M. Shafik (Ed.)

doi:10.3233/ATDE240020

Risky Driving Behaviors Among Motorcyclists in Ecuador: A Study of Associated Factors

Juan Diego FEBRES[a,1], Yasmany GARCÍA-RAMÍREZ[b] and Fabián REYES-BUENO[c]
[a] *Department of Production, Universidad Técnica Particular de Loja, Ecuador*
[b] *Department of Civil Engineering, Universidad Técnica Particular de Loja, Ecuador*
[c] *Department of Biological and Agricultural Sciences, Universidad Técnica Particular de Loja, Ecuador*

Abstract. Motorcycle crashes are a significant cause of injuries and deaths worldwide, with risky driving behaviors among motorcyclists being a significant contributing factor. This study aimed to identify the factors associated with risky driving behaviors among motorcyclists in an urban setting in Ecuador. Data were collected through observation of riders in the city of Loja, focusing on compliance with helmet usage, unfastened helmets, and distractions caused by cell phone usage while driving. The decision tree method was used to analyze the data. The results showed that wearing a helmet without fastening it and being distracted by the cell phone while driving were the most significant factors associated with unsafe driving behaviors among motorcyclists in Ecuador. Likewise, the riders of delivery motorcycles show more insecure behavior than those driving private motorcycles, especially when they are close to the economic center of the city. These findings can inform the development of road safety campaigns and the enactment of laws to reduce motorcycle accidents and improve rider safety.

Keywords. risky riding behaviors; Ecuador; helmet usage; distracted driving; decision tree.

1. Introduction

Approximately 1.3 million people die, and 20 to 50 million people sustain non-fatal injuries due to road accidents every year worldwide [1]. Although there have been worldwide attempts to reduce the number of accidents, it is predicted that the number of crashes in low and middle-income countries will keep rising. In Ecuador in 2022, 21739 crashes occurred, causing 19006 injuries and 2,202 fatalities [2]. Of those crashes, 6709 involved motorcyclists causing 750 deaths on site. Riders' behavior is the cause of most motorcycle accidents on the road [3]. The way motorcyclists behave is a significant factor in the high number of deaths resulting from traffic accidents [4]. Studies have identified several risky driving behaviors among motorcyclists, including unauthorized

[1] Department of Production, Universidad Técnica Particular de Loja, San Cayetano, CP 110107, Loja, Ecuador; E-mail: jdfebres@utpl.edu.ec.

overtaking, inappropriate speed, over-speeding, non-compliance with traffic regulations, riding after drinking alcohol, not using helmets [4], and driving while distracted.

Overtaking another motorcyclist in the same lane is generally illegal and dangerous in most cases. Several factors contribute to different types of crashes, including inexperienced motorcyclists, broad city roads that promote speeding and dangerous overtaking, smooth city roads that encourage high speeds and more interaction between vehicles, and inadequate infrastructure maintenance [5]. Additionally, inappropriate speed is a major cause of motorcycle accidents and puts road users at risk [6]. Most accidents are still caused by speeding and they cannot be ignored as they are connected to the actions of the rider [3]. Risk behaviors related to overtaking and speeding may be regulated by local laws.

Non-compliance with traffic regulations by motorcycle riders is a common issue. Studies have shown that the attitudes and behaviors of riders are the primary reasons for this non-compliance [7]. Compliance with road safety regulations among motorcycle riders is also problematic, as some studies indicate that only approximately 59% of riders adhere to these regulations [8]. Driving non-compliance is a choice that arises from unconscious practical skills developed through experience and knowledge gained in everyday life [9]. Failure to comply with the laws also includes refraining from driving a motorcycle after consuming alcohol.

Riding a motorcycle after consuming alcohol is dangerous and can lead to serious crashes [10]. Alcohol can significantly impair one's ability to perform in real-world situations, and even a small amount of alcohol can diminish brain function [11]. Individuals who ride a motorcycle while under the influence of alcohol also tend to engage in other dangerous behaviors while driving, such as not wearing a helmet [12–14] which increases the severity of injuries to motorcyclists.

Riding a motorcycle without a helmet significantly increases the risk of severe head trauma, coma, and death. Helmets protect riders from injuries such as traumatic brain injury and concussion [15]. There are also regulations in place for motorcycle helmets, and manufacturers must certify that their products follow these regulations [16]. Non-users of helmets have identified several obstacles to their use, including a belief that helmets are not very effective, pressure from peers, insufficient information about helmet use, high costs, inconvenience, vision and hearing impairment, concerns about style [17], weight of the helmet, and the feeling of heat during use [18]. On the other hand, it is not recommended to ride a motorcycle with an unbuttoned helmet as it can compromise the rider's safety. There isn't much research on unbuttoned helmets, considering that it is the law in most countries. If combined with distractions, the outcome of a crash can be fatal.

Distractions can be a major cause of motorcycle accidents. Common distractions for motorcycle riders include using a cellphone [19], eating or smoking [20], red-light running [20], adjusting music [20], and being injured by a driver [21]. Distracted driving can also cause motorcycle accidents, as drivers who are not paying attention to their surroundings may not see motorcycles and take reasonable measures to avoid accidents. Therefore, this and other risky behaviors must be thoroughly studied.

There are several techniques used to analyze rider behavior risk. For example, self-report survey [20,22], machine learning methods [23], observational study [24], among few others. A new method called decision tree based on machine learning has enabled more advanced analyses to be conducted. This algorithm can categorize or predict based on past data, handle both numerical and categorical data, and choose important features. It presents decisions in a visual format and is useful for data mining.

This analysis of previous literature emphasizes the importance of comprehending the risk behavior of motorcycle riders. Despite the fact that drivers exhibit riskier behavior than riders [25], analyzing their behavior is crucial due to a significant rise in their numbers after CoViD-19, particularly among those who make deliveries [26]. Identifying these risky behaviors is essential for preventing accidents and protecting riders and other community members from risks [27]. Despite the abundance of literature on the subject, very few studies have been conducted in an Ecuadorian context, particularly with regard to helmet usage, distractions while driving, and the utilization of decision trees. The aim of this article is to identify the factors associated with risky driving behaviors among motorcyclists in an urban setting in Ecuador by utilizing a decision tree. To accomplish this objective, data was collected from riders through observation in the city of Loja, located in the southern region of the country. The data primarily focused on compliance with helmet usage, unfastened helmets, and distractions caused by cell phone usage while driving. The results will serve as input for a more comprehensive analysis of each outcome and to allocate resources, such as road safety campaigns and the enactment of laws.

2. Materials and Methods

In this study, data were collected on motorcycle riders in the city of Loja, Ecuador, using an online survey and the direct observation method. The data were collected between December 2022 and January 2023 and included information on the number of people on each motorcycle, helmet usage, demographic data, and rider distraction. The data were processed and categorized into five groups based on hazardous rider behaviors. The analysis of the data was conducted using the R statistical software and the decision tree method to identify the most significant contributors to the riskiest behaviors.

2.1. Study city

The city of Loja is located in southern Ecuador and boasts a well-structured layout of streets and walkways that make it easy to navigate. There are numerous bus and taxi options available for transportation. The population of the Loja area is approximately 215,000 people [28], with a density of 93.1 people per square kilometer [29]. The city has experienced growth in both urban and suburban areas. The capital of the Loja canton, also known as Loja, has a population of 118,532 people [29].

2.2. Data collection

The data was gathered through the Survey123 app on ArcGISonline® [30] and can be viewed on its web application [31]. The data was collected using cell phones or tablets between December 2022 and January 2023. The information gathered includes the number of people in each motorcycle, whether they all wore helmets, if the helmet was fastened, the demographics of the passengers (adult, elderly, child, infant), and if there was any rider distraction as seen in Table 1. Other details recorded were the type of vehicle (delivery, particular), the date, time, and location.

Table 1. Set of variables in this study

Variable type: factor	
Day of week	1: 90 (6.3%) 2: 27 (1.9%) 3: 151 (11%) 4: 241 (17%) 5: 287 (20%) 6: 302 (21%) 7: 323 (23%)
Type of vehicle	Delivery 439 (31%) Particular 982 (69%)
Rider type	Adult 1,321 (93%) Elderly 100 (7.0%)
Copilot type	Adult 381 (27%) Elderly 12 (0.8%) Child 75 (5.3%) NA 953 (67%)
Extra type	Adult 6 (0.4%) Infant 14 (1.0%) Child 36 (2.5%) None 1,365 (96%)
Road type	Avenue 433 (30%) Street 988 (70%)
Infractions[1]	c001 27 (1.9%) c100 152 (11%) c101 339 (24%) c110 190 (13%) c111 713 (50%)

Variable type: numeric

	min	max	median	mean	inline_hist
Hour	0	23	16	13	
Number of occupants	1	3	1	1.37	
Distance from city center (km)	0.03	4.25	0.6	0.972	

[1]The categories of the infraction variable (n00, n01, n10, n11) are defined in data processing section.

2.3. Data processing

Initially, any incomplete or mismatched responses were removed from the database, resulting in a decrease in the amount of data from 1672 to 1421. Subsequently, to investigate hazardous rider behaviors, the data was categorized into five groups and labeled with descriptions and decision trees for ease of analysis. The categories are as follows: i) c001: The rider does not use a helmet and does not get distracted by the cellphone, ii) c100: The rider uses a helmet but does not buckle it and gets distracted by the cellphone, iii) c101: The rider uses a helmet but does not buckle it and does not get distracted by the cellphone, iv) c110: The rider uses a helmet, buckles it, and gets distracted by the cellphone, v) c111: The rider uses a helmet, buckles it, and does not get distracted by the cellphone.

The most hazardous set of conditions is when both "c001" and "c100" are present, while the safest is "c111" which represents motorcyclists who wear helmets properly, fasten them securely, and avoid using their phones while riding. The other conditions fall somewhere in between, with at least two risky behaviors not being followed.

2.4. Data Analysis

The data analysis consisted of two parts. Firstly, a description of the five conditions was performed, which involved considering several factors such as day of the week, time of day, mode of transportation, number of people in the vehicle, demographic data, type of road, and distance from the city center. Secondly, the relationship between the conditions and these factors was examined to identify the most significant contributors to the conditions, particularly the riskiest behaviors. The analysis was carried out using the R statistical software [32] with the RStudio interface [33], and the decision tree technique was applied using the recursive partitioning algorithm of the RPART package [34]. To identify patterns that significantly improve the model's overall quality, the CARET package [35] was used, and a training dataset was established to determine the optimal complexity parameter or "cp". To achieve this, the database was randomly divided into two groups in a 70/30 ratio. The first group, consisting of 70% of the database (997 observations), was used to train the decision tree model, while the remaining 30% of the database (424 observations) was used for model validation. Once the optimal cp was identified, the classification tree was constructed, variables of importance were identified, a confusion matrix was performed to validate the accuracy of the model, and the AUC (Area Under the Curve) was calculated to determine the ability of the trained model to classify the information. The AUC results were categorized based on the following intervals: 0.5: randomness, 0.5-0.6: poor, 0.6-0.7: fair, 0.7-0.8: good, 0.8-0.9: very good, 0.9-1: excellent. These steps were taken to ensure the accuracy and effectiveness of the model regardless of the algorithm used or the scale of the predictor variables.

3. Results

This section presents descriptive and inferential statistical analyses to identify factors that impact compliance rates of motorcycle riders in a city. These findings could inform policymakers and stakeholders in improving compliance rates and reducing risks associated with motorcycle riding.

3.1. Stage 1: descriptive statistics

Figure 1 displays the descriptive statistics for the five conditions. Despite the lack of an observable relationship between compliance and the rider, the data shows that Sunday has the highest non-compliance rate of the five observed behaviors. Additionally, several factors appear to impact compliance rates, such as the presence of an extra occupant, the type of motorcycle, and proximity to the city's economic center. Interestingly, compliance is higher when the co-pilot is a child or when the extra occupant is an infant, while non-compliance is more likely when the rider is alone or with an elderly adult or when the extra occupant is an adult. Furthermore, delivery motorcycles have higher non-compliance rates than private motorcycles. Although there is no trend regarding the time of day, the combination of infractions known as C100 is concentrated between 14-21 hours when it occurs. It is worth noting that there are more C001 infractions on the street than on the avenue.

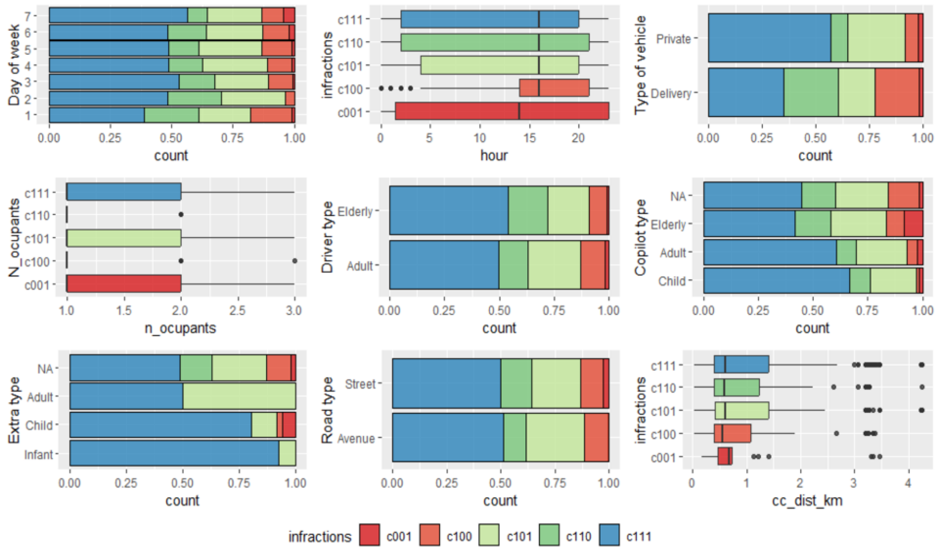

Figure 1. Descriptive statistics of the five conditions of risky rider behavior. c001: The rider does not use a helmet and does not get distracted by the cellphone. c100: The rider uses a helmet but does not buckle it and gets distracted by the cellphone. c101: The rider uses a helmet but does not buckle it and does not get distracted by the cellphone. c110: The rider uses a helmet, buckles it, and gets distracted by the cellphone.c111: The rider uses a helmet, buckles it, and does not get distracted by the cellphone.

3.2. Stage 2: inferential statistics

In the second stage, a decision tree was used as a model for decision-making in classification and regression tasks. This tree-like structure shows tests on attributes, their results, and class labels. Decision trees are used in supervised machine learning and management decision-making to clarify choices, risks, and objectives. The ultimate decision tree was built with the training dataset using a complexity parameter of 0.00471516, determined as the optimal selection during the model generation phase. The decision tree for rider analysis is visually presented in Figure 2. Each branch has a final node in the tree. The bottom nodes, represented in colors, are organized into three rows. The bottom row displays the total percentage of the training subset (70% of the sample) assigned to each node. In the middle row, five decimal numbers represent the proportions of respondents in each node who selected the following infraction categories, in order: c001, c100, c101, c110, and c111. The upper row shows the dominant infraction category.

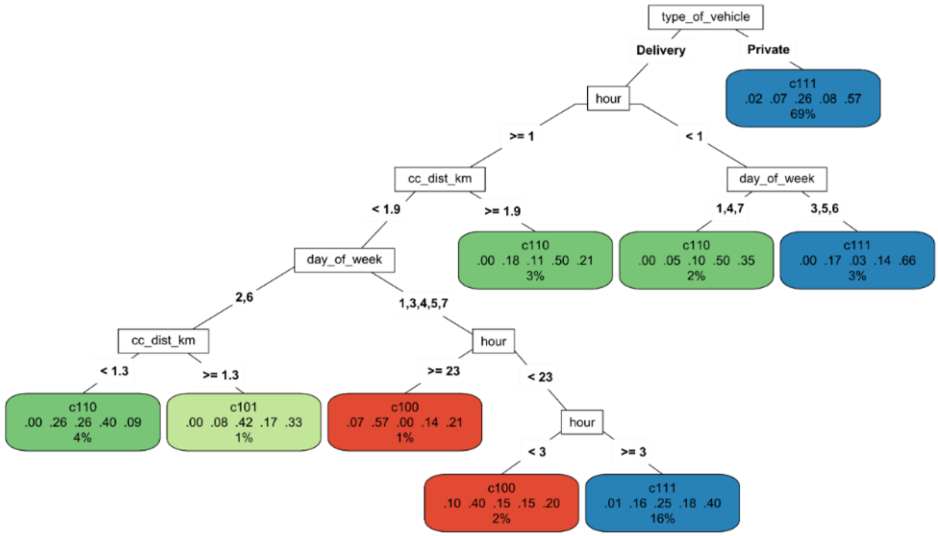

Figure 2. Decision tree of the five conditions of risky rider behavior. c001: The rider does not use a helmet and does not get distracted by the cellphone. c100: The rider uses a helmet but does not buckle it and gets distracted by the cellphone. c101: The rider uses a helmet but does not buckle it and does not get distracted by the cellphone. c110: The rider uses a helmet, buckles it, and gets distracted by the cellphone. c111: The rider uses a helmet, buckles it, and does not get distracted by the cellphone.

Figure 2 illustrates that four out of the five conditions defined in the methodology have been utilized. In this case, the C100 condition (the rider uses a helmet but does not buckle it and gets distracted by the cellphone) poses the highest risk, while C101 (the rider uses a helmet but does not buckle it and does not get distracted by the cellphone) and C110 (the rider uses a helmet, buckles it, and gets distracted by the cellphone) is considered a medium risk, and C111 (the rider uses a helmet, buckles it, and does not get distracted by the cellphone) presents no risk.

This tree shows that there is a tendency for drivers of private motorcycles to behave in a safe way (private motorcyclists make up 69% of the training sample, of which 66% behave safely), as well as for delivery vehicles at midnight, especially on Tuesdays, Thursdays and Fridays (3% of the training sample, of which 66% have safe behaviors), or from 15:00 to 23:00 in places close to the city center (less than 1.9 km), on all days of the week except Mondays and Fridays (16% of the training sample, of which 40% have safe behaviors).

As for the medium risk behavior (C110 or C101), it is mainly for delivery vehicles very close to the city center (less than 1.9 km), on Mondays and Fridays (5% of the training sample, of which 40% and 42% respectively have medium risk behaviors), or every day when they are already more than 1.9 km from the city center (3% of the training sample, of which 50% have medium risk behaviors), or on Sundays, Wednesdays or Saturdays at midnight (2% of the training sample, of which 50% have medium risk behaviors).

Finally, high-risk behavior is found for deliveries between 23:00 and 24:00 (1% of the training sample, of which 57% have high-risk behavior), and 24:00 to 3:00 the next day (2% of the training sample, of which 40% have high-risk behavior), every day except Monday and Friday.

As shown in figure 3, the AUC for the test data was 0.65, indicating that the model has moderate discriminatory ability, i.e. it can distinguish between positive and negative classes better than randomisation, but does not have strong discriminatory ability. Additionally, the model's accuracy was 48.58%, and the Kappa Coefficient was 0.0912. The results suggest that the classification model exhibits limited performance, with accuracy close to chance and a very low level of agreement (Kappa coefficient).

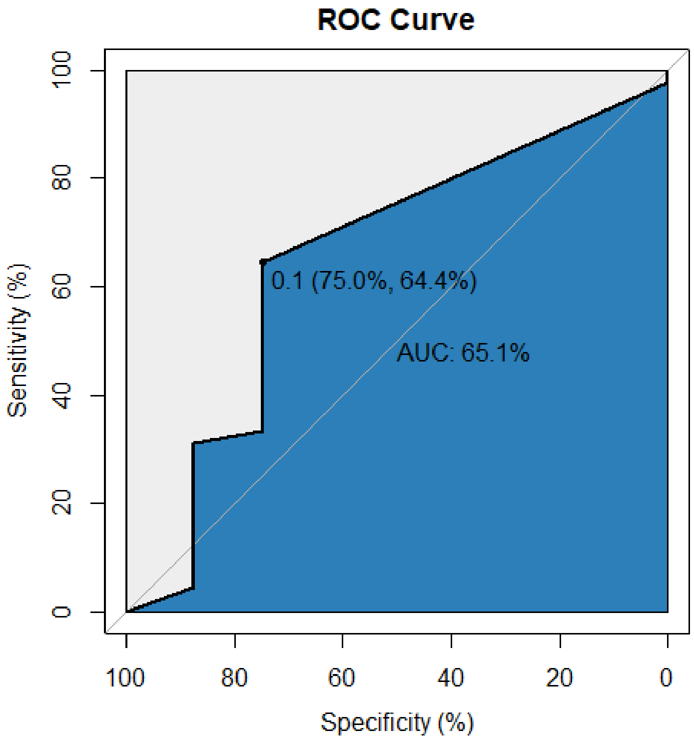

Figure 3. Area under the ROC curve (Receiver Operating Characteristic)

4. Discussion

The goal of this research was to find out what causes motorcyclists to engage in dangerous driving behaviors in a city in Ecuador. The researchers observed riders in Loja to see if they were wearing helmets, if their helmets were properly fastened, and if they were distracted by using their cell phones while driving.

Delivery motorcycles have higher non-compliance rates than private motorcycles. Delivery motorcycle riders are at risk of crashes and injuries due to the nature of their work. study in Korea discovered that delivery riders had a higher percentage of accidents caused by collisions with cars or other motorcycles, but their injuries were less severe compared to non-delivery riders [36]. A study in Malaysia found that over 50% of food delivery workers were using non-standard helmets, which increased their risk of injury in case of an accident [37]. These are some examples of studies related to crashes; however, there are very few studies on compliance with the law for delivery or private riders.

In regards to the days of the week and hours with the highest rate of non-compliance, this study found that it was on Sundays between the hours of 2-9 pm. No studies with similar results were found, however, there were few outcomes from previous research. For example, motorcyclists who ride at night, on weekends, for fun, and on well-maintained roads with many curves are more likely to commit traffic violations [38]. While 55% of respondents preferred mandatory wearing of high-visibility clothing, only 15% of daytime and 20% of nighttime riders reported actually doing so [39].

Compliance is more likely when the co-pilot is a child or when the extra occupant is an infant, whereas non-compliance is more likely when the rider is alone or with an elderly adult or when the extra occupant is an adult. However, it is possible that the behavior of a passenger can affect the risk behavior of a rider while driving. The behavior of passengers in a vehicle can either increase or decrease the chances of an accident. A distracting or risk-taking passenger can be dangerous, while a calm and supportive passenger can help the rider make safer decisions. There are not many studies regarding the topic, the closest one found that the likelihood of wearing a helmet decreased with younger age, with children under 10 years having the lowest likelihood of wearing a helmet [40].

This study has found interesting relationships between reductions and motorcycle risk driving. Motorcycle passengers comprise a considerable proportion of traffic crash victims [41]. Not only because of the risky behaviors that have been discussed but personality traits have also been found to be associated with risky driving behaviors among motorcyclists [42]. Risky behavior can not only be caused by the rider's own characteristics, but also by the poor state of engineering and maintenance of roads is one of the reasons why motorcyclists tend to ignore traffic rules [43]. In a study carried out by Zahid et al. [44] related to rider risks, it is highlighted that among the critical points where infractions are committed, are the areas of the cities related to public and commercial facilities, as highlighted in this study, where more unsafe behavior is seen near the economic center of the city.

The study has limitations due to a small sample size and data only being collected from one city in Ecuador, which may not represent the entire country. The analysis only focused on three behaviors related to motorcycle safety: if the riders use the helmet, buckle the helmet, or get distracted by the cellphone. Future studies should expand the research to include more cities and regions in Ecuador, larger sample sizes, and additional risky driving behaviors, benefits of a model that helps to more accurately predict the behavior of drivers on the road are evidenced [45]. Similarly, is important to study the behavior of drivers associated with new technologies such as assisted driving in new generation vehicles [46]. It would also be useful to investigate the effectiveness of road safety campaigns and laws aimed at reducing risky driving behaviors among motorcyclists in Ecuador.

5. Conclusions

In conclusion, this study identified factors associated with risky driving behaviors among motorcyclists in an urban setting in Ecuador, fulfilling the stated objective. The results showed that non-compliance with helmet usage and distracted driving were the most significant factors contributing to risky driving behaviors. Compliance rates were impacted by factors such as the presence of an extra occupant, the type of motorcycle, and proximity to the city's economic center. Delivery motorcycle riders were found to have higher non-compliance rates than private motorcycle riders. The study also found that Sundays between the hours of 2-9 pm had the highest rate of non-compliance. These findings can inform the development of road safety campaigns and the enactment of laws to reduce motorcycle accidents and improve rider safety in Ecuador. Further research is needed to explore the impact of passenger behavior on rider safety and compliance with helmet usage laws.

References

[1] WHO. Road traffic injuries [Internet]. 2022 [cited 2023 Apr 11]. Available from: https://www.who.int/health-topics/road-safety#tab=tab_1.

[2] ANT. Visor de siniestralidad – Estadísticas – Agencia Nacional de Tránsito del Ecuador – ANT [Internet]. 2022 [cited 2022 Oct 4]. Available from: https://www.ant.gob.ec/visor-de-siniestralidad-estadisticas/.

[3] Yousif MT, Sadullah AFM, Kassim KAA. A review of behavioural issues contribution to motorcycle safety. IATSS Research. 2020;44:142–154.

[4] Hassanzadeh K, Salarilak S, Sadeghi-Bazargani H, et al. Motorcyclist risky riding behaviors and its predictors in an Iranian population. J Inj Violence Res [Internet]. 2020 [cited 2023 Apr 12];12:161. Available from: /pmc/articles/PMC7487125/.

[5] Jiménez A, Bocarejo JP, Zarama R, et al. A case study analysis to examine motorcycle crashes in Bogota, Colombia. J Safety Res. 2015;52:29–38.

[6] Lemonakis P, Eliou N, Karakasidis T. Investigation of speed and trajectory of motorcycle riders at curved road sections of two-lane rural roads under diverse lighting conditions. J Safety Res. 2021;78:138–145.

[7] Kitson P, Asamoah B, Kombonaah N, et al. Understanding Why Motorcycle Riders Do Not Comply with Traffic Control Signals in the WA Municipality in Ghana. Research on Humanities and Social Sciences [Internet]. 2019 [cited 2023 Apr 12];9. Available from: www.iiste.org.

[8] Hagan D, Tarkang EE, Aku FY. Compliance of commercial motorcycle riders with road safety regulations in a peri-urban town of Ghana. PLoS One [Internet]. 2021 [cited 2023 Apr 12];16. Available from: /pmc/articles/PMC8009399/.

[9] Ganiem LM. Residential Area Syndrome: Reasons for Non-Compliance in Motorcycling. International Journal of Educational Research and Social Sciences (IJERSC) [Internet]. 2021 [cited 2023 Apr 12];2:102–110. Available from: https://www.ijersc.org/index.php/go/article/view/38.

[10] Kiwango G, Francis F, Moshiro C, et al. Association between alcohol consumption, marijuana use and road traffic injuries among commercial motorcycle riders: A population-based, case-control study in Dares Salaam, Tanzania. Accid Anal Prev. 2021;160:106325.

[11] NHTSA. Ride Sober or Get Pulled Over | Motorcycles & Alcohol [Internet]. 2022 [cited 2023 Apr 12]. Available from: https://www.nhtsa.gov/campaign/ride-sober.

[12] dos Santos WJ, Coêlho VM da S, Bonfim CV do, et al. Alcohol and risky behavior in traffic among motorcyclists involved in accidents in a city in northeastern Brazil. Traffic Inj Prev. 2019;20:233–237.

[13] Sauter CN, Zhu S, Allen S, et al. Increased risk of death or disability in unhelmeted Wisconsin motorcyclists. WMJ [Internet]. 2005 [cited 2023 Apr 12];2:39–44. Available from: https://pubmed.ncbi.nlm.nih.gov/15856741/.

[14] Wiratama BS, Chen PL, Ma ST, et al. Evaluating the combined effect of alcohol-involved and un-helmeted riding on motorcyclist fatalities in Taiwan. Accid Anal Prev. 2020;143.

[15] Wumbei M. Noncompliance with Regulations on the Use of Safety Helmets by Motorcyclists in Tamale, Ghana [Doctoral disertation] [Internet]. Nigeria Defence Academy. Walden University; 2021 [cited 2023 Apr 12]. Available from: https://www.proquest.com/docview/2557525361?pq-origsite=gscholar&fromopenview=true.

[16] NHTSA. Importation and Certification FAQs [Internet]. 2022 [cited 2023 Apr 12]. Available from: https://www.nhtsa.gov/importing-vehicle/importation-and-certification-faqs-0.

[17] Germeni E, Lionis C, Davou B, et al. Understanding reasons for non-compliance in motorcycle helmet use among adolescents in Greece. Injury Prevention [Internet]. 2009 [cited 2023 Apr 12];15:19–23. Available from: https://injuryprevention.bmj.com/content/15/1/19.

[18] Faryabi J, Rajabi M, Alirezaee S. Evaluation of the Use and Reasons for Not Using a Helmet by Motorcyclists Admitted to the Emergency Ward of Shahid Bahonar Hospital in Kerman. Arch Trauma

Res [Internet]. 2014 [cited 2023 Apr 12];3:19122. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4276706/.
[19] Truong LT, De Gruyter C, Nguyen HTT. Calling, texting, and searching for information while riding a motorcycle: A study of university students in Vietnam. Traffic Inj Prev. 2017;18:593–598.
[20] Umniyatun Y, Nurmansyah MI, Farradika Y, et al. Motorcycle risky behaviours and road accidents among adolescents in Jakarta metropolitan area, Indonesia. Int J Inj Contr Saf Promot [Internet]. 2021 [cited 2023 Apr 12];28:339–346. Available from: https://www.tandfonline.com/doi/abs/10.1080/17457300.2021.1928229.
[21] Lin MR, Kraus JF. A review of risk factors and patterns of motorcycle injuries. Accid Anal Prev. 2009;41:710–722.
[22] Uttra S, Jomnonkwao S, Watthanaklang D, et al. Development of Self-Assessment Indicators for Motorcycle Riders in Thailand: Application of the Motorcycle Rider Behavior Questionnaire (MRBQ). Sustainability 2020, Vol 12, Page 2785 [Internet]. 2020 [cited 2023 Apr 12];12:2785. Available from: https://www.mdpi.com/2071-1050/12/7/2785/htm.
[23] Wahab L, Jiang H. A comparative study on machine learning based algorithms for prediction of motorcycle crash severity. PLoS One [Internet]. 2019 [cited 2023 Apr 12];14:e0214966. Available from: https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0214966.
[24] Rusli R, Oviedo-Trespalacios O, Abd Salam SA. Risky riding behaviours among motorcyclists in Malaysia: A roadside survey. Transp Res Part F Traffic Psychol Behav. 2020;74:446–457.
[25] Rankin KA, Zaki T, Ou D, et al. High-risk motor vehicle drivers engage in more risk behaviors than motorcyclists. SICOT J [Internet]. 2021 [cited 2023 Apr 12];7:29. Available from: https://www.sicot-j.org/articles/sicotj/full_html/2021/01/sicotj210011/sicotj210011.html.
[26] Qin H, Wei Y, Zhang Q, et al. An observational study on the risk behaviors of electric bicycle riders performing meal delivery at urban intersections in China. Transp Res Part F Traffic Psychol Behav. 2021;79:107–117.
[27] Heydari ST, Sarikhani Y, Mani A, et al. Factors associated with Motorcyclist risky riding behaviors in southern Iran. J Inj Violence Res [Internet]. 2019 [cited 2023 Apr 12];11. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7186963/.
[28] INEC. Censo de población y vivienda en el Ecuador. Fascículo provincial Loja [Internet]. 2010. Available from: https://www.ecuadorencifras.gob.ec/wp-content/descargas/Manulateral/.
[29] INEC. Datos censales del cantón Loja [Internet]. 2001 [cited 2022 Oct 31]. Available from: https://www.ecuadorencifras.gob.ec/documentos/web-inec/Bibliotecas/Fasciculos_Censales/Fasc_Cantonales/Loja/Fasciculo_Loja.pdf.
[30] ArcGIS. Survey123 for ArcGIS | Crear encuestas y formularios inteligentes para la captura de datos [Internet]. 2020 [cited 2020 Jun 15]. Available from: https://www.esri.com/es-es/arcgis/products/survey123/overview.
[31] OSEVI-UTPL. Behavior of users on a motorcycle or car [Internet]. 2023 [cited 2023 Apr 11]. Available from: https://smartland.maps.arcgis.com/apps/dashboards/5142f0d9f3dd4575a0263824d29ddcf3.
[32] R Core Team. A Language and Environment for Statistical Computing. R Foundation for Statistical Computing [Internet]. 2022;https://www.R–project.org. Available from: http://www.r-project.org.
[33] Team P. RStudio: Integrated Development Environment for R [Internet]. Boston, MA; 2023. Available from: http://www.posit.co/.
[34] Therneau T, Atkinson B, Ripley B. An Introduction to Recursive Partitioning Using the RPART Routines [Internet]. 2019. Available from: https://cran.r-project.org/web/packages/rpart/vignettes/longintro.pdf.
[35] Kuhn M. caret: Classification and Regression Training [Internet]. 2022. Available from: https://cran.r-project.org/package=caret.
[36] Choi SJ, Kim MJ, Myung J, et al. Characteristics of crashes and injuries on delivery motorcycles: A retrospective cohort study. Traffic Inj Prev [Internet]. 2022 [cited 2023 Apr 16];23:146–151. Available from: https://pubmed.ncbi.nlm.nih.gov/35212592/.
[37] Kulanthayan S, Lai G, Kaviyarasu Y, et al. Are food delivery riders motorcycle safety helmets safe? Injury Prevention. 2012;18:A164.3-A164.
[38] Perez-Fuster P, Rodrigo MF, Ballestar ML, et al. Modeling offenses among motorcyclists involved in crashes in Spain. Accid Anal Prev. 2013;56:95–102.
[39] Reeder AI, Chalmers DJ, Langley JD. The risky and protective motorcycling opinions and behaviours of young on-road motorcyclists in New Zealand. Soc Sci Med. 1996;42:1297–1311.
[40] Wada T, Nakahara S, Bounta B, et al. Road traffic injury among child motorcyclists in Vientiane Capital, Laos: a cross-sectional study using a hospital-based injury surveillance database. Int J Inj Contr Saf Promot. 2017;24:152–157.
[41] Tavakoli Kashani A, Rabieyan R, Besharati MM. A data mining approach to investigate the factors influencing the crash severity of motorcycle pillion passengers. J Safety Res. 2014;51:93–98.

[42] Romero DL, Martins De Barros D, Okawa Belizario G, et al. Personality traits and risky behavior among motorcyclists: An exploratory study. PLoS One. 2019;

[43] Joewono TB, Vandebona U, Susilo YO. Behavioural Causes and Categories of Traffic Violations by Motorcyclists in Indonesian Urban Roads. Journal of Transportation Safety & Security. 2015;7:174–197.

[44] Zahid M, Chen Y, Jamal A, et al. Adopting Machine Learning and Spatial Analysis Techniques for Driver Risk Assessment: Insights from a Case Study. International Journal of Environmental Research and Public Health 2020, Vol 17, Page 5193 [Internet]. 2020 [cited 2023 Jun 15];17:5193. Available from: https://www.mdpi.com/1660-4601/17/14/5193/htm.

[45] Ghaemi S, Khanmohammadi S, Tinati MA, et al. Creating a Fuzzy Model for Stressful Driver's Behavior. International Journal of Computer Theory and Engineering. 2012;4:278–282.

[46] Fouladinejad N, Fouladinejad N, J. Mohd T, et al. Towards Realism in an Intelligent Car's Driving Behavior Using Fuzz Inference System. International Journal of Computer Theory and Engineering. 2015;7:187–190.