Emissions from Road Transport Vehicles and Respiratory Health in Rural and Urban Communities, Kano State, Nigeria: A Comparative Cross Sectional Study

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Abstract. Rapid urbanization and population migration encountered in developing countries results in an increasing need for transportation. To investigate the impact of vehicular emissions on air pollution/quality and respiratory health we conducted a comparative 2:1 cross-sectional study in rural and urban communities, 150 adult respondents and 30 children comprised the study population. Structured interviewer administered questionnaires; Clinical respiratory examination and digital Spirometry were conducted. Informed consent was obtained; data were analyzed using Epi info statistical software version 7. Results showed Mean age: (36.3± 12.9 years), Linear height: (median 1.65, range: 1.40 – 1.86). Adult Male: female ratio 1:1. Average Distance of households to roads/highway: 36.03± 23.79 meters and prevalent duration of daily transit 2–5 hours. In urban settlements: distance to highway/road <50 meters (OR 32.4, 95% CI: 8.57–122.3) and Non-use of protective devices (OR: 12.43, 95% CI: 2.60–59.34) showed significant associations. Twenty two (22) Spirometry results were within the obstructive index. Abnormalities detected on Spirometry in the absence of a history of respiratory conditions or abnormalities on clinical chest examination require further investigation. Recommendations were targeted to improve health education, provide sustainable mass transit, urban planning, support focused research and ensure effective emissions control.

Key words: Emissions, health, respiratory, pollution, Spirometry, Vehicles

1. Introduction
The twentieth century saw an increase in human population, due to medical advances and massive increases in agricultural productivity. The United Nations estimated that the world’s population was growing at the rate of 1.14 % about 75 million people per year in 2012 [1]. By 2050, the world population is projected to be 7.4–10.6 billion. Differing environmental standards and costs for remediation have caused the relocation of pollution-intensive industries from strictly controlled countries to those with few or no standards by creating “pollution havens”. Air pollution in the United States has decreased steadily since the 1970s, in contrast to developing countries [2, 3]. Despite increasing evidence relating...
air pollution to climate change and human health, control and regulatory measures have not been effective in all countries. A study showed vehicle emissions as the main source of Volatile organic compounds in large cities [4, 5]. Particulate matter (PM) is used to describe solid particles and liquid droplets found in the air. Two size ranges, known as PM10 and PM2.5, are widely monitored, both as major emissions sources and in ambient air. PM10 includes particles that have aerodynamic diameters less than or equal to 10 micrometers (μm), approximately equal to one-seventh the diameter of human hair. PM 2.5 is the subset of PM10 particles that have aerodynamic diameters less than or equal to 2.5 μm. Particles within the two size ranges behave differently [6]. Studies have identified variability in size, morphology and chemical composition attributed to the diverse nature of sources [7, 8].

Multiple researchers, environmental and public health policy makers concur on the substantial effects associated with fine particulate air pollution and support additional public policy efforts to reduce exposure [9]. A published review of patients with Lung disease showed significant association between exposure to higher levels of PM10 in the air and development of COPD [10]. It has been proven that Individual particle elemental composition is more useful than bulk analysis in determining various characteristics like; formation, sources and effect on climate and human health [11]. World health Organization (WHO) in 2005 has associated air pollution from motor vehicles with increased mortality risk as a result of cardiopulmonary causes and significant risk of respiratory morbidity. The ability of the released air pollutants to persist in the air for long periods of time prolongs exposure. Penetration into the lungs is facilitated by their ability to remain suspended [12]. Of greater concern is the increase in studies showing the effect of air pollution from the pregnancy period and intrauterine life. A marked increase of the effect of air pollution on adverse pregnancy outcomes linked to traffic pollution exposure has been reported in multiple studies [13, 14]. Evidence of the exacerbation of allergic reaction in asthmatics, the increased risk of myocardial infarction and adverse outcomes of pregnancy such as premature birth and low birth weight, has been reported following motor exhaust exposure. Despite the existence of clearance and translocation in the respiratory tract, a significant percentage of poorly soluble particles remain in the lungs leading to toxicity [15]. This cross sectional study was conducted to investigate the impact of Vehicular emissions; particulate and non-particulate from Road Transport Vehicles on respiratory health in Urban and rural Areas. We investigated the relationship between certain variables and health outcomes related to air pollution/emission exposure, assessed respiratory function and history of disorders.

1.1. Health effects of emissions

Health effects of emission particles are varied and dependent on particle size, duration of exposure, individual’s genetic predisposition and site affected. Some chemical reactions form new chemicals. Toxic chemicals can interfere with normal body functions, resulting in health problems. Some of these effects are acute; eye irritation, headaches, and nausea, while others may be chronic and irreversible, such as organ damage, birth defects, heart disease, cancer, and even death [16]. Children are very sensitive to the effects of air pollution, as they breathe more rapidly and inhale more pollutants per body weight. Fine particles can harm lung development and cause early childhood asthma [17]. Multiple pathways have shown how these particles exert a negative effect during intrauterine life including; oxidative stress, alteration of mitochondrial DNA contents, gene methylation in cord blood and endocrine disruption [18, 19, 20].

1.2. Respiratory assessment

In Nigeria, atmospheric pollution and its burden of respiratory diseases is still a serious menace in metropolitan cities. A study showed expended vehicles, general use of the single-engine motorcycles, traffic congestions, and the natural north-easterly Harmattan contribute to high levels of localized air pollution affecting population health [16]. The assessment of the respiratory system for abnormalities involves conducting a thorough physical examination and relevant investigations. Part of the inhaled air pollutants can be exhaled, but most reach the lungs, with some penetrating through the lungs and entering the circulation system [10]. Studies show exposure to fine particulate matter < 2.5μm is the most significant environmental risk factor contributing to morbidity and mortality [21, 22].
The deposition of aerosols in the respiratory system is location and size dependent. The short-term health effects of air pollutants are quantified using an air quality index (AQI) [23]. A study showed the risk of myocardial infarction was raised by short term exposure to PM 2.5µm within days [22]. Computation of AQI requires multiple air pollutant concentrations, often in terms of the presence of five common pollutants—sulfur dioxide, nitrogen dioxide, carbon monoxide, suspended particulates, and ground level ozone [10]. The potential chronic health effects of particulate matter are lung cancer, pulmonary emphysema, bronchitis, asthma, and other respiratory infections [24].

1.3. Respiratory Spirometry
Obstructive airways disorders (e.g. COPD, asthma) and restrictive diseases (e.g. fibrotic lung disease) can be differentiated using Spirometry. The assessment and management of respiratory diseases require reliable Spirometry reference points for both static and dynamic lung volumes. To accomplish this, the effects of disease and of environmental influences on lung growth must be understood to avoid misdiagnoses [25]. Patient’s details are confirmed prior to conducting respiratory Spirometry: Name, Age, Gender, Height and Ethnicity. The parameters are defined thus: Forced Vital Capacity (FVC): total volume of air that the patient can forcibly exhale in one breath, Forced expiratory volume (FEV) in 1s: volume exhaled in the first second after deep inspiration and forced expiration, FEV1/FVC: ratio of FEV1 to FVC expressed as a percentage. The values of FEV1 and FVC are expressed as a percentage of the predicted normal for a person.

Common acute effects of exposure to emissions include cough, chest pain and sputum production which are seen in most cases of chronic obstructive diseases (COPD). Chronic cases of exposure may present with different Spirometry outcomes [26]. Ventilatory parameters observed in measurements of respiratory mechanics should be compared with Spirometry reference values by sex, age, height, and ethnicity in accordance with the recommendations of the American Thoracic Society and the European Respiratory Society (ATS/ERS) [27, 28].

A study showed lung volumes of African children are approximately 20% lower than those of Caucasian children of equal height [29]. A study in Benin involving Spirometry among children showed European ERS-93 standards do not accurately predict FVC and FEV1 in Beninese children and adolescents [30]. In contrast, the FVCs predicted by the ITS-Black standard for 11, 15, and 16 year old boys and 16 year old girls are acceptable [31]. This study will generate race and country specific values.

2. Materials and methods

2.1. Study area
Kano State is located in north-west Nigeria (Current Projected: 14,311,246). It is 484 meters above sea level and experiences a typical savannah climate with an average of approximately 980mm (38.6 inches) of precipitation annually. Frequent heat waves with average temperatures at 26.3 degrees centigrade (79.4F) occur. Significant variations in wind speed occur frequently compounded by frequent sudden gusts of sub-Saharan dust from Northern Africa. Wind speeds can average greater than 5.3 miles/hour between November- July each year. In Figure 1 below the location of the country and study area within Northern Nigeria, with a larger Map showing the Local Government Areas (LGAs) is shown.

2.2. Study design and scope
A cross sectional study was conducted in rural and urban areas in October 2019-March 2020. Participants were adults aged >15 years (based on Nigeria Demographic and health survey-NDHS 2009) in three (3) Local Government Areas. Standardized structured interviewer administered questionnaires; Respiratory examination and Spirometry were conducted. The participants resided in: Panshekarau, Kumbotso Village and settlement around/within Yankaba Motor Park “Tashan Yankaba” located in Nassarawa, Kumbotso and Kano Municipal LGAs. There was no health risk to participants, discovered previously undiagnosed respiratory impairment were referred to a specialist at the proximal Primary Healthcare center (PHC). Informed consent (Appendix A) was obtained from all participants.
2.3. Experimental protocol
Three teams comprising of: team lead (Epidemiologist), Nurse, data officer, interviewers and representatives of the LGA were trained. Specific data tools used included; Team lead tally sheet, Spirometry results sheets (adult and children), supply monitoring forms, attendance sheets, height measurement guide and guide to respiratory Spirometry. All Individual subjects had heights (meters), information on sex, age and race recorded. A respiratory examination involving; inspection, measurement of the respiratory rate (at rest) and auscultation of breath sounds were conducted. This was followed on the same day, after 10 minutes passive rest by Spirometry measurements using Vitalograph COPD-6 monitors. Due to possible influences that can induce alterations in biorhythms, Spirometry measurements were always taken in the morning from 10 to 12 a.m. The distance from the point of Road vehicular traffic to each household (HH) was measured in meters (m).

2.4. Study variables
Outcome Measure: Abnormal Spirometry Value in the obstructive range in the absence of a history of respiratory disease, clinical evidence of respiratory disease or related co-morbidity e.g. cardiac disease
Exposure Variables: Perceived exposure to vehicular emissions, Occupational exposure; welding, painting, carpentry, electrical work, agricultural work, dentistry, non-occupational exposure e.g. smoking, use of clay masks, proximity of residence to road vehicular traffic, transit duration, inhalation of household chemicals, use of protective devices (Appendix B).

2.5. Sampling
Sample size was calculated in Epi-info statistical software version 3.5.3 and version 7 (CDC software). A P-value of 50% from prevalence (in the absence of a region and country specific study), 95% confidence level and ratio of exposed to unexposed as 1, power 80% and a risk ratio of 1.5 were used. The calculated sample size is 132 respondents, adding a 12 % non-response rate.

[Calculated sample size/ 1- non- response rate (NRR)] = Final

The final sample size used was 150 respondents.
Thirty Minors (<15 years) were selected based on parental/caregiver consent by convenience sampling in Kumbotso LGA (Urban).

2.6. Subject of the study
Local Government areas (LGAs) and communities for the study were selected using multistage sampling. The subjects were adult participants recruited via systematic sampling (final stage of multistage sampling) using a calculated sampling interval.

2.7. Inclusion and exclusion criteria
Included were residents of selected households (15-60 years) in the communities who resided for at least one year prior to data collection. All Eligible residents found too sick to be interviewed, unwilling or not permanent residents were excluded.

2.8. Data collection
Data were recorded using an interviewer administered structured questionnaire with sections on; Socio-demographics, Vehicular use, medical history and exposure in context of professional and non-professional activities. The questionnaire comprised of questions in English subsequently translated into the local “Hausa language” based on respondents’ preference. Minors were paired to their parents and caregivers questionnaires. Height in meters (m) and age of subjects were recorded. A height measure (stadiometer) measuring from zero to > two meters (2.0574m) was used to measure height of the subjects standing barefoot and upright.

2.9. Respiratory examination and Spirometry
Respiratory examinations were conducted by trained Nurses under supervision. Physical examination involving chest inspection for abnormalities, measurement of respiratory rate and auscultation of breath sounds. Auscultation was performed using adult and pediatric bells on “Rappaport sphygmomanometers” by each team on the field. Respiratory Spirometry involved measurement of Flow/volume variables (FEV1, FEV6, FEV1/FEV6 ratio) using Vitalograph’ “COPD- Digital spirometers” (Model 4000 Respiratory, Vitalograph, Ennis, Ireland). Pediatric instruments were used for Spirometry assessment of 30 children of consenting adults/caregivers in the urban settlement only. The devices were calibrated before use daily prior to testing. The participant’s; height, age and sex were entered to enable an automated calculation of the predicted expected normal values. The device is programmed to show obtained values in Comparison to normal values (NHANES) for each individual tested. Disposable Mouthpieces and antibacterial filters/wipes (Vitalograph Ltd., Innis, Ireland) were used to avoid cross contamination. The individual were assessed, while standing or sitting comfortably with nose pinched and the testing equipment and turbine between hands.

2.10. Determination of standard fev1 and fev1/fev6 ratio values
FEV1, FEV6 and FEV1/FEV6 obtained values for adults were subjected to univariate analysis (means and confidence interval) for the group. A stratification by type of settlement (rural versus urban), sex, medical history, distance of household to nearest road and exposure in the context of non-professional activities and occupational exposure (with known risk) was made. Each individual’s Spirometry value was coded based on calibrated normal for age, sex and height (NHANES Values). Participant’s descriptive statistics are shown in Table 1. The Spirometry values for children were evaluated based on normal values for age and sex, with means and standard deviation values presented.

2.11. Statistical analysis
The variables were processed using Epi-info statistical software version 7 (CDC software, Atlanta U.S.A). Descriptive statistics were generated for socio-demographic variables. The FEV1, FEV6 and FEV1/FEV6 values were analyzed for means and standard deviations. Univariate analysis was performed on obtained values in each age group and by sex to determine means as well as confidence interval. Rejection of the null hypothesis occurred at a probability of P < 0.05.
3. Results

3.1. Demographic information

Table 1 shows descriptive statistics derived from the questionnaires; age, sex, marital status, educational level, occupation and duration of stay in the community and the distribution of results by settlement type. Majority of adult respondents were married, with a male: female ratio that varied between urban and rural areas. Most respondents had secondary level of education as their highest educational qualification. Long duration of stay ≥ 5 years was prevalent in both rural and urban areas. The mean height values were higher among males than females in both rural and urban settlements. All households (HH) in both urban and rural settlements were located within a distance of Mean: 36.03 ±23.79 meters and Range: 2.45-99.0 meters.

Table 1. Socio-demographic characteristics of study respondents in both rural and urban settlements within selected LGAs.

| Descriptive Variables   | Rural settlement No (%) | Urban settlement No (%) |
|-------------------------|-------------------------|-------------------------|
| Sex                     |                         |                         |
| Male                    | 26 (52.0)               | 47 (47.0)               |
| Female                  | 24 (48.0)               | 53 (53.0)               |
| Marital Status          |                         |                         |
| Single                  | 8 (16.0)                | 30 (30.0)               |
| Married                 | 42 (84.0)               | 58 (58.0)               |
| Divorced                | 0 (0.0)                 | 2 (2.0)                 |
| Widowed                 | 0 (0.0)                 | 10 (10.0)               |
| Educational Level       |                         |                         |
| Primary                 | 9 (18.0)                | 14 (14.0)               |
| Secondary               | 24 (48.0)               | 46 (46.0)               |
| Tertiary                | 12 (24.0)               | 14 (14.0)               |
| Post-tertiary           | 2 (4.0)                 | 0 (0.0)                 |
| No formal education     | 3 (6.0)                 | 26 (26.0)               |
| Age                     |                         |                         |
| 10-19 years             | 11 (11.0)               | 0 (0.0)                 |
| 20-29 years             | 26 (26.0)               | 17 (34.0)               |
| 30-39 years             | 19 (19.0)               | 14 (28.0)               |
| 40-49 years             | 21 (21.0)               | 7 (14.0)                |
| ≥50 years               | 23 (23.0)               | 12 (24.0)               |
| Duration of stay        |                         |                         |
| <1 year                 | 1 (2.0)                 | 6 (6.0)                 |
| 3 – 5 years             | 9 (18.0)                | 20 (20.0)               |
| ≥ 5 years               | 40 (80.0)               | 74 (74.0)               |
| Occupation              |                         |                         |
| Business person         | 18 (36.0)               | 50 (50.0)               |
| civil servant           | 7 (14.0)                | 6 (6.0)                 |
| Private organization    | 4 (8.0)                 | 0 (0.0)                 |
| Agricultural/construction | 5 (10.0)           | 1 (1.0)                 |
| Unemployed              | 6 (12.0)                | 21 (21.0)               |
| Student                 | 2 (4.0)                 | 4 (4.0)                 |
| Tailoring/designing    | 8 (16.0)                | 3 (3.0)                 |
| Driver                  | 0 (0.0)                 | 15 (15.0)               |

Table 2 presents values for Spirometry by means and standard deviation; the mean height values were higher among males than females in both rural and urban settlements, while the average age of respondents in both settlements was in the 30 year age group. The mean FEV1 and FEV6 values
observed were significantly higher in males than in females regardless of age group, with highest recorded values in males within urban settlements. The mean FEV1/FEV6 ratio and obtained Standard deviations (SD) showed values largely distributed at the normal cut-off.

Table 2. Height and ventilatory parameters for adults in selected LGAs of Kano State-Nigeria.

| Sex         | Rural Male (n=26) | Rural Female (n=24) | Urban Male (n=47) | Urban Female (n=53) |
|-------------|-------------------|---------------------|-------------------|---------------------|
| Age (years) |                   |                     |                   |                     |
| Male        | 38.6±14.4         | 35.7±10.6           | 34.7±12.0         | 38.2±13.5           |
| Female      | 30.6±14.6         | 35.7±10.6           | 34.7±12.0         | 38.2±13.5           |
| Height (meters) |            |                     |                   |                     |
| Male        | 1.70±0.08         | 1.58±0.08           | 1.71±0.07         | 1.59±0.78           |
| Female      | 1.58±0.08         | 1.58±0.08           | 1.75±0.07         | 1.59±0.78           |
| FEV1 (L)    |                   |                     |                   |                     |
| Male        | 2.13±0.63         | 1.85±0.50           | 2.75±0.47         | 1.75±0.55           |
| Female      | 1.85±0.50         | 1.75±0.55           | 1.75±0.55         | 1.75±0.55           |
| **FEV1 Predicted (%)** |          |                     |                   |                     |
| Male        | 71.93±9.05        | 71.74±11.15         | 73.38±9.74        | 65.39±13.99         |
| Female      | 71.74±11.15       | 65.39±13.99         | 65.39±13.99       | 65.39±13.99         |
| FEV6 (L)    |                   |                     |                   |                     |
| Male        | 2.96±0.87         | 2.62±0.69           | 4.03±0.66         | 2.54±0.77           |
| Female      | 2.62±0.69         | 2.54±0.77           | 2.54±0.77         | 2.54±0.77           |
| FEV1/FEV6   |                   |                     |                   |                     |
| Male        | 0.72±0.03         | 0.69±0.06           |                   |                     |
| Female      | 0.71±0.05         | 0.69±0.06           |                   |                     |

For Table 2: FVC: force vital capacity; FEV1: Force expiratory in one second, FEV1/FEV6: Ratio of two values, FEV6: Forced expiratory in 6 seconds. Values are means ± SD. The Predicted normal values are for age, sex and height based on CDC reference calculator generated values for normal Spirometry. The results of Spirometry assessment of respondents (Figure 2) residing in the study sites.

Figure 2. Results of Spirometry among adults’ respondents with staging of obstructive index.

Only 22 adult participants (Figure 2) had values within the obstructive index. For adult participants the standardized reference values used to interpret findings were:
- FEV1/FEV6 ≥0.70 and FEV1 ≥80% of predicted: Normal
- FEV1/FEV6 <0.70 and FEV1≥80% OF Predicted: Stage 1
- FEV1/FEV6 <0.70 and FEV1 < 80% Predicted: Stage 2
- FEV1/FEV6 <0.70 and FEV1< 50% Predicted: Stage 3
- FEV1/FEV6 <0.70 and FEV1 <30% Predicted: Stage 4

Odds ratio (OR) of grouped exposure variables and 95% confidence interval (Table 3) in both rural and urban areas in relation to the outcome of interest were calculated. Confounding variables such as; history of respiratory illness and abnormalities on clinical examination were controlled for by stratification. Residing in households close to highways or roads <50 meters and non-use of protective devices; face masks and shields was found to increase risk.

**Table 3:** Bivariate analysis of factors associated with respiratory abnormalities due to air pollution in selected rural and urban areas of Kano State, Nigeria.

| Exposure Variable                                | Rural Odds Ratio (OR) | Rural Confidence interval (CI) | Urban Odds Ratio (OR) | Urban Confidence interval (CI) |
|--------------------------------------------------|-----------------------|--------------------------------|-----------------------|--------------------------------|
| Distance to exposure source (Highway/road)       |                       |                                |                       |                                |
| • <50 meters                                     | 2.11                  | (0.20-21.9)                    | 32.4                 | (8.57 – 122.3)                 |
| • ≥50 meters                                     |                       |                                |                       |                                |
| Duration of transit                              |                       |                                |                       |                                |
| • ≥2 Hours                                       | 3.57                  | (0.35-36.94)                   | 1.68                 | (0.60 – 4.69)                  |
| • <2 Hours                                       |                       |                                |                       |                                |
| Exposure in the context of professional activities e.g. welding |     |                                |                       |                                |
| • Present                                        | 1.20                  | (0.11-12.83)                   | 0.69                 | (0.21 – 2.31)                  |
| • Absent                                         |                       |                                |                       |                                |
| Exposure in the context of non-professional activities e.g. smoking |     |                                |                       |                                |
| • Present                                        | 1.58                  | (0.14-17.25)                   | 1.34                 | (0.48 – 3.73)                  |
| • Absent                                         |                       |                                |                       |                                |
| Traffic control on roads                         |                       |                                |                       |                                |
| • Positive                                       | 2.83                  | (0.36-22.4)                    | 0.96                 | (0.34 – 2.72)                  |
| • Negative                                       |                       |                                |                       |                                |
| Exposure to outdoor air pollution                |                       |                                |                       |                                |
| • Present                                        | 0.37                  | (0.03 –4.22)                   | 0.71                 | (0.26 – 1.97)                  |
| • Absent                                         |                       |                                |                       |                                |
| Use of protection                                |                       |                                |                       |                                |
| • No                                             | 5.12                  | (0.49-53.2)                    | 12.43                | (2.60-59.34)                   |
| • Yes                                            |                       |                                |                       |                                |

*Figure 3* shows the frequency of road transportation vehicular use in both urban and rural settlements, with the most commonly used vehicular type as the tricycle in urban areas (commonly known locally as ‘*Keke Napep*’). In rural settlements, motorcycles were identified as the most common vehicular type, as they navigate narrow paths easily. The findings show participants prefer smaller capacity and easy to maintain road transportation vehicles.
Figure 3. Types of Road Transportation Vehicles Frequently used by respondents in rural and urban settlements, Kano State.

Table 4. Spirometry characteristics among children in Kumbotso (Urban) LGA of Kano State, Nigeria.

| Age     | Male | Female |
|---------|------|--------|
| 6 years | 1.4±0| 0.0±0  |
| 7 years | 1.4±0.1| 0.0±0  |
| 8 years | 1.4±0.2| 0.0±0  |
| 9 years | 1.5±0.1| 1.5±0.1|
| 10 years| 1.5±0.3| 1.5±0.3|
| 11 years| 1.5±0.1| 0.0±0.0|
| 12 years| 1.5±0.1| 1.6±0.0|
| 13 years| 1.5±0.1| 1.2±0.2|

Table 4 above shows the results of spirometry values for children including means and standard deviations. Results obtained in this for children aged 6-13 years, showed FEV0.5, FEV1 and PEF mean values within normal range. The obtained peak expiratory flow values were lower compared to reference values in the standardized study of African children.
4. Discussion

A major finding in this study is known exposure variables related to emission/air pollution from vehicular sources showed differing interactions in urban and rural settlements. The abnormalities in a minority of study participants (22) showed predominance in urban areas, with 81.2% of the abnormal results. This may be accounted for by the study ratio of 2:1 in favor of urban communities. Though the presence of longer transit times (with increased duration of exposure) and recorded higher vehicular density are more associated in various global studies with urban settlements. The presence of Poor Urban planning and construction of residential properties in close to roads commonly encountered in developing Sub-Saharan and Asian countries increases health risk. The inhabitants of such homes experience chronic exposure to emissions and poor air quality. Studies show a 50% decrease in PM 2.5 and ultrafine particles within 100-150meters of a road [32]. A decay to background concentrations within as little 50meters has been described for PM 2.5 mass concentrations [33], although PM2.5 tends to be more spatially homogenous than ultrafine particles.

Various researchers globally have tried to determine reference values for children and healthy adults according to age, sex, height, and even ethnic group. Most of the commonly used reference parameters are for Caucasian (white) populations and most instruments calibrated to suit those references. Most predominantly black populations do not have specific predictive tools to determine normal Spirometry values for their populations. To eliminate significant differences between references equations, study sample sizes should minimally be 100 subjects [34]; the calculated sample size of 150 adults used in this study fulfills this requirement. Various studies have clearly shown that Europeans form a compact group that is clearly separated from African populations [35]. These results suggest an explanation for differences in observed FVC and FEV1 values between girls and boys in all age categories independent of sex and the European ERS-93 [30] standards.

The values we obtained in this study are comparable and in some case homogenous to values from previous studies in African Americans and African children. Studies in Nigerian schoolchildren aged 5 to 20 years have demonstrated mean FVC and FEV1 values that were significantly lower than those of their white counterparts [36]. We therefore interpreted normal Spirometry values in this study by comparing values obtained to reference values recorded from a Nigerian study on children of both sexes and to a regional African study on African children [37], therefore interpreting pulmonary function with an emphasis on ethnic impact as advocated by some authors. The interpretation of static lung function in children of African descent is limited due to inappropriate reference equations [25].

Before Spirometry reference equations were available for use in Black individuals, reference values originally derived for White individuals were used for Black individuals by applying an adjustment factor whereby the values for White individuals were reduced by 10-15%; however, the adjustment was found to be inadequate [38]. Spirometry values for adults obtained in this study though largely within the normal range for adults of African descent were lower than normal values quoted globally. A large prospective study of adults in Brazil from birth to 30 years involved pulmonary function testing, FVC and FEV1 (corrected for height and other factors) found values to be lower in males and females with a higher percentage of African ancestry [39].

Chronic obstructive disease findings are seen in exposure to air pollutants and present both as short term and long term manifestations. The short-term effects include decreases in pulmonary function, increases in inflammatory markers and respiratory symptoms, exacerbations of chronic obstructive pulmonary disease (COPD) and infections, and increases in respiratory mortality [40,41, 42]. Chronic Obstructive Airway disease (COPD) is poised to become the leading cause of death by 2030. Proximity of residential dwellings to busy roads and levels of chemical compounds known as nitrogen oxide (NOx) and nitrogen dioxide (NO2) in the air is related to the number of new cases of COPD and reduced lung function. Although the results were less clear on chronic bronchitis and asthma, this does not imply that poor air quality does not have an impact on these conditions [43] the research showed the inhalable particles in the air (PM10) to be of greatest concern.

Prevalent tricycle use and location of homes in urban areas increases exposure to particulate emissions. A study confirmed elevated Lead concentration along the streets and double the lead concentration both in blood and urine of drivers compared to controls [44]. Recurrent motorcycle use seen in rural communities and its health effects are shown in other studies [45, 46]. As the pollution from motorcycles...
are at least 15x higher/mile than larger capacity vehicles; cars and trucks [47]. It is imperative that larger capacity and environmental sustaining means of transportation be provided in such communities.

5. Conclusion
Increasing urbanization and vehicular ownership in emerging Global economies and sub-Saharan African nations has yielded a low air quality index. This coupled with a reliance on petroleum products as a major source of fuel has maintained exposure especially of the lower classes to negative health effects. Various studies have shown the disproportionate effect of environmental exposure between income levels to health. In a study on public health and air pollution in Asia (PAPA) stronger associations between pollutants (PM10 <10 micrometers), S02, NO2, ozone (O3) and daily respiratory mortality among women, elderly and lower socioeconomic status (SES) persons were reported [48]. Though this study did not investigate income levels, the present average per capita income in Nigeria and the occupational spectra of the respondents indicate their possible income strata. The location of residential houses proximal to highways and roads has been proven by studies to worsen respiratory health at distances ≤ 50 meters with effects seen upto 100-150 meters from exposure points. This study showed all households located within a hazardous distance. This study highlights a need for further investigation into the mineralo-pathology and cellular cytotoxicity of the particulate air pollutants residents are exposed to daily. There is also a need for increased health education, implementation of standardized sustainable urban planning, improvement of monitoring and legislation of vehicular emission and further country level research.

6. Declarations

6.1. Funding
Funding for this study was via an Academic Merit Scholarship grant from the Petroleum Technology Development Fund (PTDF), Nigeria awarded to the Corresponding author for PhD Research.

6.2. Conflict of interest
The Authors declare no conflict of interest.

6.3. Availability of data
Available as Epi-Info output files

6.4. Authors contributions
AAS and SK participated in the design of the study and in drafting the manuscript; IWB, AF, SPS and MAA assisted AAS with field training and data collection/analysis. AMTS assisted with review and interpretation of findings. All authors reviewed the contents presented here and consented to this final version.

6.5. Ethical considerations/consent to participate
This study was approved by the Scientific Ethics Research Committee on Health and related research, Kano State Ministry of health, Nigeria (Ref No: MOH/797/T.1:1700) Dated 30th September 2019 (Appendix C and D) in accordance with the Helsinki Act of 1975. Informed consent was obtained from participants who signed on a consent form which clearly detailed the voluntary nature of participation. Anonymity was maintained.

6.6. Consent to publish
All Authors provided consent for submission and Publication.
7. Abbreviations
AQI: Air Quality index, CDC: Centers for disease control, COPD: Chronic obstructive pulmonary disease, FEV1: Forced expiratory volume in 1s, FEV1/FVC: Ratio of FEV1 to FVC expressed in percentage, HH: Household, ITS-Black: International Thoracic Society- Black standards, LGA: Local Government Area, NDHS: Nigeria Demographic and health survey, NRR: Non response rate, OR: Odds Ratio, PEF: Peak expiratory flow rate, PM 2.5: Particulate matter < 2.5µm, PM10: Particulate matter < 10µm, PHC: Primary healthcare center, P-Value: Predictive value, SES: Socio-economic standard.

8. Appendices
These are submitted as separate files labeled appendix A-D to the conference and editors.

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Acknowledgment
The Federal Road Safety Corps, Kano State Command, Nigeria and Nigeria Field Epidemiology and Laboratory Training Programme (NFELTP), Abuja, Nigeria. We acknowledge Kano State Ministry of health and Local Government personnel.