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Effect of Ozone on COPD and asthma patients in Abuja Nigeria

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Abstract

Background: At high concentrations of ozone occurring during air-pollution episodes, airway sensitivity will increase even in healthy populations. Though there is an indication of the effects of ozone (O3) on COPD and asthma patients, few studies have the effects of short and long-term ozone exposure on them. This study investigates the effects of O3 concentration on COPD and asthma patients in Abuja, Nigeria.

Method: Data were collected on dyspnoea, daily symptoms, monthly FVC, and FEV1 data, routine monitoring O3 data, and meteorological data, we performed correction and multiple regression analyses to calculate the correlation between respiratory disease (COPD and asthma) and ozone exposure.

Results: We observed an association between O3 and lung function (FVC and FEV1). Ozone and FEV1 (-.719, p = .008), and O3 and FVC (-.566, p = 0.055). We observed a larger effect of ozone on lung function (FVC and FEV1) for females (FVC -.792, p = .002; FEV1 -749, p = .005) than males (FVC -.541, p = .070; FEV1 -645, p = .023), We also observed that O3 concentration and daily symptoms showed a significant association (.938, p =.000). Ozone had a greater impact on females than males in respiratory diseases (COPD and asthma). There was also a stronger association between O3 and respiratory condition in the dry season than in the wet season ($p < 0.05$).

Conclusions: Exposure to ozone pollution caused a higher risk to COPD and asthma patients thus worsening their condition. Ozone pollution in Abuja is at a damaging level. The government has a key role to play in control and prevention initiatives to decrease ozone pollution to protect the public. The outcome of this study provides valuable data for further research and improving environmental practice in Nigeria.

Keywords: Respiratory condition; ozone pollution; COPD, asthma; Abuja, Nigeria prospective cohort study.

Introduction

Increased ozone (O_3) concentrations have been linked with adverse health effects, particularly on respiratory conditions [1-3]. Lab-based study of O_3 exposure demonstrated acute decreases in FEV_1, increased airways resistance, and an increase in respiratory symptoms [4]. Other studies on adult non-smokers observed a greater effect of O_3 on long-term exposure and on the residents of industrial areas [5,6]. One of the effects of ozone is cell membrane damage after invading the respiratory tract and causing irritation [2-7]. The effect of ozone associated with most respiratory and circulatory diseases and deaths increases as the impact of ozone on the climate is more likely to increase health issues [3-8].

Olowoporoku et al. (2012) [9] found links between air pollution and hospitalisation in Lagos, Nigeria, due to respiratory problems, including COPD and asthma. A cross-sectional study in Southern Nigeria indicated that outdoor air pollution decreased the function of the respiratory system [10]. Also, Aliyu and Botai (2018) [11] highlighted that outdoor air pollution in Zaira, Kaduna Nigeria is significantly associated with COPD, asthma, and other lung diseases.

It is vital to conduct this research to improve understanding of the effects of ozone pollution on COPD and asthma. Therefore, the main objective of this study is to evaluate the association between ozone concentration and respiratory health conditions (COPD and asthma), as well as the effect of individual characteristics such as gender. We also examined the effect of the season (wet and dry seasons), which may affect respiratory conditions in Sub-Saharan Africa (SSA).

Method and Materials

Participants were recruited from an existing cohort used to study the effect of O_3, PM_{10}, and NO_x on respiratory health in Abuja, Nigeria.

The research was conducted in Abuja, in the Federal Capital Territory, situated in the centre of Nigeria. Abuja's population is about 3,277,740 people and covers a range of people from civil servants to farmers [12]. Abuja is a fast-developing city with high road traffic.

Like much of SSA, Abuja has tropical dry and wet seasons. Each season generally lasts for about five months. The wet and rainy season lasts between April and September, while the warm and dry season lasts between October and March. However, there is harmattan during the dry season.

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The uniqueness of harmattan is in the cold, dry, dust-laden wind and changes in temperature during day and night. The temperature oscillates between 9ºc (48ºF) and 30ºC(86ºF) during the day, and at times relative humidity drops below 10%.

Data on respiratory symptoms for the study were obtained from participants recruited from two government hospitals in Abuja used for this study. A lung function test was conducted measuring FVC and FEV_1 monthly and the dyspnoea scale was used to measure the level of breathlessness complimenting the lung function test. The participants also kept a daily diary of their symptoms.

The air pollutant and meteorological data monitoring were carried out at the Nigerian Meteorological Agency (NIMET) air monitoring station Abuja.

Statistical Analysis

Descriptive analysis was performed followed by correlation and multiple regression analyses for asthma and COPD. The association between FEV_1 and FVC and ozone concentration. Spearman rank correlations and multiple regression analyses were performed to evaluate the relationship between FEV_1 and FVC between ozone concentrations and meteorological conditions. SPSS v27 was used to examine the relationship between air pollutants, meteorological factors, and the symptoms of COPD and asthma. The statistical significance for all analyses was set as $p < 0.05$.

Ethical approval

Ethical approvals were obtained from the University of Sunderland and the National Hospital and the Teaching hospital in Abuja, Nigeria. The study was considered a multi-site study as the two hospitals operate independently.

Results

Characteristics of the COPD and asthma patients in this study is presented in Table 1. The majority of the participants were women and had a mean age of 52.8 and 51.7 years, respectively. Only 10.3% of the male and 5.6% female of participants were current smokers. The characteristics show information about lung function (FVC, &FEV_1), smoking, BMI, dyspnoea scale, and demography. Some notable results in table 1 include the age of the participants which indicates that they developed the condition early, while FVC confirmed that the participants have the condition and FEV_1 the level of the severity. Also, in table shows that percentage of participants that have smoked in this study was low. All data are presented as mean.

Table 1: Characteristics of the Participants.

	Male (157)	Female (245)
Age	52.8	51.7
Height	167.9	163.5
Weight	65.3	68.2
%Smoked	10.3	5.6
%FVC	40.3	42.5
%FEV_1	20.3	22.9
MRC Dyspnoea scale	4.2	4.7
BMI	22.9	24.3

Ozone data were monitored from January to December, at the NIMET monitoring site and obtained meteorological data and ozone concentration in Abuja.

The data from the Nigeria Meteorological Agency (NIMET) showed that the highest ozone concentration recorded in Abuja was 388µg/m^3 (1-hour mean) and 295µg/m^3 (8-hour mean). The ozone concentration during data collection was almost 3 times higher than the WHO recommended standard for O_3 of 100 µg/m^3 8-hour mean (WHO, 2005). The 1- and 8-hourly means are shown in Figure 1. As vital meteorological factors that affect ozone pollution, daily average temperature and humidity are significantly different during the wet and dry seasons. The maximum daily average relative humidity in the dry season is 43%, and the minimum daily average relative humidity is 37%. Whilst the maximum daily average relative humidity in the wet season is 83%, the minimum daily average relative humidity is 74%. Besides, the maximum average temperature in the dry season is 41°C, and the minimum daily temperature in the dry season that is lowest is 23°C. Whilst the maximum daily average temperature in the wet season is 32°C, the minimum daily average relative humidity is 19°C.

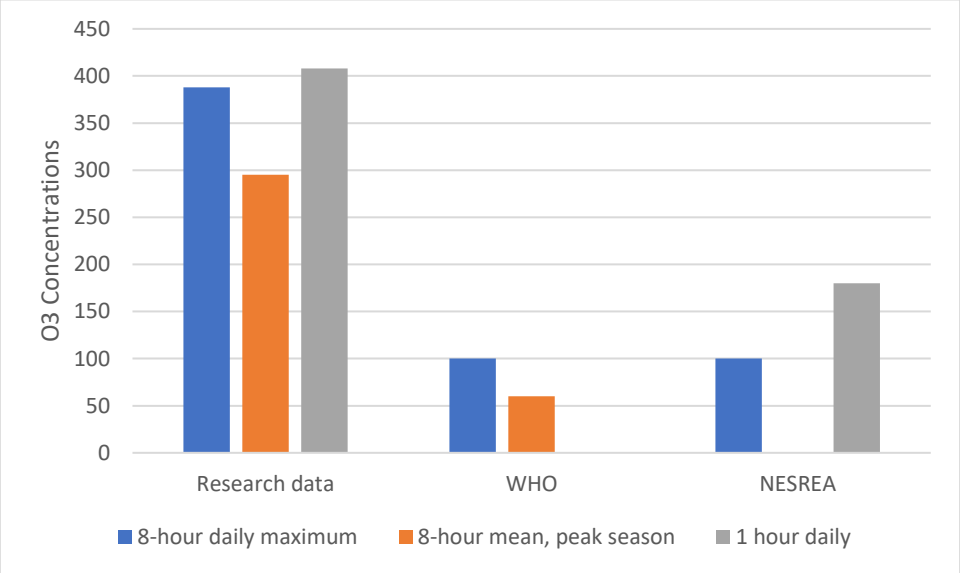

Figure 1: 8-hourly max, mean and hourly mean of O_3

Plots of O_3 concentrations in this study as presented in Figure 1 is 3 times higher than WHO guideline. The study showed a trend of negative correlation (O_3 on FEV_1 (-.719, P=.008; O_3 and FVC with a correlation coefficient of -.566 with p = 0.055 significance). It was also found that a larger effect of ozone on lung function (FVC and FEV_1) was experienced by female (FVC -.792 with P= .002, FEV_1 -.749, P=.005), as opposed to male (FVC-.541, P= .070 FEV_1 -.645, P= .023), participants. There was an association between O_3 concentration and decreased FVC and FEV_1. The association between O_3 and FEV_1 was significant during the period of the study with the stronger association of O_3 and FVC (-.945, P= .001) during dry season months and FVC (-.949, P=.014) and FEV_1 (-.894, P=.041) during wet season is likely to because of the high concentration of O_3 recorded during the study period. Therefore, the decreasing lung function observed is likely because of O_3 pollution [13]. A multiple regression test was used to predict FVC from O_3, temperature, wind, and relative humidity. The variables significantly predicted FVC, F (4, 7) = 4.725, p = .036, R^2=. 854. One variable (O_3) added statistical significance to the prediction increase in ozone concentration is negatively correlated with dyspnoea, FVC, and FEV1 in COPD and asthma patients. The difference was statistically significant.

Discussion

This study investigates the effects of O_3 concentration on COPD and asthma patients in Abuja, Nigeria among adult registered respiratory patients in the two hospitals used for the study. This has not been done in Abuja Nigeria and in most of the fields of other studies of O_3. Although exposure to air pollutants mixture is a characteristic of the environment that affects different populations. The same magnitude of Particulate matter-associated decline in lung function was observed for O_3 in this study. Findings from this research indicate that ozone concentrations affect respiratory conditions, and the effect was more on female residents compared to male residents. The findings also show that changes in ozone concentrations all through the year have varying effects on COPD and asthma patients and affect their daily experiences and conditions.

Also, the female group had the highest association with ozone compared to the male group, The strongest effects of O_3-8h exposure of respiratory disease. And the effects of O_3 concentration on COPD and asthma patients in the dry season were stronger. We did see a statistically significant association between O_3 and COPD and asthma patients in the wet season. Additionally, the season fluctuation of air pollution demonstrated that O_3 concentration had a stronger association with respiratory disease in dry season months than in wet season.

We observed that FVC and FEV_1 decreased with increased ozone concentration. Adams (2006) [14] in a human-controlled study observed a decrease in FEV_1 and FVC decrease after exposure to ozone. The predominant effect of ozone short-term exposure was observed as the inability to inhale full lung capacity. Also, controlled exposure studies illustrated that short-term exposure for ozone led to decreased FEV_1 and increased respiratory symptoms, including chest tightness, wheezing, and cough [4-14], which is similar to the findings in this study. Brown, Bateson and McDonnell (2008) highlighted the effect of O_3 on FEV_1 which is similar to the finding of this study and other studies that observed a significant decrease in FVC and FEV_1 [3-15]. Other studies that found FVC and FEV_1 decreased due to ozone exposure in both non-smokers and smokers and are consistent with the findings of this study include [2-4]. Kim et al. (2011) [4] found a decrease in FVC and FEV_1 in 59 healthy young adults after exposure to ozone concentration. Meanwhile, Bates et al. (2009 and 2014) observed that smokers and non-smokers had a similar decrease in FEV_1. Tsang et al. (2000) observed a small decline in FEV_1, in smokers following ozone exposure.

Some studies have indicated that both chronic and acute exposure to ozone decreases lung function, and repeated exposure aggravates symptoms, thereby exacerbating the existing respiratory condition [2-7]. On the contrary, Lagorio et al. (2006) [16] no association between ozone and FVC and FEV_1in adults with respiratory conditions. Moreover, many studies on the effect of ozone on health effect included sex, and in this study, we observed a significant correlation between O_3 and gender. The difference between male and female on the effect of ozone on FVC and FEV_1 showed there was a significant correlation between O_3 and female FEV_1 and FVC. The finding in this study is contrary to the study conducted by Doug et al. (2012) [17] which observed more effect in males than in females. However, the study by Kim et al. (2011) [4] observed a higher effect on lung function in females than in males.

Findings from this study show the relevance of functional impairment in evaluating health status in COPD patients and its effect on daily quality of life. Thus, COPD patients see their respiratory condition and functional impairment as general disabilities [18]. Also, from the study findings, it can be stated that interaction between ozone formations and particulate and meteorological conditions is possible. In the long term, this interaction could lead to a higher concentration of ozone and particulate pollution, a greater degree of lung malfunction, and a higher risk of worsening of existing respiratory conditions.

The significant rise in the mortality and morbidity rates during the photochemical smog incidence in Los Angeles [19], is an example of the adverse effect of the interaction between particulate and ozone pollution. The current climate condition of Abuja, Nigeria encourages the formation of ozone. Thus, there is a likely increase in potency from the pattern of ozone air pollution in exacerbating COPD symptoms in vulnerable patient groups in urban Nigeria. Our findings demonstrate that the interaction may have a significant effect on the respiratory health of residents. However, this is the first study conducted on the effect of ozone on respiratory health in Abuja, Nigeria at the time this study is conducted. In this study, ozone concentration varied each month, which is likely to influence respiratory conditions. The results show that there is an association between ozone, and decreased lung function (FVC and FEV_1). These findings are consistent with the results of previous studies [1-20].

This study also demonstrates that relative humidity and temperature show strong associations with respiratory disease, which were mainly constant in one direction and

produced various symptom severity levels. These findings exhibit that weather conditions associated with ozone formation are likely to affect respiratory symptoms in COPD and asthma adversely. Also, ozone association with respiratory patients in this study was statistically significant. High ozone concentrations have an effect on COPD and asthma.

This confirms the significance of symptoms in investigating COPD status, and the effect on daily life, as reported by Gold (2015) [21]. A significant effect was observed on both lung function and respiratory symptoms. Therefore, O_3 has an adverse effect on adult COPD and asthma patients, with a greater effect on females.

A benefit of our study is the repeated measurements of lung function and use of the dyspnoea scale and the daily diary recordings of symptoms, leading to a more precise assessment of these health effects. The application of multiple regression allowed this benefit to be exploited. Also, our study used a sample drawn from the registered adult COPD and asthma population, which allows an impact calculation of O_3 concentration applicable to the whole population of this age range and was applied in a location with high O_3 concentrations.

Our study had limitations. Only one pollutant was monitored and indoor O_3 pollution or personal exposure to O_3 were not monitored. Nevertheless, the NIMET monitoring site in Abuja does ensure that the concentrations of air pollutants used in this study are broadly representative of the area. This study only investigated the effect of O_3 on registered asthma and COPD patients registered in the hospitals used for this study. Demographic, socio-economic, or behavioural variables of the individual participants could be an area of further research.

Our results have valuable policy implications as O_3 is a secondary pollutant produced by the photochemical reaction and is harmful effects on lung function. In Nigeria, air pollution is a major environmental issue. Addressing the problem will be of great value to the general public.

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Competing interests: there is no competing interest.

Ethics approval and consent to participate
Ethical approval was obtained both from Sunderland University and Both hospitals used for this study

Consent for publication
The Consultants from the respective hospital and NIMET have given consent for the research to be published.

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