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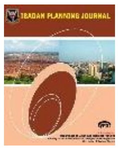

Auto-Vehicle Operation and Emission Assessment Tested under Ambient Conditions within Minna, Nigeria

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Abstract

Heightened levels of auto-vehicle emissions are deemed to be one of the significant contributors to environmental air pollution and health hazards for road users. The frequent use of various auto-vehicles for commuting purposes involving people and freight, especially within urban centres proliferates this concern. This study deployed secondary data obtained from the computerized vehicle inspection office in Minna, via the use of an exhaust gas testing device (F 5000 – 5 series) to examine idle emission data from the exhaust pipes of auto-vehicles. Emission data involving three main pollutants namely, carbon monoxide (CO), nitrous oxide (NO), and sulfur dioxide (SO_2) was collected from 385 vehicles inspected at the computerized vehicle inspection office in Minna. For reliability and credibility, purposive sampling involving valid vehicular records was used for data analysis. Empirical findings from the gas analyzer indicated that CO and NO were the major pollutants with significant isolated concentrations among auto-vehicles. Their peak values observed were 19 ppm and 0.24 ppm respectively, for mass transit buses and heavy-duty vehicles. Results from the Binary Logistic Model (BLM) indicated that the frequency of vehicle maintenance through regular oil change (X_1) as a predictor, was a significant factor in determining emission levels for tested auto-vehicles ($P < 0.05$). The likelihood ratio, Exp(B) for X_1 compared to other predictors was 2.904.

Keywords
Auto-vehicle, Emission, Frequency, Hazard, Analysis

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1. Introduction

Transportation systems significantly affect our environment because these systems majorly use and dissipate energy through the combustion of fuels. This creates air pollution in the form of nitrous oxides, carbon monoxide, and particulates, which are significant contributors to global warming. Within the transport sector, road transport is the largest contributor to global warming resulting from greenhouse gas emissions (GHGs) (USEPA, 2006).

Because energy use and emissions vary largely between transportation modes, environmentalists have often advocated for a transition from air and road-based transport to rail and human-powered transport, and also to increase transport electrification (use of electric vehicles) thus maximizing energy efficiency. However, the ubiquitous nature of road transport makes it indispensable due to its relative speed of travel, flexibility in operation, and ease of conveying light to medium luggage (Atta, 2018). Despite environmental and safety concerns in context, the demand for fossil fuels which powers the vast majority of these vehicles and constitutes a major pollutant hazard remains on the ascend with natural gas projected to be the second largest fuel source until the year 2035 (IEA, 2016).

Environmental regulations in developed countries have reduced individual vehicle emissions through technological advancements and quality checks ensuring that vehicles with lighter and improved combustion engines are deployed on roadways thereby eliminating the use of old and heavily polluting automobiles. However, this has been offset by an increase in the number of vehicles, and increased use of each vehicle.

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In developing nations like Nigeria, obsolete vehicles are still in use thus constituting energy and emission concerns within the environment. Rapid urbanization has resulted in the proliferation of private vehicle usage, and inter-city and intra-city commuting for various socio-economic purposes. While undesirable effects such as congestion, auto crashes, and parking difficulties are evident, air pollution resulting from auto-vehicle haulage constitutes a long-term detrimental effect on human health and the environment (Sati and Dare, 2022). By reducing transportation emissions globally, it is predicted that there will be significant positive effects on Earth's air quality, acid rain, smog, and climate change. (Oyetunji et al., 2023).

Minna, the capital city of Niger State, Nigeria, has over the years experienced a substantial level of rural-urban migration and population growth as a result of socio-economic activities thus increasing vehicle ownership. Private vehicle owners and commercial transport operators commute daily to facilitate work-based trips, leisure trips, and business trips. The major vehicle types in operation include motorcycles, tricycles, passenger cars, buses, and trucks. The study aims to provide a context to auto-vehicle emission concerns that have proliferated over time so that regulators and administrators can develop strategies and policies to mitigate or curb such a growing trend.

The study’s objective is centred on checking vehicular emission levels and possible factors contributing to increased auto-vehicle emission by determining the relationship existing among tested variables.

2. Literature Review

Transportation systems significantly affect our environment because these systems majorly use and dissipate energy through the combustion of fuels. This creates air pollution, including nitrous oxides and particulates, and is a significant contributor to global warming through the emission of carbon dioxide. Within the transport sector, road transport is the largest contributor to global warming through emissions.

2.1 Air Pollutants

Auto vehicles including cars, buses, and trucks produce significant pollution throughout their life cycle as a result of their operation leading to fuel combustion. The major pollutants from vehicles include the following:

i. *Nitrous Oxides (NO_x)*: These pollutants are responsible for the formation of ground-level ozone and particulate matter. They are harmful as primary pollutants and can result in long-term lung diseases and also weaken the body’s immune system against other respiratory infections such as influenza and pneumonia (Oyetunji et al., 2023).

ii. *Carbon monoxide (CO)*: The combustion of fossil fuels including gasoline from machine parts and engines of cars and trucks produces this toxic, colourless, and odourless gas. When inhaled, CO blocks the oxygen supply to the brain, heart, and other vital body organs (UCS, 2023).

iii. *Sulfur dioxide (SO_2)*: This pollutant is created when power plants and motor vehicles burn fuels containing sulfur, especially diesel and coal. When sulfuric compounds are released into the atmosphere, they form fine particles that clog the respiratory system in humans posing significant health risks to children and asthmatic people (Oyetunji et al., 2023).

iv. *Particulate matter (PM)*: Particulate matter from auto vehicles exists in the form of soot seen in vehicle exhaust pipes (Laskowski, 2018). They are tiny fine particles that pose a serious threat to human health when they penetrate deep into the lungs. They are either primary or secondary pollutants from hydrocarbons, nitrogen oxides, and sulfur dioxides. Diesel combustion engines are a major source of PM pollution.

v. *Volatile Organic Compounds (VOCs)*: VOCs are emitted from cars, trucks and buses. These toxic air pollutants include benzene, acetaldehyde, and 1,3-butadiene which are all linked to different types of cancer. Ground-level ozone (a main ingredient in smog) is formed when these pollutants react with nitrogen oxides in the presence of sunlight. Though beneficial in the upper atmosphere, at the ground level this gas irritates the respiratory system, causing coughing, choking, and reduced lung capacity (UCS, 2023).

vi. *Greenhouse Gases (GHGs):* Motor vehicles are a significant source of air pollution as they emit carbon dioxide, a major greenhouse gas that contributes to global climate change. Emissions from the exhaust pipes of cars, trucks, and buses account for more than 20% of the total global warming pollution in the United States. All modes of transportation, including airplanes, trains, and ships, contribute to around 30% of all heat-trapping gas emissions (UCS, 2023).

2.2 Hazards Associated with Air Pollution from Auto-vehicles

The implication of constant exposure to pollutants from auto vehicles can result in challenges that range from mild to complex health risks which can cause premature death (Ajayi et al., 2023). The impacts of climate change, driven by heat-trapping emissions, have been associated with poor health and the general well-being of those under such exposure. The frequent and intense heat waves caused by climate change are especially detrimental to people. Heat waves also produce adverse effects on the environment such as sea level rising, flooding, drought, and wildfires that can devastate local communities (USC, 2023).

Mega-cities with significant traffic densities are exposed to higher levels of air pollution as a result of mobility dynamics. This lowers the quality of life in such cities by making the air quality worse. With population increase affecting many urban communities, the proliferation of vehicles for mobility has become inevitable. This has led to sudden deaths in cities, especially within low- and middle-income countries, where children, women, and the elderly are most likely affected (WHO, 2017; Ayetor et al., 2021).

2.3 Emissions from Heavy-duty Automobiles

Heavy-duty vehicles including trucks and buses powered by diesel fuels play a significant role in mass transit operations involving, construction activities, hauling goods and raw materials from manufacturing sites to stores, picking up trash items for disposal, delivering packages, and transporting thousands of people around cities, every day. But these vehicles also greatly affect public health and global warming.

According to UCS (2023), although heavy-duty vehicles comprise only about 10 percent of all automobiles on the road, yet they generate more than 25 percent of global warming emissions, with 45 percent of NOx emissions, and nearly 60 percent of direct $PM_{2.5/10}$ emissions from on-road vehicles that come from the transportation sector. Communities adjacent to ports and border regions known as "freight-adjacent communities" bear the brunt of exposure to this dangerous air pollution. As these communities move more and more freight each year, the challenge of reducing emissions from this sector continues to grow.

Addressing heavy-duty vehicle pollution is critical for improving air quality and reducing heat-trapping emissions in communities nationwide. Today, zero-emission heavy-duty vehicles are available for nearly every application. The market for these trucks is beginning to accelerate, but not nearly at the pace needed to adequately affect equitable access to clean air (UCS, 2023).

2.4 Review of Empirical Studies on Auto-vehicle Emission

Extensive studies on vehicular emission have been carried out with a major focus on health implications. However, there still lies significant gaps in the aspect of access to quantitative data that would significantly impact policymaking at local levels. While the level of awareness and development for alternative transportation with net-zero emission levels is growing, there exists the need for more management strategies to curb emissions in rapidly expanding urban centres yet to come to terms with the present reality. Some related studies on the subject of auto-vehicle emissions have been briefly outlined below.

Okonkwo et al., (2014) conducted a study on automobile-induced pollution within selected urban areas in Port Harcourt, Nigeria. The study methodology deployed the use of a standard emission gas monitor to detect emission levels for toxic gases (SO_2, NO_2, and CO) within two weeks at two heavily trafficked routes. Based on WHO standards, the results indicated that these emissions were beyond permissible levels during weekdays and weekends except for Sunday, thus implying significant levels of gas toxicity during work days.

In another study conducted by Laskowski et al., (2018) the Monte Carlo simulation technique was deployed to determine five (5) hydrocarbon emission characteristics for various internal combustion engines investigated. The essence was to estimate emission factors and determine the environmental impact assessment of various vehicles. The result of the simulation confirmed the effectiveness of the test technique deployed in detecting emissions produced by various vehicle engines. It was also inferred that the combustion characteristics for fuel types and driving conditions in congested environments significantly increased gas emission toxicity.

Diagi et al. (2022) also investigated pollutants concentration from auto-vehicle movements at selected markets in Owerri, Nigeria. The assessment was conducted during peak-hour movements (mornings and evenings) within the market vicinities. Findings indicated a significant concentration of CO_2, NO_2, and $PM_{2.5/10}$ beyond standard permissible limits suggested by the National Ambient Air Quality Standard (NAAQS) and the World Health Organization (WHO), thereby establishing the claim that frequent vehicle concentration within market areas were big contributors to emissions that could be hazardous to human health.

In the same vein, Sati and Dare (2022) investigated vehicular emissions within the Kaduna metropolis by sampling major parks attracting large fleets of different vehicles. Pollutants including CO, VOC, NO_2, H_2S, and SO_2 were investigated. It was observed that the concentration of CO within the study area, exceeded the acceptable safe limits as stipulated by the Federal Environmental Protection Agency (FEPA). It was also noted that almost all auto drivers operating within the parks had previously reported cases of protracted respiratory diseases thus indicating an emission crisis within the study location.

Ajayi et al., (2023) in a study titled "The impact of traffic mobility measures on vehicle emissions for heterogenous traffic in Lagos City", assessed emission levels of air pollutants from vehicle exhaust pipes. Using a portable gas analyzer, five distinct pollutants from vehicular traffic were analyzed. The results from the multiple exponential regression model (MER) showed a significant contribution from traffic flow, speed, vehicle fleet proportion, and pollutant concentration to overall emission levels. Findings deduced CO levels to be significant at ambient conditions and general emission levels to be highest at peak hours during heterogeneous traffic situations.

Oyetunji et al., (2023) juxtaposed vehicle emission levels with the characteristics of commonly operated vehicles within the Ilorin metropolis of Kwara State. These characteristics observed included the age of the vehicles, frequency of serviceability, and frequency of haulage. It was deduced that over 50 percent of the 65 vehicles examined, fell short of thresholds for CO and NO_2 emissions (based on WHO standards).

While these studies highlighted are by no means exhaustive, they provide the basis for this investigation as land use activities, population, travel patterns, and other demographic indices continue to evolve. This research breaches the gap for auto-vehicle emission data within the Minna metropolis required to expedite action on the consideration of alternative and multi-modal transit options by policymakers. It is intended that quantitative data needed to assess the contribution of auto vehicles to air pollution as well as to improve awareness and expedite anti-emission policy implementation by relevant stakeholders can be obtained.

3. Methodology

3.1 Area of Study

Minna, the capital of Niger State, Nigeria, is a fast-growing city with a current estimated metro population of 531,491 persons, according to the United Nations World Urbanization Prospects (2024). This represents a 3.63% annual growth in the last year, thus suggesting an urban agglomeration of Minna in addition to adjacent suburban areas. This region lies between 9° 36′ 50″ N, and 6° 33′ 25″ E, and covers a land area of 6,789 square kilometers (Daniyan and Mohammed, 2018). Due to the relative proximity of its location to the Federal Capital Territory (Abuja) at a land distance of 151.6 kilometers, it experiences dynamic travel patterns from commuters for business, medical, leisure, and educational purposes. Socioeconomic activities, predominantly farming, also facilitate the influx of commuters from neighboring local government areas and border States.

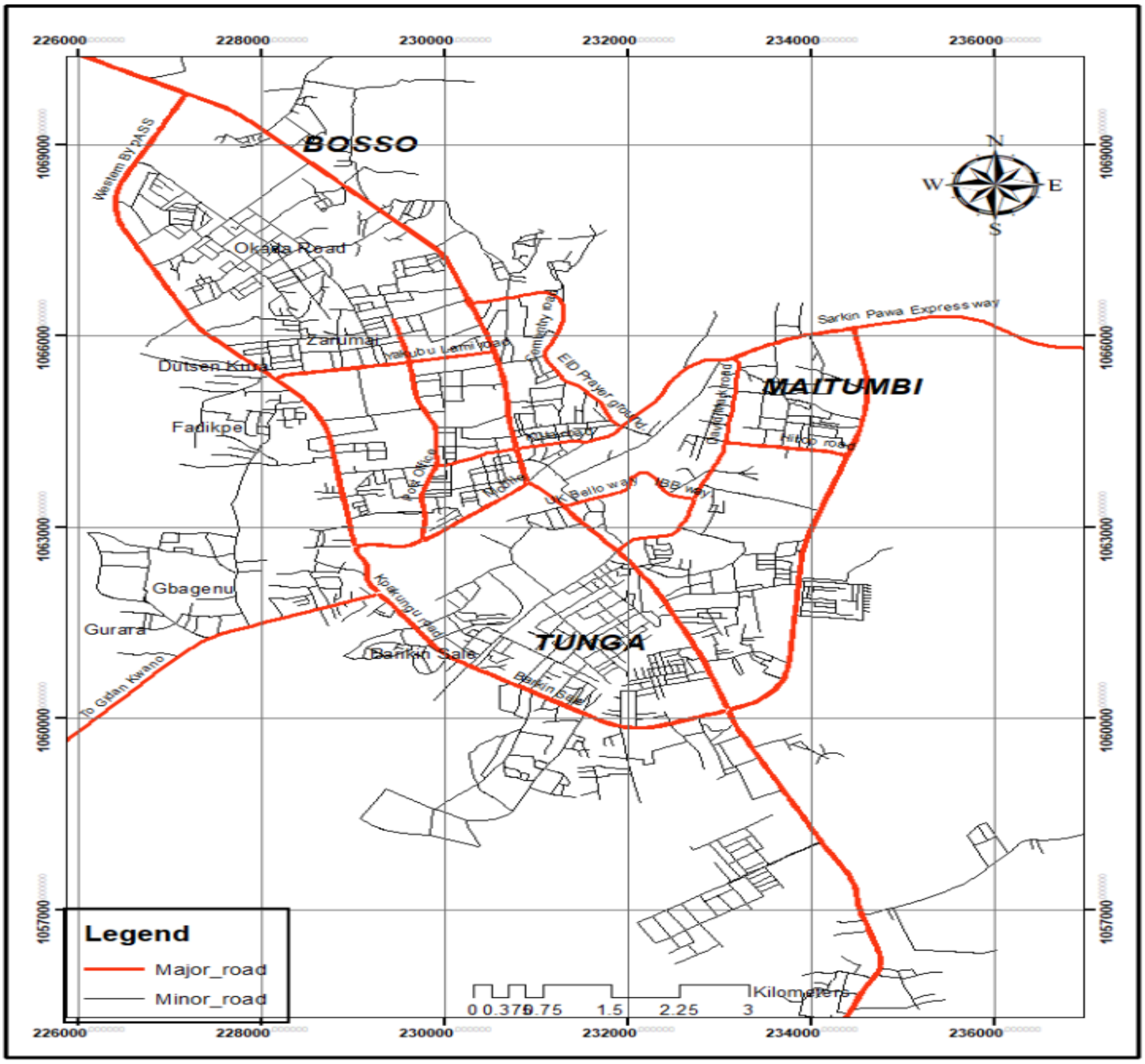

Figure 1: Map of the study area highlighting major road links in Minna

Source: NIGIS, 2022

3.2 Sampling of Auto-Vehicles

For this survey, secondary data involving vehicle testing and inspection records between October – December 2023 were obtained from the Computerized Vehicle Inspection Office (VIO) in Minna. These months of the year were selected following vehicular usage patterns and travel behaviour of road users within the period. According to the Federal Road Safety Commission (2022), the frequency of trips towards the later part of the year was significant as a result of festivities, ceremonies, and vacations during the period. To establish credibility, records from the testing centre were relied upon since the vast majority of road users were issued certificates of roadworthiness from the inspection office after testing. The data obtained from the VIO registry included:

i. Type/Category of the vehicles inspected.
ii. Vehicle model.
iii. Emission reports (Carbon monoxide – CO, Nitrous oxide – NO, and Sulphur dioxide – SO_2,) all measured in parts per million (ppm).
iv. Vehicle's year of manufacture
v. Frequency of vehicle servicing (oil change)
vi. Vehicle's total travel mileage covered, and
vii. The type of combustion engine (petrol or diesel) propelling the vehicle.

The data obtained from some of these parameters were used to test and establish vehicular emission levels. Only vehicles for which complete data were obtained, were used for the analysis.

Purposive sampling was adopted to collect the vehicle records since not all vehicle data could supply adequate data for all the parameters to be tested. Multiple types of vehicles (4-wheeled and above) were represented among the population mix considered. According to the National Bureau of Statistics (2018), an estimated 12,109 vehicle license plates were issued within the State, although no vivid information on the total number of vehicle registrations could be reliably verified. Hence, to obtain a valid and acceptable representation of the secondary vehicular data, the sample size for the study was adopted using Cochran's formula for unknown or infinite populations. Thus:

$$n_0 = \frac{Z^2pq}{e^2} \quad (1)$$

Where:

$n_0 = sample\ size.$

$Z = Z_{\left(1-\frac{\alpha}{2}\right)}$ value from the normal distribution table (1.96) at 95% confidence level.

$p =$ estimate proportion for an attribute present in a given population (50%=0.5)

$q = 1 - p$

$e = margin\ of\ error$ (5% = 0.05)

Hence, $n_0 = \frac{1.96^2 * 0.5 * 0.5}{0.05^2} = 384.16$

3.3 Testing Technique

The use of the exhaust gas analyzing device (F 5000 – 5 series gas analyzer) was adopted to detect the level of pollutants from idle running engines of automobiles being inspected. The device measured contaminants by percentage volumes for oxygen (O_2) and carbon dioxide (CO_2), while the concentration of carbon monoxide (CO), nitrous oxide (NO), and sulfur dioxide (SO_2) (deemed to be hazardous pollutants) were measured in parts per million (ppm).

3.4 Binary Logistic Model

A binary logistic regression model was deployed to analyze the influence of auto-vehicle characteristics such as frequency of vehicle servicing (oil change) (X_1), model of vehicle (X_2), total vehicle mileage travelled (X_3), and the type of combustion engine (X_4), on the emission data (y) obtained. In this case, the emission level for all auto-vehicles tested was the dependent categorical (dichotomous) variable designated (high or low based on the measured empirical data), while other auto-vehicle characteristics were the predictors. The mathematical relationship explaining the logistic function is given by:

$$f(y) = \frac{1}{1 + e^{-y}} \quad (2)$$

For y, the equation of the linear regression is used thus;

$$y = \beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots \beta_nX_n + \varepsilon_i \quad (3)$$

Hence, the probability that the dependent variable is 1 is given by this equation for values of the predictors in the form;

$$P(y = 1|x_1 \ldots x_n) = \frac{1}{1 + e^{-(\beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \ldots \beta_nX_n + \varepsilon_i)}} \quad (4)$$

Where:

$X_1, X_2, X_3, X_4 = predictor\ variables$

$\beta_1, \beta_2, \beta_3, \beta_4 = slope\ coefficient\ of\ each\ predictor$

$\varepsilon_i = error\ term.$

$y = dependent\ variable.$

4. Results and Discussion

4.1 Data Analysis

Table 1 shows the frequency of vehicle types inspected by their weight category and axle loading. A total of 385 vehicle records were inspected and thus analyzed.

Table 1: Vehicle Characteristics

Vehicle Type	Weight Category	Axle loading	Frequency	Percentage
Passenger Cars (Private/Commercial)	Less than 3 tons	1	207	53.77
Mini-buses/ Vans	Up to 3.5 tons	1-2	66	17.14
Mass Transit Buses	8-10 tons	2 or more	29	7.53
Trucks (Light and Heavy)	3.5-20 tons	2-4	83	21.56
Total	**N/A**	**N/A**	**385**	**100**

Source: Author's Survey, 2024

As indicated from the data obtained, passenger cars under private and commercial vehicle ownership with single-axle configuration, were the dominant type of vehicles tested (53.77%). The reason for this pattern of statistics is, perhaps, associated with purchasing, operating, and maintenance costs which tend to be relatively cheaper than other vehicle types. Other categories of vehicles including public service (mini-buses, vans, mass transit buses), light and heavy-duty vehicles with 2 axles or more accounted for (46.23%) of the total vehicles sampled. These vehicles constitute those mostly used for intra and inter-state travel and movement of freight involving agricultural produce and other raw materials.

4.2 Auto-vehicle Exhaust Emission Analysis

According to the Federal Environmental Protection Agency (FEPA) in Nigeria, the limits for toxic gases such as Carbon monoxide (CO), Nitrous oxide (NO), and Sulphur dioxide (SO_2) are stipulated within the following ranges: 10 ppm, 0.04 – 0.06, and 0.01 – 0.1ppm respectively (Sati and Dare, (2022).

Results obtained indicated that Carbon monoxide (CO) was the most significant pollutant. Although mean values obtained were within the acceptable limits (10ppm) for the various types of auto-vehicles tested, mass transit buses and heavy-duty trucks were the major contributors to increased levels with maximum values observed to be 19ppm and 17ppm respectively. It was generally observed that under ambient environmental conditions, increased vehicular operational activities were associated with an increased likelihood of significant amounts of CO pollutants. Descriptive statistics showing the summary of the analysis are presented in Table 2.

Table 2: Auto-vehicle Emission Record for CO

Vehicle types	Count	Sum value of CO emission (ppm)	Minimum (ppm)	Maximum. (ppm)	Mean (ppm)	Standard Deviation
Passenger car (private/ commercial)	207	595.70	2.80	9.50	5.79	2.46
Mini-bus	66	202.79	4.00	12.70	6.28	1.84
Mass transit bus	29	286.88	5.50	19.00	9.80	3.56
Light truck	57	408.70	4.20	15.50	7.17	2.47
Heavy-duty truck	26	206.98	4.50	17.00	7.96	3.63

Source: Author's Survey, 2024

The mean value concentration of Nitrous oxide (NO) was significant and beyond the tolerable level based on FEPA regulations for all types of auto-vehicles tested. However, mass transit vehicles and heavy-duty trucks had the highest mean concentration of NO pollutants with values ranging between 0.12 and 0.14 ppm respectively. A probable reason for such concentration could be a result of older vehicle models and engine models within the vehicle mix (Sati and Dare, 2022). Table 3 highlights a summary of this analysis.

Table 3: Auto-vehicle Emission Record for NO

Vehicle types	Count	The sum value of NO emission (ppm)	Min. (ppm)	Max. (ppm)	Mean (ppm)	Standard Deviation
Passenger car (private/ commercial)	207	8.13	0.01	0.28	0.08	0.06
Mini-bus	66	4.29	0.01	0.19	0.09	0.04
Mass transit bus	29	3.52	0.08	0.19	0.12	0.03
Light truck	57	5.02	0.06	0.14	0.08	0.04
Heavy-duty truck	26	3.58	0.09	0.28	0.14	0.05

Source: Author's Survey, 2024

Sulfur dioxide concentration (SO_2) within the exhaust pipes of most of the tested vehicles yielded results that were within the stipulated limit by FEPA (0.1ppm). However, when considering isolated cases, passenger cars and heavy-duty trucks had slightly higher figures at 0.110 and 0.140 ppm respectively. The observed difference may have been due to vehicle fuel impurities and poor engine efficiency. A summary of the analysis is presented in Table 4.

Table 4: Auto-vehicle Emission Record for SO_2

Vehicle types	Count	Sum value of SO_2 emission (ppm)	Minimum (ppm)	Maximum (ppm)	Mean (ppm)	Standard Deviation
Passenger car (private/commercial)	207	0.63	0.001	0.110	0.068	0.004
Mini-bus	66	0.28	0.001	0.088	0.020	0.003
Light truck	57	0.19	0.003	0.029	0.015	0.002
Mass transit bus	29	0.14	0.005	0.010	0.060	0.059
Heavy-duty truck	26	0.42	0.010	0.140	0.088	0.048

Source: Author's Survey, 2024

4.3 Regression Analysis

Table 5 summarizes data for all respondents whose vehicles were tested. The result indicates that all parameters were complete with no missing cases. A summary of the parameter coding for the categorical variables is also presented in Table 6. Each categorical parameter was defined by fixed dichotomous characteristics.

Table 5: Case Processing Summary for all Vehicles

Unweighted Cases[a]		N	Percent
Selected Cases	Included in Analysis	385	100.0
	Missing Cases	0	.0
	Total	385	100.0
Unselected Cases		0	.0
Total		**385**	**100.0**

Source: Author's Survey, 2024

Table 6: Categorical Variables Coding

Categorical Variables		Criteria	Frequency	Parameter coding
combustion engine	Petrol	Fuel type	330	0
	Diesel	Fuel type	55	1
vehicle age/model	New	2013 till date	200	0
	Old	Before 2013	185	1
total travel mileage	Low	< 50,000 miles travelled	66	0
	High	> 50,000 miles travelled	319	1
frequency of oil change	Regularly	Within 3 months	203	0
	Irregularly	Above 3 months	182	1

Source: Author's Survey, 2024

The summary of the omnibus test of model coefficients produced the Chi-square statistics of goodness of fit which indicated an overall model significance at $P < 0.05$. This result is presented in Table 7.

Table 7: Omnibus Tests of Model Coefficients

		Chi-square	Df	Sig.
Step 1	Step	89.548	4	.000
	Block	89.548	4	.000
	Model	89.548	4	.000

Source: Author's Survey, 2024

The model summary is presented in Table 8. The variance in the dependent variable that is explained by the model through the Cox and Snell as well as Nagelkerke R^2 is deemed as the approximate prediction variable criteria obtained to be 0.208 and 0.281 respectively. Thus, the explained variance by these two criteria ranged between 20.8% and 28.1% respectively based on the output data highlighted.

Table 8: Model Summary

Step	-2 Log likelihood	Cox & Snell R Square	Nagelkerke R Square
1	428.671[a]	.208	.281

Source: Author's Survey, 2024

The Hosmer and Lemeshow Chi-square statistics goodness of fit was carried out to determine whether the model adequately described the data obtained or not. Unlike the omnibus test of the model coefficient, the P-value in this case must be greater than 0.05 to indicate model fitness.

As indicated in Table 9, the P value obtained was 0.754, thus indicating ($P > 0.05$) which signifies the predictors were able to describe the dependent outcome adequately.

Table 9: Hosmer and Lemeshow Test

Step	Chi-square	Df	Sig.
1	1.902	4	.754

Source: Author's Survey, 2024

The classification result as shown in Table 10 was important to indicate how well the predictors were able to estimate the correct category based on the specificity and sensitivity of the dependent output. From the table, the model indicates a 68.3% accuracy in the data classification.

Table 10: Variable Classification

		Predicted		
		level of auto-vehicle emission		%
Observed		Low	High	Correct
level of auto-vehicle emission	Low	111	43	72.1
	High	79	152	65.8
Overall Percentage				**68.3**

Source: Author's Survey, 2024

Table 11 shows the relationship between the predictors and the output as well as the predictor(s) with a significant contribution to the output. From the table, the frequency of vehicle maintenance, indicated by oil change was the statistically significant predictor influencing emission level in auto-vehicles ($P < 0.05$). The odds ratio as indicated in the Exp(B) column showed that values greater than 1 meant increased likelihood or probability of occurrence while values less than 1 indicated less likelihood for the target group. Therefore, based on the odds ratio, the frequency of vehicle maintenance through oil change was 2.904 times more likely to affect emission level than travel mileage, vehicle model, and type of combustion engine in auto-vehicles.

Table 11: Variables in the Model Equation

		B	S.E.	Wald	df	Sig.	Exp(B)	95% C.I. for EXP(B)	
								Lower	Upper
Step 1[a]	Oil_change (X_1)	1.066	.299	12.682	1	.000	2.904	1.615	5.223
	Veh_model (X_2)	-.076	.282	.072	1	.788	.927	.533	1.612
	Travel_milage (X_3)	.457	.331	1.903	1	.168	1.580	.825	3.025
	Comb_engine (X_4)	20.838	5276.924	.000	1	.997	1121918235.874	.000	.
	Constant	-.652	.287	5.140	1	.023	.521		

a. Variable(s) entered on step 1: Oil_change, Veh_model, Travel_milage, Comb_engine.

Source: Author's Survey, 2024

5. Conclusion

Significant auto-vehicle haulage and emissions have major consequences on human health and the environment generally. The mitigation of vehicular emission can be imperative in curbing environmental air pollution resulting in global warming effects and respiratory disease prevalence such as asthma, lung cancer, chronic obstructive pulmonary disease (COPD), and other cardiovascular diseases among road users as adjudged by previous research (Atta, 2018; Ajayi et al., 2023; Oyetunji et al., 2023).

Findings from this study showed that the concentration of Carbon monoxide (CO) and Nitrous oxides (NO) were the most significant air pollutants with the highest values detected at 19 and 0.28 ppm respectively. These emission values also tend to increase with continuous and frequent vehicle use over longer travel distances or mileages. However, vehicle user attributes such as frequency of maintenance through servicing and oil changes and newer engine models were observed to reduce emission levels for these toxic gases. It is therefore recommended that:

i. Routine periodic maintenance involving regular oil changes should be encouraged and enforced by transport regulatory agencies, especially for commercially registered vehicles.
ii. The introduction of more mass transit vehicles in urban centres with subsidized fares as incentives should be undertaken by the government to discourage private vehicle usage thus decongesting traffic and reducing emission levels.

The use of modern and green energy-powered vehicles with zero emission such as solar, or fully electric-propelled cars and vehicles with lower emission combustion systems such as Compressed Natural Gas (CNG) should be adopted.

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