	Sirjananagar	30/43	M	Car/Jeep	Private	Overspeed	0	2	Non-Fatal
5.	078/05/02	13:10	Jagati	27/36	M	Motorbike	Private	Overspeed	0	3	Non-Fatal
6.	078/05/02	8:00	Adarsha	35/44	M	Motorbike	Private	Overspeed	0	3	Non-Fatal
7.	078/05/09	6:00	SS chowk	32/33	M	Motorbike	Private	Overspeed	0	3	Non-Fatal
8.	078/05/10	4:45	Radhe Radhe	18/20	M	Bus	Commercial	Overspeed	0	2	Non-Fatal
9.	078/05/16	6:50	Sallaghari	25/27	M	Tipper/ Motorbike	Commercial	Overspeed	0	0	Non-Fatal
10.	078/05/22	0:30	Sallaghari	30/43	M	Motorbike	Private	Overspeed	0	1	Non-Fatal

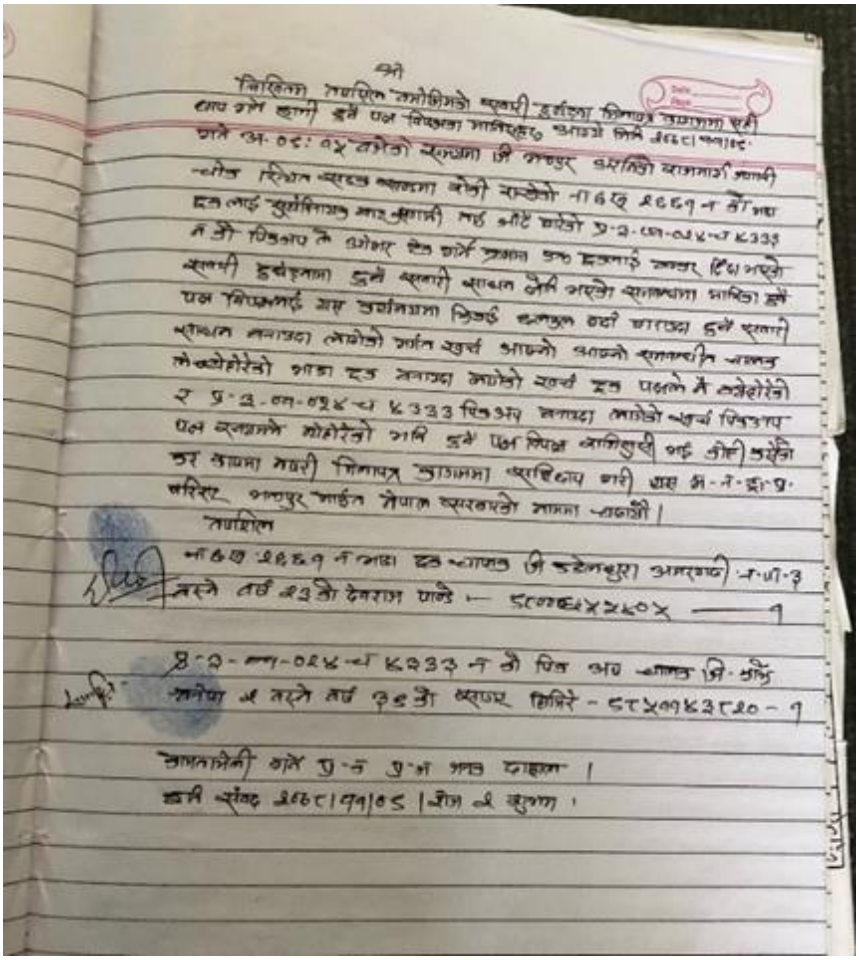

Figure 4. Sample of Handwritten data

3. Result and Discussion

The visualization based on frequency analysis revealed many interesting facts that were hidden in statistics, making it easier for users to understand them.

3.1 Hotspots

The cartographic representation using ArcGIS makes it easier to identify the accident hotspot location with a higher mode without any extensive statistical calculation to recognize the spot.
The red dots show the accident-occurring hotspots (both fatal and non-fatal accidents) based on the collected data, as shown below in Figure 5. From the map, it is visible that Thimi (0+400m, frequency: 25), Radhe Radhe (1+700m, frequency:22), and Sallaghari (2+700m, frequency:25) are the places where accidents occur more frequently than other spots within the study area. All of these hotspots are at straight-stretched-intersections. Based on data from 2009-2012, (Adhikari, 2016) found the same locations were hotspots with higher accident frequency. This demonstrates that even though the speed limit has been plied, both the road-environment conditions and the locations have remained equally vulnerable. Moreover, it has been observed that there were no traffic light at Radhe Radhe and Sallaghari intersection.

3.2 Injuries and Fatalities

Among the 214 numbers of Road traffic accidents (RTAs) recorded by the traffic police, 315 people were injured and 21 people died. The pie chart, shown in Figure 6, shows the majority were injured with 94% and the remaining were fatalities. However, the nature of fatality and the condition of injuries are difficult to figure out from the database provided.

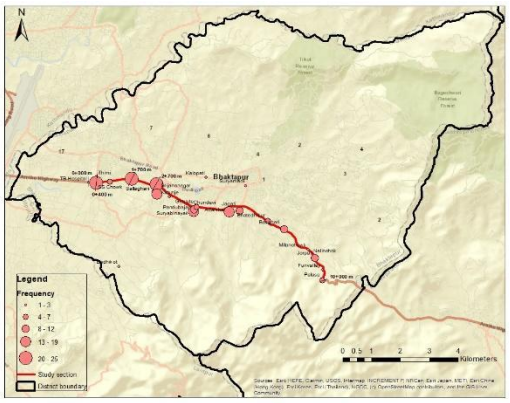

Figure 5. RTAs Visualization showing hotspots

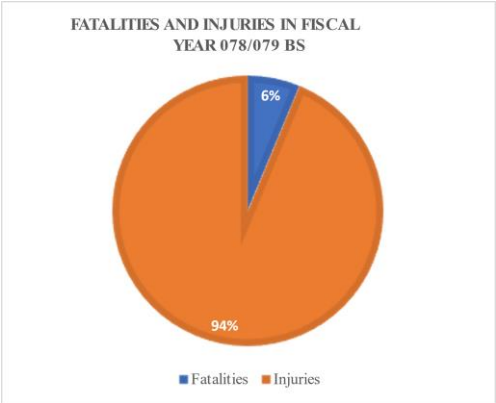

Figure 6. Fatalities and Injuries

3.3 Accident vs Age Group Involved

Age is another major cause of accidents. The age group of 18-25 years old road was maximum with users' crashes of 107 number. From the bar chart, Figure 7, the age group from 18-45 was found to be a vulnerable group (94.67%). Risk-taking behavior and inexperience could be one of the reasons.

3.4 Accident vs Gender involved in RTA

The male drivers were mostly involved in accidents with the number of accidents reaching up to 91.44% while 8.56% female drivers experienced accident cases as shown in Figure 8. One of the reasons could be their aggressive nature and higher number of male driver's population (Ojha, 2021).

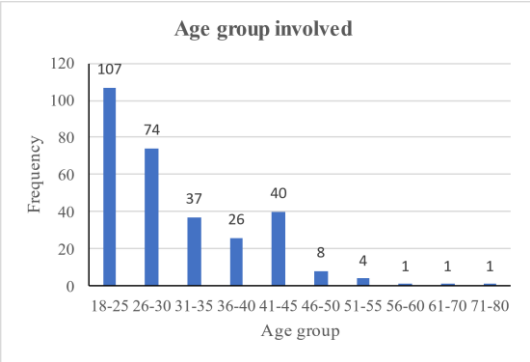

Figure 7. Accident vs Age group involved

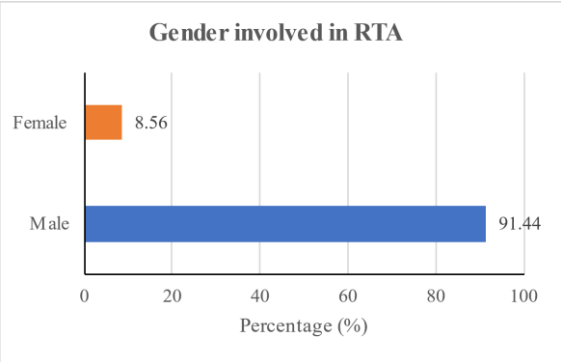

Figure 8. Accident vs Gender involved in RTA

3.5 Accident vs Time of Day

As shown in Figure 9, there were 129 accidents during the day, compared to 85 accidents at night. This means that there were 50% more accidents during the day than at night. This may be because of higher traffic volume during day time than at the night.

3.6 Vehicle type responsible in RTA

Figure 10 visualizes the types of vehicles involved in accidents, revealing a clear disparity. Private vehicles take the largest slice, accounting for a significant 79%. While commercial vehicles make up a considerably smaller portion at 20%. Government vehicles hold the least representation, occupying only 1% of the chart.

Motorbikes major mode of transportation is involved in accidents (48%), as shown in Figure 11. The reason for this is that motorcycles comprise more than half the number of total vehicles plying in this section and frequently violate traffic rules and regulations. Pedestrians were also found to be involved in the accident, where they were recorded as victims. Mainly, the most contributing factors for RTAs were found to be over speeding and reckless driving as shown in Figure 12.

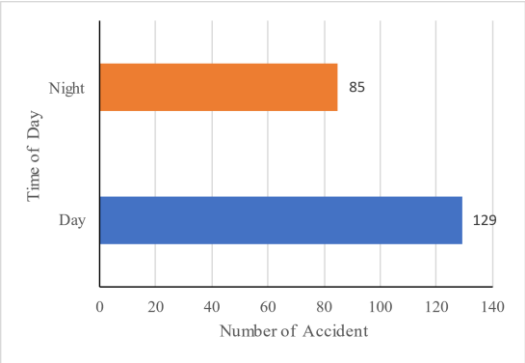

Figure 9. Accident vs Time of Day

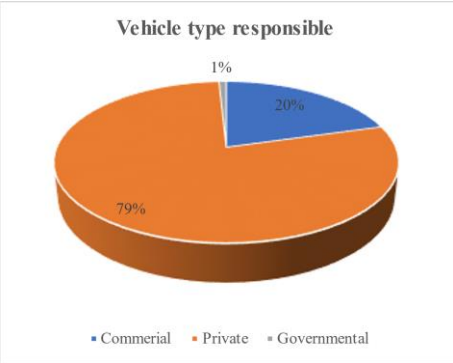

Figure 10: Vehicle type responsible in RTA

3.7 Causes of accidents

Based on the database provided and the frequency analysis, the most contributing factors for RTAs were found to be over speeding and reckless driving as shown in Figure 12. The causes were mainly found to be focused on drivers' mistake and various other environmental factors; vehicular factors were not found to be neglected while recording in any of the cases.

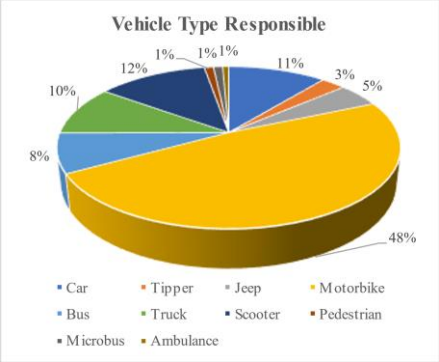

Figure 11. Vehicle type responsible for accident

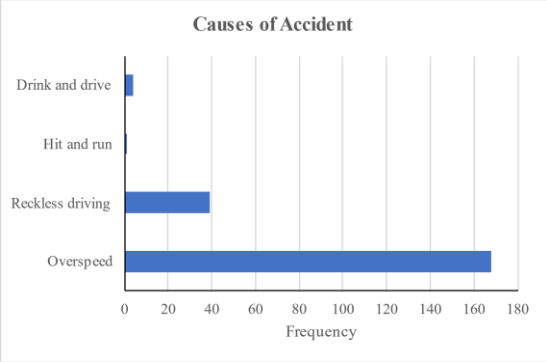

Figure 12. Causes of Accident

4. Conclusion and Recommendation

The study was completed with road traffic data visualization and analysis. It reveals various noteworthy trends and patterns that can be utilized to make strategic plans and policies for the safe regulation of traffic in the study area. Also, it shows significant insights into the prevailing challenges and contributing factors in the study area. The vulnerability of the 18-45 age group, predominantly male drivers, underscores the need for targeted interventions addressing risk-taking behavior and inexperience. Daytime accidents outnumbering nighttime ones suggests the importance of enhancing safety measures during peak traffic hours. Furthermore, the prevalence of accidents involving private vehicles and motorcycles highlights the necessity of addressing traffic rule violations and improving enforcement mechanisms. Overall, over-speeding and reckless driving emerge as major contributing factors to RTAs, necessitating comprehensive measures to mitigate these behaviors and enhance road safety.

The following recommendations can be made from the study:

- Enhance data collection methods to include precise location information and detailed descriptions of injuries and fatalities for more comprehensive analysis.
- As Thimi, Radhe Radhe, and Sallaghari emerge as high-risk areas with a higher frequency of accidents, various traffic calming measures, and signage can be incorporated by policymakers, engineers, and planners.
- To address the younger age group who were found to be involved more in road crashes, road safety can be made a part of the curriculum followed by education programs targeted to drivers.
- Gender-wise, male drivers were significantly more involved in accidents, comprising 91.44% of the total cases. As a part of the policy to reduce accidents, awareness as well as stress management programs could be introduced.
- Implement stricter enforcement measures, especially during daytime hours when accidents are more prevalent, to curb over-speeding and reckless driving.
- Improve infrastructure and signage to mitigate the risk of accidents, particularly in high-risk areas identified through data analysis.
- Strengthen enforcement of traffic rules, particularly targeting violations by private vehicle and motorcycle drivers.
- Conduct further studies to explore additional factors contributing to RTAs and evaluate the effectiveness of interventions in reducing accident rates.
- Collaborate with relevant stakeholders, including policymakers, engineers, law enforcement agencies, and community organizations, to develop and implement comprehensive road safety strategies.

Although the study highlights the facts based on the gathered data, a detailed investigation is further required to assess the human behavior in causing road accidents which plays an important role when an accident occurs. The study can further be extended on a larger scale which makes it easier to highlight the appropriate causes of the accidents. Even though the data acquired were consisting of major intersections, rather than exact locations from it, the main purpose of this study is to make all the stakeholders aware of the situation.

For any analysis, data and facts are the critical factors, which in this study reveals limitations in the current method of recording accident data in Bhaktapur, Nepal. Handwritten records, as shown in Figure 4 in traffic offices often fail to record minor accidents and lack precise location information, accuracy, and accessibility. Only major injuries and accidents are summarized in official reports like in Table 1. The Nepal government's effort to develop a road crash database system - Road Accident Information Management System (RA-IMS)- in 2019 piloting it at traffic police stations in Kathmandu and Birgunj (The World Bank, 2020) couldn't be extended further beyond these regions by 2022. The RA-IMS would offer accuracy, efficiency, and accessibility compared to handwritten databases but has yet to be fully implemented nationwide. Thus, the handwritten database in the traffic office of Bhaktapur is not an effective approach.

Acknowledgments

The authors would like to thank the Kathmandu Valley Traffic Police Office, Ramshahpath, Kathmandu, and the Traffic Police Office, Chundevi, Bhaktapur for the support provided for this research. Also, authors thank Er. Hemant Tiwari for valuable guidance throughout the study.

References

Adhikari, G. P., 2016. Road Traffic Accidents (RTAs) Trends on. *Open Journal of Civil Engineering,* pp. 388-396.

Adhikari, G. P., 2016. Road Traffic Accidents (RTAs) Trends on Kathmandu-Bhaktapur Road after Addition of Lanes. *Open Journal of Civil Engineering,* pp. 388-396.

Alaloul, W. S. et al., 2021. Systematic Review of Life Cycle Assessment and Life Cycle Cost Analysis for Pavement and a Case Study. *Sustainability,* Volume 13, p. 4377.

Alaloul, W. S., Musarat, M. A., Mehmood, H. & Altaf, M., 2021. ASSESSMENT OF LABOR PRODUCTIVITY IN ROAD CONSTRUCTION PROJECTS OF PAKISTAN. *Journal of Civil Engineering, Science and Technology*, Volume 12, pp. 32-38.

Ali, R. M. B. et al., 2021. Road Traffic Accident Data Analysis and Its Visualization. *Civil Engineering and Architecture*, Volume 9, pp. 1603-1614.

Aziz, H. A., Ukkusuri, S. V. & Hasan, S., 2013. Exploring the determinants of pedestrian–vehicle crash severity in New York City. *Accident Analysis and Prevention*, pp. 1298-1309.

Blincoe, L. J. et al., 2002. *The economic impact of motor vehicle crashes, 2000*, United States: National Highway Traffic Safety Administration.

Falyo, D. & Holland, B., 2017. *Medical and psychosocial aspects of chronic illness and disability.* s.l., s.n.

Global Burden of Disease Collaborative Network, 2017. *Global Burden of Disease Study 2016 (GBD 2016) Incidence, Prevalence, and Years Lived with Disability 1990-2016*, Seattle: United States of America: Institute for Health Metrics and Evaluation (IHME).

Gutierrez-Osorio, C. & Pedraza, C., 2020. Modern data sources and techniques for analysis and forecast of road accidents: A review. *Journal of Traffic and Transportation Engineering (English Edition)*, 7(4), pp. 432-446.

ICIMOD, 2009. *Road Network of Nepal.* [Online]
Available at: https://rds.icimod.org/home/datadetail?metadataid=3620

Ioannis, K. et al., 2023. Towards Sustainable Transportation: The Role of Black Spot. Volume 15, p. 14478.

Khadka, A. et al., 2022. Completeness of police reporting of traffic crashes in Nepal: Evaluation using a community crash recording system. *Traffic Injury Prevention.*

Leuhery, H. L., 2020. Determination of Black Site Area Based on Equivalent Accident Number Analysis: Case Study National Roads in Ambon City. *Civil Engineering and Architecture*, Volume 8, pp. 1063-1073.

Ojha, K. N., 2021. Road safety status and some initiatives in Nepal. *Journal of Engineering and Technology for Industrial Applications* , 7(27), pp. 20-40.

Rafiq, W. et al., 2021. Modeling and design optimization of reclaimed asphalt pavement containing crude palm oil using response surface methodology. *Construction and Building Materials*, Volume 291.

Rizal, S. & Tiwari, H., 2023. *Analysis of Road Traffic Crash Cost in Kathmandu Valley.* s.l., 2nd International Conference on Integrated Transport for Sustainable Mobility.

Santoso, D. & Tjahjono, T., 2020. Determination minimum distance between ramp entry and exit on the freeway reviewed from the road safety aspect. *Civil Engineering and Architecture*, Volume 8, pp. 268-273.

Skyler, J. et al., 2017. *Differentiation of diabetes by pathophysiology, natural history, and prognosis.* s.l., s.n.

Thapa, A. J., 2013. *Status Paper on Road Safety in Nepal*, New Delhi, India: Europe-Asia Road Safety Forum And The 67th Session of the Working Party 1(WP1) of UNECE.

The World Bank, 2020. *Delivering Road Safety in Nepal: Leadership Priorities and Initiatives to 2030*, Washington DC : World Bank Publications, The World Bank Group.

Tiwari, H. & Luitel, S., 2023. Re-orienting towards Safer Roads Infrastructure in Nepal. *Journal of Recent Activities in Infrastructure Science.*

World Health Organization; United Nations Regional Commissions, 2021. *Global Plan Decade of Action for Road Safety 2021-2023*, s.l.: s.n.

World Health Organization, 2023. *Global status report on road safety 2023*, Geneva: s.n.

Zhang, C., Yan, X., Ma, L. & An, M., 2014. Crash Prediction and Risk Evaluation Based on. *Mathematical Problems in Engineering.*