International Journal of Data and Network Science 7 (2023) 821–826

Contents lists available at GrowingScience

International Journal of Data and Network Science

homepage: www.GrowingScience.com/ijds

Severe accidents on Peruvian national and regional roads

Franklin Adolfo Lazo Castro[a*], Richard Torres Vicente[a], Anthony Bernard Lucero Lujan[a] and Arturo Daniel Del Pozo Castro[a]

[a]*Universidad Continental, Peru*

C H R O N I C L E

Article history:
Received: October 20, 2022
Received in revised format: October 28, 2022
Accepted: January 24, 2023
Available online: January 24, 2023

Keywords:
Accidents
Roads
National roads
Regional roads

A B S T R A C T

Peru is a country with a complex geography. Moreover, it lacks minimal safe roads, higher in Andean and jungle territories. Depending on the classification they might receive, the number of kilometers without pavement can reach up to 80%. Such a rate is alarming, considering that internationally the United Nations promotes actions for road security since road accidents are among the most common causes of death causes in the world. Then, employing data from Sutran, the current research has analyzed how the severity of accidents can affect road administration in Peru roads in 2021. Hence, the multinomial logistic regression was employed due to the nature of the data. It was found that regional routes had a higher risk than national roads when estimating the probability of having many dead and injured people because of a road accident.

1. Introduction

One global challenge that must be handled seriously is traffic safety. According to World Health Organization (2018), car accidents are one of the foremost leading causes of death causes for people from 15 to 29 years old. Moreover, it became the fifth death cause worldwide. It is stated that the primary causes of traffic accidents include people, cars, roads, the environment, and interactions between these variables (Pembuain et al., 2019). Therefore, all user safety concerns should be considered during road design and construction to reduce the likelihood of traffic accidents.

Some variables contributing to traffic accidents include excessively narrow or non-compliant roadways, sharp curves, steep downhill and uphill grades, surface degradation to the pavement, and unlit roads (Ahmed, 2013). Ironically, the road infrastructure that is supposed to ensure the users' safety and comfort is the reason for accidents (Cuenca et al., 2018). Consequently, a thorough study should be done to reduce traffic accidents caused by road infrastructure and to understand the effects of each element that forms road infrastructure on traffic accidents (Jirovský, 2015)

It is necessary to understand that the road network design impacts crash risk because it affects how drivers view their surroundings (Ahmed, 2013). Then, the road guides drivers on what they should be doing. For instance, a road flaw that causes a collision directly is one example of a nasty road engineering factor (Cuenca et al., 2018). Another is when a road user is misled by a road environment feature, leading to human error (Pembuain et al., 2019). The Haddon Matrix is a framework for connecting the sequence of events in a traffic incident to the categories of crash-contributing elements (Williams, 1999). This matrix identifies three distinct types of characteristics that affect traffic accidents: human factors, vehicle factors, and road/environment factors. Road factors are compounded by road elements and the wayside (Williams, 1999). A study in the United States claimed that 3 percent of road crashes are solely attributable to roadway factors, whereas 34 percent of road crashes are

* Corresponding author.
E-mail address: 75994822@continental.edu.pe (F. A. Lazo Castro)

ISSN 2561-8156 (Online) - ISSN 2561-8148 (Print)

doi: 10.5267/j.ijdns.2023.1.007

caused by a combination of roadway factors and other variables (American Association of State Highway and Transportation, 2011). Another research revealed that 17% of all expressway impacts in the Republic of Korea were caused by environmental and road-related variables (Ahmed & Vveinhardt, 2018)

Therefore, the United Nations has arranged a global effort through its Global Plan for the Decade of Action for Road Safety 2011-2020 (World Health Organization, 2013). The organization emphasized the requirement to improve the inherent security and safety of road networks for the benefit of all users of the roads (Rassokha et al., 2021). It can be accomplished by taking steps such as more cautious road planning, design, construction, and operation to identify dangerous road locations or sections where excessive numbers or severity of crashes occur and take corrective action as necessary. Also, it is encouraged to develop new infrastructure that satisfies mobility and access needs with safety standards (World Health Organization, 2013). By completing and disseminating studies on the commercial case for safer road infrastructure, one of the pillar activities also stresses research and development in safer roads and mobility (World Health Organization, 2013).

Peru has seen an increase in traffic accidents (Superintendencia de Transporte Terrestre de Personas, 2021). Here, the number of automobiles rises by 10% per year, and it seems that there is no solution for the accidents tool (Posada, 2018). Additionally, in the following decades, this tendency appears to double or even treble (Dirección de Seguridad Vial, 2021). It indicates a substantial need for the country's road system, which has an offer-to-demand imbalance of more than 72 billion dollars (Bonifaz et al., 2020). Therefore, it makes sense that overused roadways would become hazardous for both automobiles and pedestrians (Jirovský, 2015). To determine the potential influence of the inadequate Peruvian road systems on automobile accidents in a country with only 1300 kilometers of motorways, 20 000 kilometers of two-way roads, and more than 140 000 kilometers of unpaved roads, it is essential (Bonifaz et al., 2020).

The Peruvian bureaucracy classifies the Peruvian roads into three: the national road system, the regional system, and the local (Superintendencia de Transporte Terrestre de Personas, 2022). Data availability on car accidents is focused on national and regional road systems. Hence, those road systems were taken into consideration. It is essential to mention that the national road system has about 80% of its kilometers pavemented. However, the regional road system has only 16% of its kilometers pavemented (Superintendencia de Transporte Terrestre de Personas, 2021). Therefore, is there any link between the road system on car accidents? This study aims to answer that question.

Consequently, this study employed secondary sources like relevant academic literature and official databases to analyze the possible relationship between road classification and accidents in Peru. Moreover, this study intends to know the odds of having an accident on those roads.

2. Literature review

Pembuain et al. (2019) stated that the prevention of road accidents starts with planning, designing, constructing, and improving the road infrastructure. Moreover, they noted that the government was obliged to ensure road security. Sun et al. (2021) examined how the different types of roads in a northern Chinese region affected traffic accidents. The study was able to comprehend the link between the different types of roads in this Chinese province and the number of traffic accidents by using the road traffic accident dataset for the Guizhou Province from 2009 to 2018. The following are the categories of roads used in this study: administrative roads, functional roads, public urban roads, and urban expressways. According to the report, the province's administrative roadways were the riskiest. The geographic features of this region of China may have contributed to this discovery. Tsubota et al. (2018) aimed to establish the relationship between road pavement and road accidents. This study points out the importance of good road maintenance, established as a risk factor in the analysis. The pavement condition was classified according to their age. Here, the period of construction or its total repair was counted. The Poisson regression model was employed to analyze the collected data. After the analysis, a positive relationship between pavement age and accident risk and the differences in risks according to road condition was found. Shiomi et al. (2017)investigated the link between geometric road characteristics and the likelihood of an accident. This study concentrated on urban settings where crosswalk length and setback distance affect automobile accidents. This study discovered a link between these traits and the likelihood of a car collision.

The studies above showed that road design was related to the occurrence of accidents. From all the literature reviewed, the current research will focus on the investigation of Sun et al. (2021) since it aims to establish the possible association between the political classification of roads and road accidents.

3. Methodology

The current research had as its primary data source Sutran's database. This database had information about the occurrence of accidents and road classification. As stated before, the Peruvian road security authority -i.e., Sutran- classifies the national roads into national, regional, and local. The accident classifications were classified according to the effects they had on people. Then, it was classified as accidents that left wounded people and accidents that occasioned death—the database dating from 2021. Hence, the classification was according to the seriousness of the accident. It started from 0 to 4 as follows: 0 for accidents that did not have any wounded or dead people, 1 for accidents that affected people in the first quantile, 2 for accidents that were in the second quantile, 3 for accidents that left affected people in the third quartile and 4 for accidents that left involved people in the fourth quantile. Since the data were categorical, it was necessary the employment of the Multilogic model and the usage of the Stata package.

3.1 Multiple logic regression

An extension of binary logistic regression is multiple logistic regression. Its primary distinction is that it permits the dependent variable to have more than two categories (Schafer, 2006). The probabilities of categorical membership are assessed by this regression, similar to binary logistic regression (Starkweather & Kay, 2002). Although the normal distribution, linearity, and homoscedasticity assumptions are not required for this regression, verifying the variables' independence is still essential (Schafer, 2006). In other words, it forbids any connection between membership decisions made for one category and those made for another. There are methods for assessing this condition. One approach is using the Hausman method; however, alternate tests like the Small-Hsiao or McFadden test may also be used (Vijverberg, 2021).

Furthermore, a sizable sample is necessary for this form of regression. Therefore, a critical sample size is required to provide reliable results. The logistic regression leads to multiple logistic regression (El-Habil, 2012). As a result, the model is $Logit[P(Y=1)] = \alpha + \beta_1 x_1 + \cdots + \beta_k x_k$ whether we let *K* designate certain predictors for a binary outcome, *Y*, by *x1, x2,…,xk*,. If we give a value for π (x), then: $\pi(x) = \frac{\exp(\alpha+\beta_1 x_1+\cdots+\beta_k x_k}{1+\exp(\alpha+\beta_1 x_1+\cdots+\beta_k x_k}$

In this case, β_i shows the impact x_i on the logs of Y=1 and at the same time managing other x_j. Similarly, exp (β_i) arises as the multiplicative effect of a unit increase in x_i while controlling other x_j. If the study has n observations with p-regressors and multiple categories in the qualitative response, adding one logit into a base level is mandatory, while the other needs to be created around it (Schafer, 2006). Add that to the model; any category can be taken as the base level. Hence, for theoretical motivations, the k category will represent the base level (El-Habil, 2012). Furthermore, π_j is the observation odd in the j^{th} category. To find a relationship between this odd and a set of explanatory variables x_1, x_2 ..., the multiple logistic regression will be: $\log\left[\frac{\pi_j(x_i)}{\pi_k(x_i)}\right] = \alpha_{0i} + \beta_{1j}x_{1i} + \cdots + \beta_{pj}x_{pi}$. If π is added to the unity, it reduces to: $\log\left(\pi_j(x_i)\right) = \frac{\exp(\alpha_{01}+\beta_{1j}x_{1i}+\cdots+\beta_{pj}x_{pi})}{1+\sum_{j=1}^{k-1}\exp(\alpha_{01}+\beta_{1j}x_{1i}+\cdots+\beta_{pj}x_{pi})}$

Consequently, for j =1, 2, …, (k-1), the multiple logistic regression obtains the required results.

4. Results

Table 1
Number of cases between road administration and injured quantiles

	Road		
Injured	1	2	**Total**
1	1258 44.28%	59 51.30%	1317 44.55%
2	771 27.14%	28 24.35%	799 27.03%
3	382 13.45%	7 6.09%	389 13.16%
4	430 15.14%	21 18.26%	451 15.26%
Total	2841 100%	115 100%	2956 100%

Table 2
Number of cases between road administration and deaths quantiles

	ROAD		
DEADS	1	2	Total
1	2544 89.55%	98 85.22%	2642 89.38%
4	297 10.45%	17 14.78%	314 10.62%
Total	2841 100%	115 100%	2956 100%

Table 3
Accident probabilities with deaths by road administration

Road administration	Margin	Standard Error	z	P>z	95% confidence interval	
1	0.10	0.00	18.21	0.00***	0.09	0.11
2	0.15	0.03	4.47	0.04**	0.08	0.21

*** significant at 1%, ** significant at 5%

Table 4
Accident probabilities with injured people by road administration (quantile 2)

Road administration	Margin	Standard Error	z	P>z	95% confidence interval	
1	0.27	0.00***	32.53	0.00***	0.26	0.29
2	0.24	0.04**	6.08	0.04**	0.17	0.32

*** significant at 1%, ** significant at 5%

Table 5
Accident probabilities with injured people by road administration (quantile 2)

Road administration	Margin	Standard Error	z	P>z	95% confidence interval	
1	0.13	0.01	21.01	0.00***	0.12	0.15
2	0.06	0.02	2.73	0.01**	0.02	0.10

*** significant at 1%, ** significant at 5%

Table 6
Accident probabilities with injured people by road administration (quantile 4)

Road administration	Margin	Standard Error	z	P>z	95% confidence interval	
1	0.15	0.01	22.51	0.00***	0.14	0.16
2	0.18	0.04	5.07	0.00***	0.11	0.25

*** significant at 1%

Table 1 shows the number of cases registered of accidents and injured people because of them. The column called roads was classified between national and regional roads assigning them the number 1 and respectively. In the case of wounded people that these accidents occasioned, that column was classified in quartiles. Therefore, it is seen that most accidents caused injured people inside the quartile one in both road types. Analogously, quartile three was the one that had the least quantity of accidents. It is essential to clarify that the data shown in Tables 1 and 2 follow Sutran's database and were classified jointly. That is the reason there are no quantile two and quantile 3 in the deaths caused by accidents in Table 2. Table 2 shows that both road types had the majority of generated deaths by accidents in quartile one.

Table 3 shows the accident odds with deaths by road administration. In that table it is seen that in regional road type, there is an increasing risk of 15% percentage points of having an accident with subsequent death. Surprisingly Table 4 shows that national roads had a higher probability of having a car accident with few injured people than regional roads. The trend is the same for Table 5 since it found that it was more probable to have an accident with injured people on national streets than in regional ones. It is necessary to mention that both results focus on the number of injured between quartile two and quartile three because of car accidents. However, the situation changes for the wounded of quartile fourth, which hosts the highest cases of injured people, because it is shown that it is riskier to have this kind of accident on regional roads than on a national one.

5. Discussion

The current analysis classified the severity of accidents by the number of people affected. Hence, the quartiles were employed to organize them. Recent research found that the most severely injured and deadly accidents are riskier on regional roads than on national ones. Moreover, accidents that leave wounded people on average are more probable on national roads than on regional one. It might have a relationship with the roads' security, as Pembuain et al. (2019) claimed. Similarly, the current research results match the findings of Sun et al. (2021) in China since they concluded that provincial or regional roads were the riskiest.

As stated before, more than 80% of kilometers of regional roads are not pavemented, which might cause such severity when accidents happen. Then, it matches the findings of Shiomi et al. (2017) and Tsubota et al. (2018) since they mentioned that specific road characteristics seem to increase the likelihood of accidents. Here, it is mandatory to note that all the analyzed regional roads were placed in the Andean and Jungle areas. These areas are by themself difficult because of their geographic conditions, but the risk is higher due to the lack of safe roads to connect their people.

6. Conclusion

The lack of safe roads makes road connectivity in Peru more difficult. This country has outstanding scenery due to its privileged localization in South America. However, it also made its geography difficult due to the high quantity of mountains, rivers, and canyons, among other features that causes heterogenous altitudinal zonation in the country. Those factors, added to the lack of infrastructure in this country, added risks of having deadly and severe road accidents, especially on regional roads. A similar situation is the Chinese case analyzed by Sun et al. (2021) since China is also a country with many geographical accidents, making road connectivity harder. It was then somewhat expected that similar results would be found. Consequently, it might be plausible for Peruvian authorities to follow the Chinese policies to reduce such risk on their roads. Although it was not found in the literature, a remarkable case of managing the hazardous geography to construct safe roads is Ecuador and Colombia, Peruvian neighbors.

The execution of projects to improve the secure road connectivity of the country must be prioritized since it can represent the difference between staying alive or dying when a road accident happens. Of course, vital education is vital to educate drivers about safe driving. However, as claimed, it is not enough (Ahmed, 2013). Consequently, all governmental efforts should be put into improving the road quality of this beautiful but dangerous country.

References

Ahmed, I. (2013). Road infrastructure and road safety. *Transport and Communications Bulletin for Asia and the Pacific*, *83*, 19–25. https://www.unescap.org/sites/default/files/bulletin83_Article-3.pdf
Ahmed, R. R., & Vveinhardt, J. (2018). Estimating causal relationship between world gold prices and KSE 100 index: Evidence from Johansen cointegration technique. *Acta Oeconomica*, *68*(1), 51–77. https://doi.org/10.1556/032.2018.68.1.3
American Association of State Highway and Transportation. (2011). *Roadside Design Guide* (Fifth). U.S. Department of Trasnportation Federal Highway Administration.
Bonifaz, J. L., Urrunaga, R., Aguirre, J., & Quequezana, P. (2020). Brecha de infraestructura en el Perú: Estimación de la brecha de infraestructura de largo plazo 2019-2038. In *Brecha de infraestructura en el Perú: Estimación de la brecha de infraestructura de largo plazo 2019-2038* (First). Banco Interamericano de Desarrollo. https://doi.org/10.18235/0002641
Cuenca, L. G., Puertas, E., Aliane, N., & Andres, J. F. (2018). Traffic Accidents Classification and Injury Severity Prediction. *2018 3rd IEEE International Conference on Intelligent Transportation Engineering, ICITE 2018*, *September*, 52–57. https://doi.org/10.1109/ICITE.2018.8492545
Dirección de Seguridad Vial. (2021). *Boletín Estadístico de Siniestralidad Vial: I-Semestre, 2021*. https://www.onsv.gob.pe/boletin-estadistico-de-siniestralidad-vial-primer-semestre-2021/
El-Habil, A. M. (2012). An application on multinomial logistic regression model. *Pakistan Journal of Statistics and Operation Research*, *8*(2), 271–291. https://doi.org/10.18187/pjsor.v8i2.234
Jirovský, V. (2015). Classification Of Road Accidents From The Perspective Of Vehicle Safety Systems. *Journal of Middle European Construction and Design of Cars*, *13*(2), 1–9. https://doi.org/10.1515/mecdc-2015-0005
Pembuain, A., Priyanto, S., & Suparma, L. (2019). The Effect of Road Infrastructure on Traffic Accidents. *Advances in Engineering Research*, *186*(Apte 2018), 147–153. https://doi.org/10.2991/apte-18.2019.27
Posada, C. (2018). Aumento Continuo Del Parque Automotor, Un Problema Que Urge Solucionar. In *La Cámara* (Vol. 44). https://www.camaralima.org.pe/repositorioaps/0/0/par/r816_3/comercio exterior.pdf
Rassokha, V., Nikitin, N., & Savina, Y. (2021). Determination of the types of road accidents at roundabouts. *MATEC Web of Conferences*, *341*, 00059. https://doi.org/10.1051/matecconf/202134100059
Schafer, J. (2006). Multinomial Logistic Regression Models. In *STAT 544-Lecture 19*. http://web.pdx.edu/~newsomj/cdaclass/ho_multinomial.pdf
Shiomi, Y., Watanabe, K., Nakamura, H., & Akahane, H. (2017). Assessing Safety of Signalized Intersections: Influence of Geometric Attributes and Regionality on Traffic Accident Risk. *Transportation Research Record*, *2659*(1), 71–79. https://doi.org/10.3141/2659-08
Starkweather, J., & Kay, A. (2002). Multinomial logistic regression. *Nursing Research*, *51*(6), 404–410. https://doi.org/10.1097/00006199-200211000-00009
Sun, T. J., Liu, S. J., Xie, F. K., Huang, X. F., Tao, J. X., Lu, Y. L., Zhang, T. X., & Yu, A. Y. (2021). Influence of road types on road traffic accidents in northern Guizhou Province, China. *Chinese Journal of Traumatology - English Edition*, *24*(1), 34–38. https://doi.org/10.1016/j.cjtee.2020.11.002
Superintendencia de Transporte Terrestre de Personas. (2021). *Portal de Datos Abiertos*. https://www.datosabiertos.gob.pe/
Superintendencia de Transporte Terrestre de Personas. (2022). *Plan estratégico institucional 2020-2025 ampliado*. Superintendencia de Transporte Terrestre de Personas.
Tsubota, T., Fernando, C., Yoshii, T., & Shirayanagi, H. (2018). Effect of Road Pavement Types and Ages on Traffic Accident Risks. *Transportation Research Procedia*, *34*, 211–218. https://doi.org/https://doi.org/10.1016/j.trpro.2018.11.034
Vijverberg, W. (2021). Testing for IIA with the Hausman-Mcfadden Test. In *SSRN Electronic Journal* (Issue 5826). https://doi.org/10.2139/ssrn.1882845
Williams, A. (1999). The Haddon Matrix: Its Contribution to Injury Prevention and Control. In *3rd National Conference on Injury Prevention and Control* (pp. 15–16).
World Health Organization. (2013). *Supporting a decade of action* (First). World Health Organization. http://www.who.int/about/licensing/copyright_form/en/index.html
World Health Organization. (2018). Global Status Report on Road. In *World Health Organization*. http://apps.who.int/bookorders.