Income Inequality and Road Transport Accidents in Nigeria

Ahmed T. Yakubu, [†] Folorunsho M. Ajide, [‡] & Idris A. Abdulrahman[*]

Abstract
In this paper, we examine the impact of income inequality proxied by Gini coefficient on road accident in Nigeria. Data for period of 1986-2019 are obtained from various sources including World Development Indicators (WDI), International Country Risk Guide (ICRG), Federal Road Safety Corps (FRSC), and World income inequality database (WIID). The study employs autoregressive distributed lag (ARDL) model estimating technique to analyse the data. The results suggest that income inequality has a positive impact on road crashes in the long run and short-run analyses. The paper adds value to the empirics by analyzing the impact of income disparities on road accidents in a developing nation within an ARDL framework. It suggests that uneven distribution of income may have positive relationship with the level vehicle collision. Importantly, higher level of income inequality may create uneven distribution of vehicle ownership, leading to heterogeneous road users. Due to higher level of income disparities, some road users may prefer motorcycles and bicycles while others could be classified as vulnerable group of pedestrians who compete with vehicle road users. Consequently, this contributes to the higher rate of road accident per vehicle on land transport system in Nigeria.

Keywords: Income Disparity; Road Crashes; Road Transport; Corruption
JEL Classification Codes: E25, R4,

[†] Corresponding author, Department of Economics, University of Ilorin, Ilorin, Nigeria, Email: taruwere@gmail.com
[‡] Department of Economics, University of Ilorin, Ilorin, Nigeria, Email: ajide2010@gmail.com
[*] Department of Economics, University of Ilorin, Ilorin, Nigeria,Email: agrahman2006@yahoo.com

1. Introduction

According to the World Health Organization (2018) reports, Africa is ranked among the most affected regions by road accident crashes; accounting for road related death of 26.6 per 100,000 population globally. This situation has attracted many researchers to investigate the likely reasons for higher road accident rate in the region ranging from crime related issues (Wright & Ribbens, 2016; Ajide, 2020) to stages of development (Akinyemi, 2020; Yakubu & Muhammed, 2021). Surprisingly, to the best of our knowledge, no study has considered how income inequality may affect road accident rate in Africa, a region with a significant level of poverty and income disparities. Anbarci, Escaleras and Register (2009) theoretically conceptualize that regardless of the income level, income disparity among households may create externality and increase the level of heterogeneity in the distribution of vehicular ownership; leading to road fatal accidents in the economy. This issue has not been given more attention it deserves globally and in sub-Saharan Africa (SSA) specifically.

On this note, our study fills this lacuna found in the extant literature. The objective of our study is to investigate the impact of income inequality on road accident per vehicle in developing country (Nigeria). Nigeria provides an interesting study ground for the analysis bothering on the nexus between income inequality and road crashes in SSA. The country has more than 194,394km of road networks making one of the nations with a large road network in SSA. Majority of these roads were constructed when alternative land transport systems including trains were functioning effectively. However, in recent times, there have been a rise in vehicular ownership and urban settlements which do not match with road network development at the same rate (Federal Road Safety Corp, FRSC, 2009; 2010; Atubi, 2009). Given the level of ineffectiveness of the rail transport system, overdependence on road transport has increased over the years, given rise to higher number of road traffic accidents in the country (Ajide, 2020). According to Federal Road Safety Corp (2022), about 5,053 persons were lost to road accidents in 2016 while in 2018 about 5, 181 lives were lost in 2018. Between 2016 and 2021, a total of 65,053 accidents were documented in which 32,617 persons lost their lives to road crashes in Nigeria (FRSC, 2022).

Furthermore, the level of inequality in the country is alarming (Ajide, 2022). The World population review (2022) documents that the Gini coefficient of Nigeria stands at 35.1 on a scale of 100 points. In West Africa, the country is ranked 11th on the basis of income inequality and positioned at 100th among 163 nations in the World. This further justifies the lopsided distribution of income and wealth in the country. In this study, we conjure that income disparity may increase heterogeneously the manners of roadway entries, and raise the level of deadly interactions between vehicular operators and other vulnerable road uses including bicyclists, motorcyclists, pedestrians who compete with each other on the road; thereby resulting in road fatality rates in the country. We contribute to this budding literature by investigating the impact of income inequality proxied by Gini coefficients on road accidents in an African nation (Nigeria). Differences in road topographies, road users' regulations and economic conditions in many nations further provide support for a single country's analysis of this kind. Using ARDL estimation technique that accounts for endogeneity and possible dynamics among the variables, the study shows that income inequality positively influences road accidents in Nigerian transport industry.

The remainder of this study is organized as follows. Section 2 presents the methodology. Section 3 presents and discusses the estimated results. Section 4 concludes.

2. Materials and methods

2.1 Empirical model and estimating technique

Following the previous studies on the nexus between road accidents and its determinants (Law et al. 2006; Li et al. 2018; Wright & Ribbens, 2016; Dills & Mulholland, 2018; Ajide, 2020; Akinyemi, 2020),we specify the functional relations between road accident rate and income inequality as stated below:

$$RAPV = f(GINI, URBAN, LGDPPC, IF, CORP, LWPOP) \quad (1)$$

$$RAPV_t = \alpha + \beta_1 GINI_{2_t} + \beta_2 URBAN_t + \beta_3 LGDPPC_t + \beta_4 IF_t + \beta_5 CORP_t + \beta_6 LWPOP_t + \mu_t \quad (2)$$

Where α is the intercept, $and\ \beta_1,\ \beta_2,\ \beta_3, \ldots\ldots\ldots.., \beta_6$ are coefficients while $\mu_t = error\ term$. *RAPV* represents road accident per vehicle while *GINI* is the income inequality. It is the main variable of interest that proxy the level of income disparities in the economy. The control variables include *URBAN* which is the level of urbanization, *LGDPPC* is the proxy for economic development, *IF* is inflation rate, CORP is the corruption level while LWPOP is the proxy for working population.

The inclusion of these control variables are informed by the extant literature. For instance, the adults' working population are more dependent on road for their movements in Nigeria (Atubi, 2009; FRSC, 2009; 2010). This overdependence increases the rate of road fatal accidents. Previous studies also suggest that economic development influences road accident per vehicle in developing nations (Dills & Mulholland, 2018; Li et al. 2018, ,also see Cabrera-ArnauI and Bishop (2021) for the case of urbanization. Inflation rate also affects the purchasing power of the citizens (increases the cost of living) and may reduce their ability to acquire own vehicles, thereby putting pressure on the commercial motor vehicles in the economy (Elias et al. 2014; Akinyemi, 2020; Ajide, 2020). Corruption is a contributing factor to road accident. It puts the conditions of road transport system at risk. This occurs when the money appropriated for road maintenance is diverted to private purse for personal gains (Hua & Pei, 2010; Oleinik, 2016).

On econometric strategy, the study utilizes Autoregressive Distributed lag Model (ARDL) analytical technique. The technique does not require previous knowledge of the properties of the variables. This means that irrespective of the integrated order of the variables provided the order is below or equal to one, the technique is still applicable. A detailed specification of the ARDL with respect to the study variables is presented by transforming equation (2) to (3)

$$
\begin{aligned}
\Delta RAPV_t = \beta_0 &+ \sum_{i=1}^{k} \prod\nolimits_i \Delta RAPV_{t-i} \\
&+ \sum_{i=0}^{k} \gamma_i \Delta \mathrm{GINI}_{\mathrm{t-i}} + \sum_{\mathrm{i=0}}^{\mathrm{k}} \theta_{\mathrm{i}}\ \Delta URBAN_{t-i} + \sum_{i=0}^{k} \delta_i \Delta \mathrm{LGDPPC}_{\mathrm{t-i}} + \sum_{\mathrm{i=0}}^{\mathrm{k}} \partial_{\mathrm{i}}\ \Delta IF_{t-i} \\
&+ \sum_{i=0}^{k} \rho_i \Delta \mathrm{CORP}_{\mathrm{t-i}} + \sum_{\mathrm{i=0}}^{\mathrm{k}} \sigma_{\mathrm{i}}\ \Delta LWPOP_{t-i} + \beta_1 GINI_{t-1} + \beta_2 URBAN_{t-1} \\
&+ \beta_3 LGDPPC_{t-1} + \beta_4 IF_{t-1} + \beta_5 CORP_{t-1} \\
&+ \beta_6 LWPOP_{t-1} \quad e_t \qquad (3)
\end{aligned}
$$

Where Δ is first-difference operator and ***k*** is the optimal lag length, the estimation of the above equation would reveal the long run causality test by comparing the results from F-test of the Wald test with the critical values at 5% level of significance with unrestricted and no trend series. Furthermore, where there is long run co-integration, the long run equation is regressed and the error term included as an explanatory variable, this results in the Error Correction Model (ECM) as presented in equation (4)

$$
\begin{aligned}
\Delta RAPV_t = \sigma &+ \sum_{i=1}^{k} \prod\nolimits_i \Delta RAPV_{t-i} \\
&+ \sum_{i=0}^{k} \gamma_i \Delta \mathrm{GINI}_{\mathrm{t-i}} + \sum_{\mathrm{i=0}}^{\mathrm{k}} \theta_{\mathrm{i}}\ \Delta URBAN_{t-i} + \sum_{i=0}^{k} \delta_i \Delta \mathrm{LGDPPC}_{\mathrm{t-i}} + \sum_{\mathrm{i=0}}^{\mathrm{k}} \partial_{\mathrm{i}}\ \Delta IF_{t-i} \\
&+ \sum_{i=0}^{k} \rho_i \Delta \mathrm{CORP}_{\mathrm{t-i}} + \sum_{\mathrm{i=0}}^{\mathrm{k}} \sigma_{\mathrm{i}}\ \Delta LWPOP_{t-i} \\
&+ \beta_0 ECM_{t-1} \qquad (4)
\end{aligned}
$$

The ARDL technique uses *F-statistic* to test for the existence of co-integration which involves the use of asymptotic critical value bounds; and depend whether the variables are I(0) or I(1) or a mixture of both. Critical values for the I(1) series are referred to as *upper* bound critical values, while the critical values for I(0) series are referred to as the *lower* bound critical values. If the *F* test statistic exceeds their respective upper critical values, the study would conclude that there is evidence of a long-run relationship between the variables regardless of the order of integration of the variables.

2.2 Data sources, measurement and variables' descriptions

The study employs time series data covering the period of 1986-2019. This scope is based on data availability. Table 1 provides the measurements and sources of data. The data are obtained from various sources including Federal Road Safety Corps /National Bureau of Statistics, World development indicators and so on as explained in the table.

Table 1: Data sources and measurement

Variables' names	Measurements	Sources of data
Road accident per vehicle (*RAPV*)*	The number of road accident per number of registered vehicles.	Federal Road Safety Corps (FRSC)/National Bureau of Statistics (NBS)
Income inequality (*GINI*)	Gini coefficients. It is a measure of income distributions among the citizens in a country.	World income inequality database (WIID)-UNU-WIDER
Urbanization (URBAN)	Urban population as a percentage of total population.	World Development Indicators
Economic development (LGDPPC)*	Gross domestic product per capita at constant price.	World Development Indicators
Inflation rate (IF)	Inflation, annual percentage change in consumer price index	World Development Indicators
Corruption level (CORP)	Corruption level, an ordinary scale ranged between 0 (highly corrupt) and 6 (less or no corrupt).	International Country Risk Guide
Active working adult population* (LWPOP)	Number of employed/working population.	World Development Indicators

Source: own compilation, * the natural logarithm used to minimize the effect of outliers in the estimated results.

In Table 2 and 3, we present the descriptive statistics and correlation of the variables. The average value of the variables fall within the maximum and minimum value. The road accident per vehicle is 32. 339 on average while the income inequality is 45.721. The correlation between road accident and income inequality is positive, implying that income inequality increases road fatality rate in Nigeria. However, the potential impacts can best explain using the regression analysis as documented in the next section.

Table 2: Descriptive statistics of the variables

	RAPV	GINI	URBAN	LGDPPC	IF	CORP	LWPOP
Mean	32.339	45.721	4.630	1295.366	19.933	1.583	70662688
Median	11.504	44.700	4.590	760.170	12.938	1.500	70745355
Maximum	81.077	52.900	5.596	3200.953	72.850	2.000	98882303
Minimum	6.201	35.130	4.053	270.027	5.380	1.000	4939205.0
Std. Dev.	29.721	5.882	0.476	927.110	17.998	0.360	20549077
Skewness	0.531	0.035	0.663	0.556	1.637	-0.227	-0.751
Kurtosis	1.494	1.495	2.623	1.794	4.354	1.958	4.164
Observations	34	34	34	34	34	34	34

Source: own compilation

Table 3: Pairwise correlation

	RAPV	GINI	URBAN	LGDPPC	IF	CORP	LWPOP
RAPV	1.000						
GINI	0.189	1.000					
URBAN	-0.108	-0.608	1.000				
LGDPPC	-0.845	-0.443	0.132	1.000			
IF	0.590	0.203	-0.126	-0.536	1.000		
CORP	0.738	-0.309	0.079	-0.369	0.510	1.000	
LWPOP	-0.547	0.110	-0.351	0.549	-0.440	-0.424	1.000

Source: own compilation

3. Results and discussion

Before testing for long run relationship among the variables, it is important to examine the unit root of the variables in order to ensure that none of the variables is more than integration of order one, *I(1)*. Table 4 shows the results of the unit root test of the variables. The study employs Augmented Dickey-Fuller (ADF) test and further confirms the results using Phillip-Perron (PP). The two tests show that IF and LWPOP are stationary at level while other variables are stationary at first difference.

Table 4: Unit root tests

Variables	ADF-statistic		PP-statistic		Remarks
	Level	First Diff	Level	First Diff.	
RAPV	-0.869	-9.444***	-0.877	-8.327***	I(1)
GINI	-1.592	-4.860***	-1.645	-4.860***	I(1)
URBAN	-2.353	-5.255***	-2.352	-5.254***	I(1)
LGDPPC	-0.321	-4.578***	-0.321	-4.561***	I(1)
IF	-4.692***		-2.836*		I(0)
CORP	-2.130	-3.281***	-1.631	-3.164***	I(1)
LWPOP	-3.687***		-3.661***		I(0)

Source: own compilation

Table 5: ARDL Bounds Test

Null Hypothesis: No long-run relationships exist		
Test Statistic	Value	K
F-statistic	14.362***	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Source: Own analysis, Selected Model: ARDL (1, 1, 2, 2, 0, 1, 2)
***,**, * denote significant at 1%, 5% and 10% respectively.

To ascertain the long run equilibrium among the variables, the study applies bound test approach to cointegration as reported in Table 5. It shows that the variables have a long-run relationship. The F-statistic value is 14.362 which is more than the upper bound at 10% and 5% level of significance. Hence, the study rejects the null hypothesis of no co-integration. This implies that there is a long run relationship among the variables. On this note, we proceed to estimate the model using ARDL estimation technique.

Table 6: Estimated results based on ARDL⁺ , dependent variable: RAPV

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Short Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GINI)	0.022***	0.007	2.923	0.010
D(URBAN)	1.908**	0.772	2.470	0.025
D(URBAN(-1))	-0.922*	0.517	-1.782	0.093
D(LGDPPC)	0.049	0.378	0.130	0.897
D(LGDPPC(-1))	0.333	0.326	1.019	0.322
D(IF)	0.004*	0.002	1.781	0.093
D(CORP)	-0.445**	0.204	-2.181	0.044
D(LWPOP)	-0.238	0.153	-1.552	0.140
D(LWPOP(-1))	0.876***	0.232	3.765	0.001
CointEq(-1)	-0.657***	0.083	-7.884	0.000
Long Run Coefficients				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
GINI	0.055***	0.015	3.516	0.002
URBAN	0.753	0.873	0.862	0.400
LGDPPC	-0.473	0.379	-1.248	0.229
IF	0.006*	0.003	1.767	0.096
CORP	1.502***	0.219	6.857	0.000
LWPOP	-2.511***	0.638	-3.936	0.001
Constant	17.652***	5.019	3.516	0.002

Source: own analysis. ***,**, * denote significant at 1%, 5% and 10% respectively.
⁺Selected model: ARDL (1, 1, 2, 2, 0, 1, 2)

Table 6 presents the short-run and long-run analysis for the impact of income inequality on road accident in Nigeria. The coefficient of error correction is negative and significant, and prove that there is truly a long run adjustment rate in the model at 65.7%. The long run and short run coefficients of income inequality have positive and significant impact on road accident rate in Nigeria. In the short run, a 1- point increase in income disparities increase road accident by 2.2 percent while in the long run analysis, a 1-percentage increase in income disparities increase by 5.5 percent. This means that income inequality increases road accident per vehicle in Nigeria. This result is consistent with study of Yakubu and Muhammed (2021) who confirm that economic conditions proxied by unemployment rate may contribute to the incidence of road accident. Roshanfekr et al. (2020) suggest that unequal distributions of income among the households restrict access to good road networks because more citizens would be living in poor geographical locations. Income disparity may increase the crime rate in an economy which may further contribute to road crashes as confirmed by Ajide (2020). To make up for income differences, criminals may engage in robbery and attacks in interstate or intercity which may contribute to road transport accidents. This is because income disparities among households lead to mental stress and worsening the driving behavior such as lack of attention, aggression and risk-taking in a bid to make up for income short falls. This contributes to the incidence of road accidents. Income disparities among the iron benders, tailor and technicians lead to emergency road transport drivers among the artisans who are not professional drivers. This further fuels road traffic fatalities in the country.

On the control variables, the coefficients of urbanization, inflation, corruption and working adult population are significant. Corruption control is positive and significant in the long run, implying that absence of corruption or an effective mechanism of corruption control may serve as a good tool for reducing road transport accident. However, the short-run analysis reveals that higher level of corruption in Nigeria contributes to road accidents in Nigeria. This is consistent to the study of Hua and Pei (2010) that confirms that corruption compromises the institutional quality and enforcement framework of laws and order, thereby increasing the number of road accidents in an economy. In the case of selective and unjust application of the road offences and penalties, it encourages motorists to drive abnormally on roads with the hope of getting preferential treatments by offering bribe to the traffic officers on the road (Oleinik, 2016). The coefficient of inflation is positive and significant at 10% showing that inflation contributes to road accidents in Nigeria due to the harshness brought to citizens, in terms of increasing the cost of living in the short-run and long run. Also, the short-run results show that working adults are more expose to road accident, confirming the results of Ajide (2020). This is due to their overdependence on road for economic transactions as explored by Atubi, (2009). Meanwhile, in the long run, since the working adults are used to the road system of transportation, they are being careful in the process of using the road not to be a victim of accident. Therefore, their previous experiences avail them to be a good road users which further reduces the incidence of road accident rate. The coefficient of urbanization is negative and significant in the short-run. Urbanization rate reduces the incidence of road accident because most urban cities have good road network. This minimizes the issue of road accident per vehicle.

Table 7: Diagnostic indicators

Indicators	**Statistics**
R-squared	0.993
R-squared (adjusted)	0.988
F-statistic	172.321
Prob (F-statistic)	(0.000)
Jarque-Bera(Normality test)	1.326
Prob. (Jarque-Bera)	0.515
Heteroskedasticity test: Breusch-Pagan-Godfrey ((Obs*R-squared)	11.154
Prob. chi-square	(0.741)
Breusch-Godfrey serial correlation LM test (Obs*R-squared)	1.415
Prob. chi-square	0.275
CUSUM	Stable
CUSUM of Squares	Stable

Source: own computation

Table 7: Diagnostic indicators

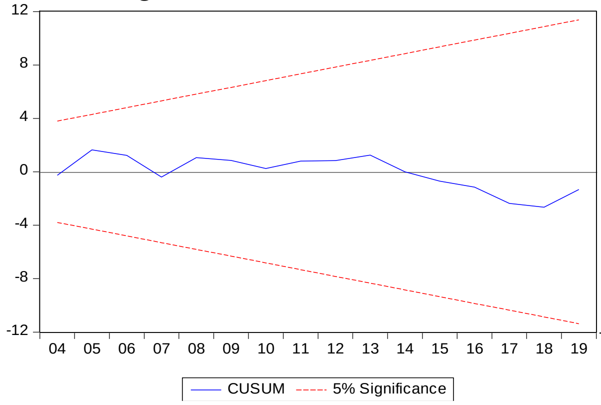

Figure 1: CUSUM

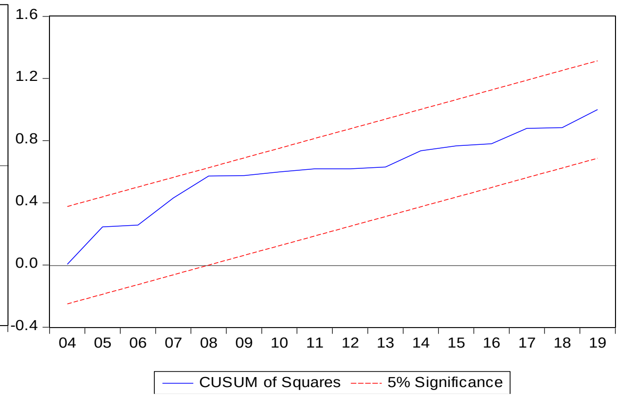

Figure 2: CUSUM-Square

Source: own compilation

In Table 7, we present the diagnostic analysis of the estimated ARDL model so as to ascertain the suitability and reliability of results. The R-square shows that the model explains the larger percentage of factors leading to road accident in Nigeria while F-statistic reveals the overall significance of the model at 1% level. The heteroskedasticity test, normality test and serial correlation test confirm the validity and suitability of the results because their probability values are significant. The cumulative sum (CUSUM) and that of cumulative sum of square (CUSUM square) reveal that the parameters are stable as the graphs are within limit boundaries as shown in Figures 1 and 2. Overall, the ARDL model is reliable.

4. Conclusion

Studies have unveiled many factors leading to higher rate of road accidents in developing nations. However, the nexus between income inequality and road accidents in the economy has not been given much attentions. On this note, this paper fills this lacuna found in the literature by examine the impact of income inequality on road accident per vehicle in Nigerian transport industry. The study utilizes Nigerian data spanning over a period of 1986-2019. Using autoregressive distributive lag model estimation technique to estimate the model, the results reveal that income inequality contributes to the road accident in Nigeria. We also discover, among others, that corruption worsening the case of road accidents because no good road is built for the masses due to diversion of huge amount of money meant for road construction to personal purses by the politicians and public officials.

There is urgent need to look into the road traffic accident issues and to have safety policies and plan so as to reduce the incidence of road crashes in the country. Policies should focus on addressing the institutional and socioeconomic structure that create income inequality. Economic inequality should be reduced by providing citizens' access to public goods. Public enlightenment on effective use of road transport should be organized. Income inequality can be controlled by reallocation of income through effective fiscal policies. Living-wage policies and strong minimum wage laws should be strengthened to address income inequality problems in Nigeria.

References

Ajide, F. M. (2020). Criminal activities and road accidents in Nigerian transport industry. *Transportation in developing economies*, *6*, 1-10.

Ajide, F. M. (2022). Entrepreneurial development in Africa: A boon to income equality. *Journal of Developmental Entrepreneurship, 27(4),* 2250029, 1-26.

Akinyemi, Y. (2020). Relationship between economic development and road traffic crashes and casualties: empirical evidence from Nigeria. *Transportation research procedia*, *48*, 218-232.

Anbarci, N., Escaleras, M., & Register, C. A. (2009). Traffic fatalities: does income inequality create an externality? *Canadian Journal of Economics / Revue canadienne d'Economique, 42(1),* 244-266.

Atubi, A. O. (2009). Modelling road traffic accidents in Lagos state, South Western Nigeria. *Journal of Society and State*, *1*(1), 57-74.

Dills AK, & Mulholland, S.E. (2018) Ride-sharing, fatal crashes, and crime. *South Econ J 84(4)*,965–991. https://doi.org/10.1002/ soej.12255

Elias, W., & Shiftan, Y. (2014). Analyzing and modeling risk exposure of pedestrian children to involvement in car crashes. *Accident Analysis & Prevention*, *62*, 397-405.

Federal Road Safety Corp (2010). *Report on road traffic crashes (RTC) involving buses on Nigerian roads (2007–2010).* FRSC publication, Abuja

Federal Road Safety Corp (2009) *Traffic digest, a transport digest publication of PRS department*. FRSC Publication, Abuja

Federal Road Safety Corp (2022). *Road traffic reports*. Abuja: FRSC Publication.

Ghiasvand, H., Roshanfekr, P., Ali, D., Ardakani, H. M., Stephens, A. N., & Armoon, B. (2020). Determinants of road traffic injuries in Iranian children; results from a National Representative Demographic-Health Survey 2010. *BMC pediatrics*, *20*(1), 1-7.

Law, R. (2006). The perceived impact of risks on travel decisions. *International Journal of Tourism Research*, *8*(4), 289-300.

Li, R., Pereira, F. C., & Ben-Akiva, M. E. (2018). Overview of traffic incident duration analysis and prediction. *European transport research review*, *10*(2), 1-13.

Hua, M., & Pei, J. (2010, March). Probabilistic path queries in road networks: traffic uncertainty aware path selection. In *Proceedings of the 13th International Conference on Extending Database Technology* (pp. 347-358).

Oleinik, A. (2016). Corruption on the road: A case study of Russian traffic police. *IATSS research*, *40*(1), 19-25.

World Population Review (2022). Wealth inequality by country. Retrieved on January 20, 2023, from https://worldpopulationreview.com/country-rankings/wealth-inequality-by-country

World Health Organization (2018). Road safety reports. Retrieved on January 18, 2023, from https://www.who.int/data/gho/data/themes/road-safety

Wright G, & Ribbens H (2016) Exploring the impact of crime on road safety in South Africa. Proceedings of the 35th Southern African Transport Conference, pp 436–455.

Yakubu, A. T., & Muhammed, I. A. (2021). Economic condition and road transport crashes in Nigeria: Evidence from state level data. *Ilorin Journal of Economic Policy*, *8*(2), 36-44.