Exposure To Traffic-Related Air Pollution : A Public Health Concern?

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1 Introduction

With the rapid growth of the number of motor vehicles in Africa, traffic emission has become one of the primary sources of urban environmental air pollution that restrict the quality of the urban living environment (Ayetor et al, 2021). The World Health Organization (WHO) recorded in 2016 that "more than 80% of people living in urban areas are exposed to air quality levels that exceed [WHO] limits (Sicard et al, 2021). The Global Burden of Disease (GBD) study showed that about 4.2 million died prematurely due to exposure to ambient air pollution worldwide (Liao et al, 2020). Particulate matter (PM2.5) is harmful to human health. In 2017, exposure to ambient PM2.5 was estimated to be associated with 2.9 million premature deaths globally which are about 9 percent of total deaths in the world today. In the West Africa region, it was responsible for about 80,000 premature deaths in the same year (Adama et al, 2018) resulting from ischemic heart disease; this is a condition of recurring chest pain (angina) or discomfort that occurs when a part of the heart does not receive enough blood), stroke, chronic obstructive pulmonary disease, and obstructive lung disease characterized by long-term breathing problems and poor airflow, shortness of breath and cough, lung cancer, lower respiratory infections, and diabetes mellitus type 2 (Stanaway *et al*., 2018). There are serious risks to health not only from exposure to Particulate Matter (PM) but also from exposure to ozone (O_3), nitrogen dioxide (NO_2), carbon monoxides (CO), and sulfur dioxide (SO_2). The problem is particularly acute in Nigeria, which had the highest number of premature deaths due to ambient PM2.5 in the region; and especially in Lagos, the country's commercial capital and one of the world's fastest-growing megacities. Despite growing concern about air pollution in Lagos, there is currently no reliable estimate of the impact of ambient air pollution, nor a comprehensive air pollution control. Another major contribution to transportation emissions especially in sub-Sahara Africa is bad fuel quality (Hirota and Kashima, 2020). In 2020, Sulphur concentration in petroleum products used by vehicles in Nigeria was 204 times above recommended levels for advanced emission systems. In 2015, Euro 3 fuel standards were adopted in Nigeria these changes are still awaiting Government approval and implementation (Maduekwe et al., 2020). The car fleet of West African cities is mainly constituted of used vehicles from European and American countries. These old vehicles often lack emission and noise reduction technology.

Several studies have been conducted on emission inventories around the world today. This is based on the methodology of measurement and inventories of vehicles emission, various emission models, (Bikam, 2022; Ayetor et al., 2021; Meng et al., 2020; Zhou et al.,2019; Khreis, and Nieuwenhuijsen, 2019; Adeyanju et al., 2017). Ajayi et al., (2023) assess the perception of vehiuclar traffic emissions for Lagos metropolis and deduced road

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side proximity, vehcile owbership, age, eductaion and employment status as, major factors that affect the level of awareness. They gave emphaseid that social-economic factors affrect the level of awareness/perception for the roadside dwellers.

Traffic congestion increases vehicular emissions and degrades ambient air quality (Sharmilaa and Ilango, 2021). Recent studies have shown excess morbidity and mortality for drivers, commuters, and individuals living or working near major roadways (Kumar et al., 2021). Unfortunately, in Sub-Sahara Africa today, there are few or no studies on emission impacts on public health, the health of the public around the pollution zones are deteriorated due to the ambient air quality with increased population growth, motorization, and industrial expansion. More attention is geared towards increased infrastructural development and little attention is paid to the health hazard of urban transport to public health.

The study aims to investigate the ambient air quality and its health implications on the public near selected roadways in Lagos Metropolis. This aligns with the Sustainable Development Goals 3, 9 & 11; by 2030, collectively seek to develop safe, inclusive, and resilient cities and ensure healthy lives and wellbeing for persons of all ages through adequate sanitation and air pollution prevention. (WHO, 2016).

2 Materials and Methods

2.1 Site description

Lagos City is chosen for this study, due to some specific characteristics that the city presents. It is one of the most important and densely populated urban centers with serious air pollution problems in Nigeria. It is Nigeria's main commercial centre, with N70% of the nation's industries and economic activities , making it the country's most economically important state (Okimiji et al., 2021). Lagos is located on latitude 60 22l and 60 42l North and longitude 20 42l and 30 22l East and has over 224 vehicles per kilometer as against 15 vehicles per kilometer in other states in Nigeria, hence heavy traffic congestion is experienced by over 10million commuters on its roads on daily basis. (Odekanle et al., 2017) Fig. 1 shows the map of Lagos showing the studied routes.

2.2 Selection of routes

The five routes selected for this study are; Tollgate – Meiran; Ikeja Along – computer village; Agege-pencinema; ile epo-iyana ipaja and shogunle-oshodi. These routes were selected in Lagos based on their existing information and survey on congestion, vehicles characteristics and composition, high density of vehicles, speeds of vehicles, road geometry and observed population around the corridors and they are representatives of typical commuting routes in residential, commercial and industrial districts in Lagos with high traffic volume. The mode of transport on these routes are not the same. Motorcycle, tricycle, passenger car, bus/vans, large bus, and Heavy goods vehicle HGV are the vehicles plying these routes. Fig. 2 shows the picture of Shogunle-Oshodi road.

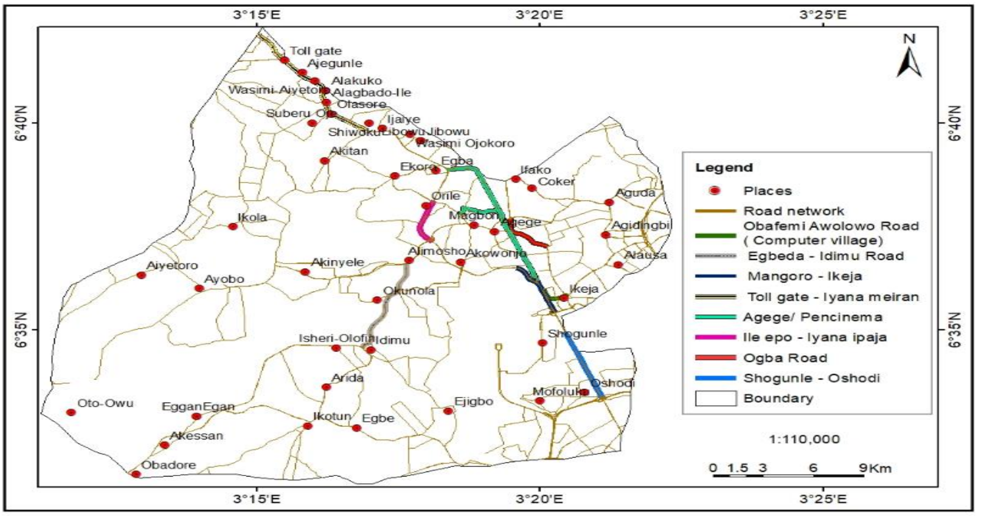

Fig. 1. Map of Lagos showing transport routes

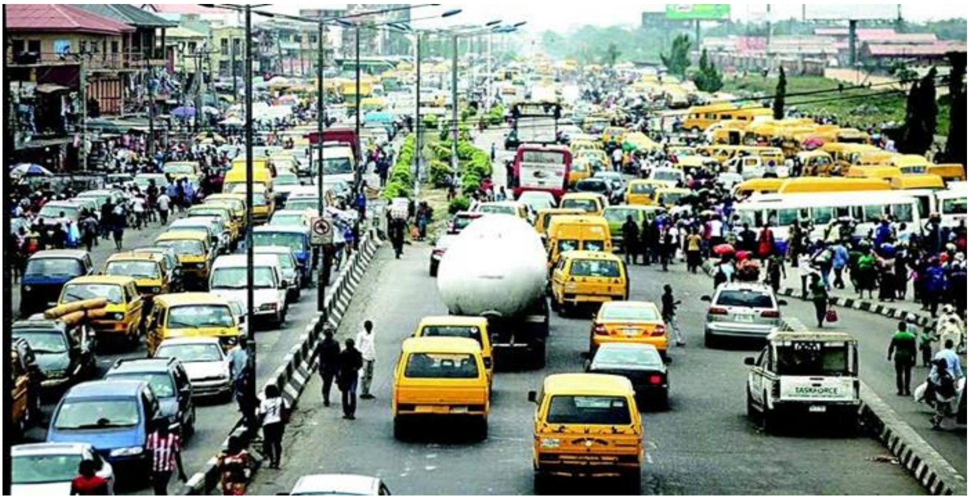

Fig. 2. The traffic situation on Shogunle-Oshodi road.

2.3 Traffic mobility measures

Mobility measures; volume, traffic composition were collected with the aid of pneumatic tubes on the five road corridors. The classified counts were conducted for the 7 days of the week (Mondays to Sundays) for morning and evening rush hours and afternoon non-rush hours. The volume counts were taken throughout the week to capture all traffic parameters variation on the routes for the whole week. Traffic counts were usually conducted on Tuesday, Wednessday, and Thursday because Monday morning and Friday evening rush hours may show exceptionally high volumes and are not normally used in the analysis. The situation in Lagos conforms to this protocol due to the unforeseen activities on Monday, Friday, Saturday, and Sunday. The traffic count was performed along the two routes for 12 weeks

. 2.4 Vehicle emission monitoring

Five emission sampling points were established along the study route with their coordinates determined by using Mobile Mapper 10 hand-held Geographical Positioning Systems (GPS). Vehicle emission measurement for each route was carried out using portable handheld gas analyzers. These detectors were used for outdoor sampling by measuring the pollutants for every 15-minute interval at a point located 2 m away from the road edge at each sampling point located along the route under study. A multigas monitor ; with a 3.7V lithium battery and a measuring range of 0 -999ppm was used to measure CO. Handheld laser particle counter (KANOMAX): measured particulate matter, $PM_{2.5}$, and PM_{10}, ToxiRAE gas detectors: measure SO_2 and NO_2 concentrations. A handheld device (kestrel): measured meteorological parameters such as relative humidity and temperature. The emission measurement ran for 24 hours for morning, afternoon, and evening peaks periods for each corridor/intersection for a period of seven (7) days {Monday to Sunday) on each corridor. A statistical analysis was run to determine the Pearson correlation between the pollutants levels and traffic flow by the use of R-Studio statistical tool.

2.5 Ambient air quality

The ambient air quality on each corridor was determined by comparing it with the air quality index standard. Air Quality Index is a tool for effective communication of air quality status to people in terms, which are easy to understand. It transforms complex air quality data of various pollutants into a single number (index value), nomenclature and colour. There are six AQI categories : Good, Satisfactory, Moderately polluted, Poor, Very Poor, and Severe. Each category is decided based on ambient concentration values of air pollutants and their likely health impacts (known as health breakpoints). AQ sub-index and health breakpoints are evolved for eight pollutants (PM_{10}, $PM_{2.5}$, NO_2, SO_2, CO, O_3, NH_3, and Pb) for which short-term (up to 24-hours) as prescribed in the National Ambient Air Quality Standards.

2.6 Public health impact assessment

The health of the public around the selected routes is very germane. Computer village intersection was chosen for the health impact asssessment. A structured Questionnaire (400) were administered to road side residents (Traders, Hawkers, Shop owners, School children, Drivers/conductor) around the computer village intersection. A total of 400 respondents were approached with the questionnaires. However, 355 filled out and returned the questionnaire, which gave a response rate of 89%. The average population at the computer village intersection was assumed to be 300,000 (three hundred thousand). A purposive sampling technique was used to distribute 400 questionnaires to the residents who live or undertake activities near the intersection, where emission levels were observed. The questionnaire asked questions about the respondent's social-demographic characteristics, occupation or line of work, proximity to a road corridor, work schedule, time off from work, and activities, as well as their perceptions of the potential effects of inhaled pollutants on their health and any potential health symptoms they may have. Additionally, participants were asked if they experienced any cardiorespiratory symptoms or conditions, including chest pains, frequent coughing, runny nose and sneezing, sore throat, eye irritation, breathing difficulties, body weakness and fatigue, loss of appetite, headaches, and rapid breathing. The Questionnaire was based on demographics, proximity to the road corridor, time spent and activities at the corridor, and perceptions of impacts of the inhaled pollutants on their health. Health conditions or symptoms such as chest pain, frequent cough, nose running and sneezing, sore throat, difficulty breathing, body weakness, fatigue, loss of appetite, headache, fast breathing were also collected. Fig. 3 shows the satellite view of emission monitoring points on the intersection and location of the roadside residents

Fig. 3. Emission monitoring points on the intersection

3 Results and discussions

3.1 Traffic volume and pollutants concentration

Pollutants were assessed 24 hours through the week. The emission is on the high side on Friday in all the routes unlike Sundays, this is due to the high volume of vehicles during the weekends for various activities and especially some people travel out of the city. Fig. 4 shows the emission levels for PM on the study routes. In computer village road, the emission levels increased in the morning rush hour from 7 to 9 am, this is when workers ply on the route to work, the vehicular traffic is high at this period and this has greatly contributed to the high emissions of CO, $PM_{2.5}$, and PM_{10}. The SO_2 and NO_2 emission on computer village is high at the morning and evening rush hour because of ongoing road construction works on the intersection. This has greatly affected the concentration of SO_2 and NO_2 with the presence of industrial equipment for construction. This also occurs at Tollgate meiran routes at one of the carriageways and has caused traffic gridlock as vehicles in both directions have to take the available lanes. The Particulate matter in all the routes is on the high side as the volume of vehicles increases and the vehicle fleet in the routes affected the concentration. Although the information on the vehicle fleet characteristics has yet to be discovered, this has affected the particulate matter emission, a hazardous pollutant. Most vehicles in Lagos are old and imported and often lack emission

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reduction technology. (Ayetor et al, 2021). The CO emission is high for all the routes. It is expected to react with oxygen to form CO_2 which is atmospheric "greenhouse gas that influences the global climate by internal molecular vibration and rotation which causes these molecules to absorb infrared radiation. The cars and bus show a larger proportion of vehicles on all the routes, this responds to the fact that the public goes to work in their private cars and some go by commercial buses and vans. The heavy goods vehicle is more on Tollgate-meiran road as it is a link from an industrial town (ota, OgunOgun state) into the city, unlike computer village which is a single carriageway and centre of commercial activities in Lagos. This is the usual mode of transport in the Lagos metropolis. The correlation analysis indicated statistically significant positive correlations between the traffic volume and the concentration of pollutants with r values of 0.838 and 0.885, this implies that the volume of vehicles directly impact the concentration of pollutants

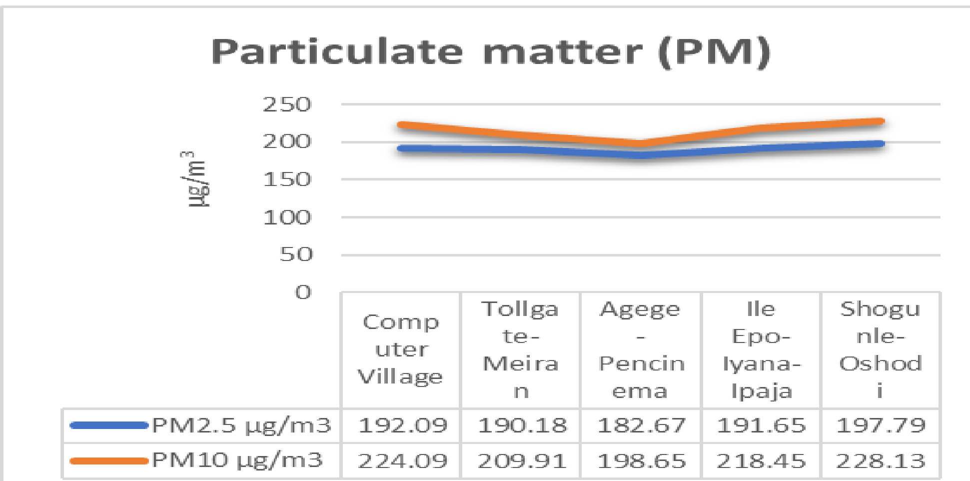

Fig. 4. Average hourly result for PM concentration

3.2 Ambient air quality

The average 24-hours concentration of pollutants levels was further compared to the permissible thresholds set by the WHO and the EPA Victoria and the Air Quality Index AQI was determined for each road corridor. This is shown in Table 1 to 3. The SO_2 levels are moderately polluted for all the routes, this implies that the air quality is accepted. However, there may be a risk for some people, particularly those who are usually sensitive to air pollution. i.e children and the elderly. However, SO_2 and NO2 levels (280µg/m3) are highest especially during the heavy traffic in computer village due to the ongoing construction and lowest (100µg/m3) in Agege-pencinema road due to low volume of Heavy Goods Vehicles. The SO2 emission implies that the usually sensitive people should consider reducing prolonged or heavy exertion. They are usually accompanied by symptoms such as coughing or shortness of breath. NO2 (100 µg/m3) is highest at Shogunle-Oshodi road due to considerable numbers of Heavy Good vehicles, followed by Tollgate road (90 µg/m3) due to the large proportion of industrial vehicles plying the routes. CO (54ppm) concentration is highest at computer village due to large proportion of motorcycle. Motorcycles are found to emit more CO to the atmosphere and are one of the causes of Greenhouse gases. (Ribeiro et al, 2021). The air quality for CO is severe for all the routes, this implies that the risk for health effects is increased for everyone and should avoid outdoor activities; especially individuals with heart and breathing ailments, children, and older adults. Motor vehicles significantly contribute to ambient carbon monoxide (CO) concentrations. All motor vehicles emit CO, but the majority of CO emitted from this source occurs from light-duty, gasoline-powered vehicles. (Adeyanju, 2018). In addition to health concerns from CO exposures, CO may be a useful indicator of the transport and dispersion of inert, primary combustion emissions from traffic sources since CO does not react in the near-road environment. (Smit et al, 2019). The $PM_{2.5}$ levels (197.79 µg/m3) are highest in Shogunle-Oshodi routes and it can be considered as very poor air quality for all the routes as it exceeds 121-250 µg/m3 EPA threshold. The implication is that it's unhealthy for everyone, especially for sensitive groups. PM2.5 consists of particles less than one-tenth the diameter of human hair and can be inhaled deeper into the lungs and can affect lungs and cause serious health effects. Particles less than 2.5 micrometers in diameter are termed "fine particle or PM2.5 poses the most serious threat to human health. The particle size is directly linked to their potential for causing health problems. (Olukanni et al., 2021). The air quality for PM10 is poor for the routes and moderately polluted for Agege-pencinema road. Particles that are ten micrometers (PM10) in diameter generally pass through the nose into the lungs. Once inhaled these particles can affect the health and lungs and cause serious health effects.

Table 1. CO -Ambient Air Quality for the routes based on EPA Victoria threshold

Routes	AQI	CO (mg/m3)- 8 hours mean	AQI category	Description of Air Quality
Computer village	34+	64	Severe	Health Alert: the risk for health effects is increased for everyone and should avoid outdoor activities; especially individuals with heart and breathing ailments, children and older adults
Tollgate-Meiran	34+	53	Severe	
Agege/pen-cinema	34+	36	Severe	
ile epo-Iyana-ipaja	34+	60	Severe	
Shogunle-Oshodi	34+	63	Severe	

Table 2. $PM_{2.5}$ -Ambient Air Quality for the routes based on EPA Victoria threshold

Routes	AQI	PM2.5 (µg/m3)- 24 hours mean	AQI category	Description of Air Quality
Computer village	121-250	192.09	very poor	Some members of the General public may experience health effects, members of sensitive groups may experience more serious health effects
Tollgate-Meiran	121-250	190.18	very poor	
Agege/pen-cinema	121-250	182.67	very poor	
ile epo-Iyana-ipaja	121-250	191.65	very poor	
Shogunle-Oshodi	121-250	197.79	very poor	

Table 3. PM210 -Ambient Air Quality for the routes based on EPA Victoria threshold

Routes	**AQI**	**PM_{10} (μg/m3)-24 hours mean**	**AQI category**	**Description of Air Quality**
Computer village	251-350	224.09	Poor	Members of sensitive groups may experience health effects. The General public is less likely to be affected
Tollgate-Meiran	251-350	209.9	Poor	
Agege/pen-cinema	101-250	198.65	Moderately polluted	Air Quality is accepted. Sensitive groups like children and the elderly may be affected
ile epo-Iyana-ipaja	251-350	218.45	poor	Members of sensitive groups may experience health effects. The General public is less likely to be affected
Shogunle-Oshodi	251-350	228.13	Poor	

3.3 Health impact assessment

Table 4 shows the demographic characteristics of respondents. The age group ranged from ≤16 to ≥60, with the majority (35.2%) in the ≤40 age group. Male respondents were more than female in all the age groups. 84.5% of the respondent have their business, workplace, and residence close to the corridor at about 10-50meters away from the corridor and 88.2% have their activities daily around the corridor, 53% spent more than 8 hours daily, 59.4% have spent less than 5 years while 23.1% have spent between 5 to 10 years at the corridor. This implies that a larger proportion of respondents are exposed to air pollution at the road corridor daily. Respondent has health symptoms chest pain, frequent cough, nose running and sneezing, sore throat, difficulty in breathing, body weakness, fatigue, loss of appetite, headache, fast breathing. Some have multiple symptoms.. Fig. 5 shows the health symptoms frequency by the different respondents. Traders (13.5%); Hawkers (9.3%); Shop owners (23.4%); School children (4.2%); Drivers/conductor (15.2%); Office staff (20%), Police (0.8%); Traffic officer (1.4%); Pedestrian/Passerby (5.1%) and Construction workers (0.8%). Figure 6 shows 54% and 6% of women and children perceived health different health symptoms as a function of their exposure to vehicle emission impacts.

Table 4. CO -Ambient Air Quality for the routes based on EPA Victoria threshold

S/N	Category	Response	Frequency (%)
1.0	Participants Information Questionnaire Respondent Non-Respondent	 400 355 45	 88.8 11.2
2.0	Gender Male Female	 184 171	 51.8 48.2

3.0	Age		
	< 15	21	5.9
	16-20	102	28.7
	31-40	125	35.2
	41-50	52	14.6
	51-60	42	11.8
	>60	13	3.7
4.0	Marital Status		
	Single	165	46.5
	Married	187	52.7
	Prefer not to say	3	0.8
5.0	Workers Around the Corridor		
	Traders	50	14.1
	Hawkers	34	9.6
	Shop owners	83	23.4
	School children	21	5.9
	Drivers/conductor	58	16.3
	Office staff	74	20.8
	Police	4	1.1
	Traffic officer	5	1.4
	Pedestrian/Passerby	22	6.2
	Construction workers	4	1.1
6.0	Proximity to Road Corridor?		
	Yes	300	84.5
	No	55	15.5
7.0	Proximity to Road Corridor - Distance		
	Less than 50m away	300	84.5
	50-100m away	18	5.1
	100-300m away	33	9.3
	300m and above	4	1.1
8.0	Schedule of Activities		
	Everyday	313	88.2
	Monday to Friday	42	11.8
	Once a week	0	0
	Twice a week	0	0
9.0	The period spent (years) near the corridor		
	< 5 yrs	211	59.4
	5-10yrs	82	23.1
	10-15 yrs	50	14.1
	15-20 yrs	10	2.8
	>20 yrs	2	0.6
10.0	Work Duration per Day		
	< 8 hrs	5	1.4
	8 hrs	162	45.6
	> 8 hrs	188	53.0

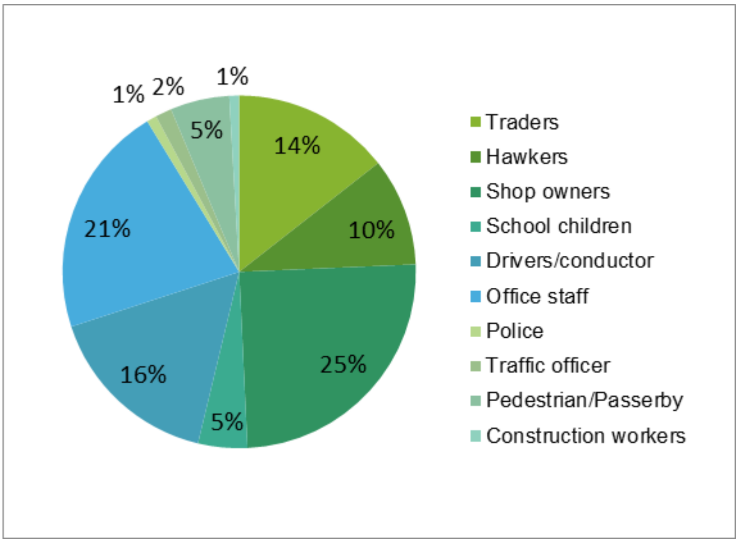

Fig. 5. Respondent health symptoms

4 Conclusion

The study focused on assessing ambient air quality caused by vehicle emission and its health implication on the public near selected roadways in Lagos Metropolis. Air pollution is exacerbated by car emissions in urban areas, especially during rush hours when drivers sit in gridlock for extended periods. The correlation analysis indicated statistically significant positive correlations between the traffic volume and the concentration of pollutants. The air quality is not safe and it is hazardous to health as the impact of CO, $PM_{2.5}$, and PM_{10} on the routes were severe, very poor, and poor respectively. This implies that the risk for health effects is increased for residents at this point and should avoid outdoor activities, especially those with heart and breathing ailments, children and older adults. Furthermore, the health impacts assessment for residents near the roadways (Traders, Hawkers, Shop owners, School children, Drivers/conductors, Office staff, Police, Traffic officer, Pedestrian/Passerby and construction workers) shows symptoms of chest pain, frequent cough, nose running and sneezing, sore throat, difficulty in breathing, body weakness, fatigue, loss of appetite, headache, fast breathing. This is due to daily exposure to traffic rellated air pollution. However, the study is limited as it does not inculcate the direct impact of these pollutants exposure on the health of the resident through a model but only elucidates on the public health implications. To address these issues, it is important to utilize knowledge about congestion levels and emission inventories and real-time traffic data to inform the public about air pollution hotspots and the temporal and spatial characteristics of pollutant concentrations on the road network. Efforts should be made to discourage residents from engaging in economic activities near the road corridor and consider relocation options. Additionally, implementing non-discriminatory policies that educate and guide residents near the road corridor can help mitigate their exposure to pollutants. Reducing congestion at the intersection through implementing an efficient traffic intelligence system would also be beneficial in minimizing bottleneck delays and subsequently reducing vehicular traffic pollution. Long-term monitoring of the health impacts of transportation in cities is crucial for assessing their resilience to urbanization and increasing motorization. Therefore, conducting health impact assessments is important to comprehensively quantify the effects of air pollutants on public health, particularly for individuals living near roadways.

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