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# Potential health implications of exposure to non-combusted liquefied petroleum gas on vendors

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## Abstract

Exposures to environmental pollutants have been associated with respiratory diseases in humans and Continuous exposure to non-combusted liquefied petroleum gas (LPG) is suspected as a leading hazardous factor that might result in the development of impaired pulmonary functions. The study is aimed at assessing the effects of chronic exposure to non-combusted LPG on the prevalence of respiratory symptoms and appraising the potential pulmonary impairments among LPG vendors. Seventy five (75) apparently healthy LPG vendors and Seventy five (75) apparently healthy non LPG vendors, aged 18 to 50 years were recruited into this study. The Forced expiratory volume in 1second ($FEV_1$), forced vital capacity (FVC) and peak expiratory flow (PEF) were obtained using a Spirometer while $FEV_1$/FVC was calculated. Independent t-test was applied to determine the mean difference between the exposed and control groups at 5% level of significance. Chi-square test/Fisher's exact test was used to investigate all forms of associations in the study. The prevalence of respiratory symptoms in LPG vendors was highest in nasal irritation/sneezing (56%), followed by cough (53.3%), wheeze (40%) and chest tightness (26.7%), respectively. Only the symptoms of nasal irritation/sneezing and cough showed significant association with the LPG vendors ($P<0.05$). Association between respiratory symptoms and age, association between respiratory symptoms and duration of exposure were not significant ($P>0.05$). There was a recorded significant decrease in $FEV_1$, FVC, PEF except $FEV_1$/FVC for the LPG vendors ($P<0.05$) compared to the non LPG vendors. The health implications of exposure to LPG are high prevalence rate of respiratory symptoms (nasal irritation/sneezing and cough) and impaired pulmonary functions.

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## Introduction

The demand for energy has continued to be on the increase, not only in Nigeria but all over the world due to increasing population, standard of living and growth of agricultural and manufacturing industries. The major reoccurring effect of the increasing demand for energy is the air pollution, hence, the higher need for fuel shifting that is environmentally, ecosystem and health friendly (Thompson, 2018; Ajah, 2013). About three billion people worldwide who continuously depend on solid fuels, cooking and heating on open fires or traditional stoves are exposed to high levels of health-damaging pollutants including small particulate matter and carbon monoxide, sometimes exceeding accepted guideline values by a factor of 20. According to the WHO, household air pollution is responsible for 7.7% of global mortality or 4.3 million deaths, mostly in Asia and Sub-Saharan Africa (WHO, 2006). In 2010, household air pollution from solid fuels was the third leading risk factor for global disease burden contributing to 4.3%. Health problems linked to both indoors and outdoors air pollution from use of solid fuels include acute lower respiratory infections in children under five years, ischaemic heart disease, asthma, chronic obstructive pulmonary disease and lung cancer in adults (Thompson, 2018; Ferkol and Schraufnagel, 2014; Alphonsus and Adesuwa, 2014; Rehfuess, Eva and WHO, 2006). The overarching principle of the 2014 WHO guidelines on indoor air quality is that there is no “acceptable” level of air pollution, and even the lowest levels of air pollution are harmful to human health. Cleaner burning solid fuel cook stoves cannot achieve the WHO annual intermittent air quality target-1 (AQT-1) for particulate matter, set at 35 µg/m3 for PM2.5 (particulate matter less than 2.5 microns in aerodynamic diameter). In order to reach the AQT-1 for PM2.5 in areas with persistent high background levels of PM2.5, where household air pollution (HAP) contributes to outdoor (ambient) air pollution, community-level adoption of clean cooking technologies is essential. Consequently, the Liquefied petroleum gas (LPG) which is said to be clean-burning, efficient, versatile and portable fuel, produced as a by-product of natural gas extraction and crude oil refining appeared to be the answer to fuel shifting and is one of several pathways to meeting the objective of universal access to clean cooking and heating solutions by 2030; one of the three pillars of the UN Sustainable Energy for All (SE4All) initiative (Thompson, 2018). LPG is currently used predominantly by the upper half of the income groups in low and lower-middle-income countries and especially urban and suburban households. Thus, the byproducts of incomplete combustion of LPG which contains a considerable level of polycyclic aromatic hydrocarbons (PAHS), oxides of nitrogen (NOx), carbon monoxide (CO), and other compounds can cause undesirable health consequences (Cecelski and Matinga, 2014; Nazurah bt Abdul Walud, Balalla and Koh, 2014; Vainiotaloa and Matveinena, 1993). On the contrary, very limited studies in the literature made an attempt to assess the possible undesirable health effects due to exposure to non-combusted LPG.

Prior studies such as Kaur-Sidhu *et al.*, 2019; Svedah *et al.* 2009; Willers *et al.*, 2006; Corbo *et al.*, 2001; Moran *et al.*, 1999 predominantly assessed the effects of combustion by-products and cooking gas used in indoor environments and found that exposure to such fuel is associated with negative health effects including pulmonary functions reduction. Meanwhile, the studies of Fedak *et al.*, 2019; Quinn *et al.*, 2017; Pena *et al.*, 2015 investigated the effects of exposure to cooking gas on blood pressure and found possible hypertensive health implications among the exposed group. On the other hand, very little attention is given by previous studies to assess the effects of non-combusted LPG on vendors who are constantly exposed to it. However, Moitra *et al.*, 2014 made an attempt and understudied the effects of non-combusted LPG among those who refill cigarette lighters and observed that such practice may cause adverse health effects from LPG exposure among such workers. In addition, the study of Sirdah *et al.*, 2013 considered the effects of exposure to non-combusted LPG on haematological and biochemical parameters among workers and those LPG workers at Gaza Strip petroleum stations are at higher risk of health-related symptoms and clinical abnormalities.

Therefore, borrowing a leaf from the studies of Moitra *et al*., 2014 and Sirdah *et al*., 2013, this study seeks to identify the effects of chronic exposure to non-combusted LPG on the prevalence of respiratory symptoms and their associations between vendors, age of exposed group and duration of exposure.

The study also seeks to appraise the potential pulmonary impairments associated to non-combusted LPG in an occupational exposed group such as vendors who by virtue of the volume (being cooking cylinders) are heavily exposed than cigarette lighter fillers.

## Materials and methods

*Study Design*

A case control design in which vendors and non-vendors of LPG were used for the study. The sizes of cylinders refilled ranged from 4kg to 50kg. The amount sold per participant each day was obtained from their record books over the period of two weeks.

The average of this was 755kg and was taken to indirectly represent the daily LPG exposure since we were not able to directly determine the amount of LPG escaping into the ambient air. A total of 150 subjects were recruited which consist of seventy five (75) apparently healthy LPG (cooking gas) vendors and seventy five (75) apparently healthy non gas vendors/users (control).

The inclusion criteria for the exposed group were: residence in Calabar, Cross River State, Nigeria; age ranging from 18 to 50 years, having at least one year exposure to LPG and selling for at least 6 hours daily, and devoid of respiratory diseases history before commencing the trade.

The inclusion criteria for the control were: residence in Calabar, age ranging from 18 to 50 years, apparently healthy, no work-related exposure to LPG and devoid of history of hospitalization due to respiratory diseases. The purpose and nature of the research was explained to the participants and written consent was obtained.

*Subjects Selection*

A structured questionnaire was randomly administered to the participants to obtain information on age, family history, medical history, physical lifestyle, drug usage, occupation and duration on the job. Cooking gas vendors who consistently sold it at least for the past one year as at the time of this study and non LPG vendors /users who never sold or used gas (control) were recruited into the study.

*Lung function test*

The lung function of the participants was measured with a portable office SP10 Spirometer from Contec Medical Systems Company Ltd, China (Ghulam *et al*., 2017). It was calibrated following approved procedures (Moore, 2012). The following Lung function parameters were measured; forced expiratory volume in 1 second ($FEV_1$), forced vital capacity (FVC) and peak expiratory flow (PEF). $FEV_1$/ FVC ratios were mathematically calculated (Miller *et al*., 2005; Pretty and Enright, 2003; Kim *et al*., 2019).

*Data Analysis*

The Statistical Package for Social Sciences (SPSS) version 20.0 was used in performing the statistical analysis. Descriptive statistics was used to explore the characteristics of the subjects considered while independent t-test was used to study the difference in the means of cooking gas vendors and non-vendors. Chi-square test/Fisher's exact test was used to investigate the association between respiratory symptoms and LPG vendors, association between respiratory symptoms and age of LPG exposed group, association between respiratory symptoms and duration of exposure to LPG. Fisher's exact test was applied when more than 20% of cells have expected frequencies less than 5. For determination of significant difference, P-value of less than 5% significance level was considered statistically significant.

## Results

*Characteristics of Subjects*

Table 1 gives the description of the characteristics of the participants in the study. Hundred and fifty participants took part in the study, 75 were cooking gas vendors exposed to LPG and 75 non vendors not exposed to LPG. The SBP (122.97mm Hg), DBP (81.06mm Hg) and BMI (26.02kg/ m²) for the gas vendors are higher compared to the SBP (119.53mm Hg), DBP (78.89mmHg) and BMI (21.24kg/ m²) for the non-vendors with significant difference ($p<0.05$) in these subjects.

*Prevalence of Respiratory Symptoms among LPG Vendors*

Among the respiratory symptoms considered in LPG vendors, nasal irritation/sneezing has the highest rate of prevalence (56%), followed by cough (53.3%), wheeze (40%) and chest tightness (26.7%), respectively (Table 2).

**Table 1.** Description of Study Participants.

| Characteristics | Vendor N | Vendor Mean | Vendor SD | Non Vendor N | Non Vendor Mean | Non Vendor SD | T-value | P-value |
|---|---|---|---|---|---|---|---|---|
| SBP (mmHg) | 75 | 122.97 | 2.66 | 75 | 119.53 | 1.36 | 9.975 | < 0.001** |
| DBP (mmHg) | 75 | 81.06 | 3.19 | 75 | 78.89 | 1.32 | 5.455 | < 0.001** |
| BMI (kg/m²) | 75 | 26.02 | 4.85 | 75 | 21.24 | 3.06 | 7.216 | < 0.001** |

Abbreviations: LPG = liquefied petroleum gas, SD = standard deviation, SBP = systolic blood pressure, DBP = diastolic blood pressure, BMI = body mass index.

*Significant at .05 level; **Significant at .01 level.

**Table 2.** Prevalence of Respiratory Symptoms in LPG Vendors.

| Respiratory Symptoms | N | Frequency | Prevalence (%) |
|---|---|---|---|
| Wheeze | 75 | 30 | 40 |
| Cough | 75 | 40 | 53.3 |
| Chest tightness | 75 | 20 | 26.7 |
| Nasal irritation/Sneezing | 75 | 42 | 56 |

*Association between Respiratory Symptoms and LPG Vendors*

The prevalence of nasal irritation/sneezing and cough was found to be significantly associated with the LPG vendors given that the hypothesis of no association was rejected with probability value related to the Chi square ($\chi^2$) statistic is 0.001, respectively and is less than 5% significance level. Otherwise, the prevalence of wheeze and chest tightness appeared to show no significant association with the corresponding probability value being greater than 5% significance level (Table 3).

**Table 3.** Association between Respiratory Symptoms and LPG Vendors.

| | | Wheeze | | | Cough | | | Chest tightness | | | Nasal Irritation/Sneezing | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | Yes | No | Total | Yes | No | Total | Yes | No | Total |
| Vendor | Nonseller | 25 | 50 | 75 | 20 | 55 | 75 | 13 | 62 | 75 | 21 | 54 | 75 |
| | Seller | 30 | 45 | 75 | 40 | 35 | 75 | 20 | 55 | 75 | 42 | 33 | 75 |
| | Total | 55 | 95 | 150 | 60 | 90 | 150 | 33 | 117 | 150 | 63 | 87 | 150 |
| | $\chi^2$ | | 0.718 | | | 11.111 | | | 1.904 | | | 12.069 | |
| | P-value | | 0.094 | | | 0.001** | | | 0.237 | | | 0.001** | |

*Significant at .05 level; **Significant at .01 level.

*Association between Respiratory Symptoms and Age of LPG Exposed Group*

The respiratory symptoms were found to be independent of age at $P>0.05$ as shown in Table 4. The hypothesis of no association between respiratory symptoms and different age groups was not rejected. For chest tightness and age, Fisher's exact test was used since more than 20% of cells have expected frequencies less than 5. The Fisher's exact test value is 1.268 with the corresponding p-value of 0.781 greater 5% significance level. The Chi square ($\chi^2$) values for wheeze, cough and nasal irritation/sneezing against age are 1.147, 1.983 and 0.117 with the corresponding p-values of 0.776, 0.596 and 1.000 which are greater than 5% significance level.

**Table 4.** Association between Respiratory Symptoms and Age of LPG Vendors.

| | | Wheeze | | | Cough | | | Chest tightness | | | Nasal Irritation/Sneezing | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | Yes | No | Total | Yes | No | Total | Yes | No | Total |
| Age | 18-27 years | 9 | 12 | 21 | 11 | 14 | 25 | 5 | 17 | 22 | 12 | 9 | 21 |
| | 28-37 years | 6 | 14 | 20 | 9 | 8 | 17 | 5 | 16 | 21 | 10 | 9 | 19 |
| | 38-47 years | 8 | 10 | 18 | 10 | 5 | 15 | 5 | 14 | 19 | 12 | 9 | 21 |
| | 48 years and Above | 7 | 9 | 16 | 10 | 8 | 18 | 5 | 8 | 13 | 8 | 6 | 14 |
| | Total | 30 | 45 | 75 | 40 | 35 | 75 | 20 | 55 | 75 | 42 | 33 | 75 |
| | $\chi^2$/Fisher's Exact Test | | 1.147 | | | 1.983 | | | 1.268 | | | 0.117 | |
| | P-value | | 0.776 | | | 0.596 | | | 0.781 | | | 1.000 | |

*Association between Respiratory Symptoms and Duration of Exposure to LPG*

There was no association between respiratory symptoms and duration of exposure at (P>0.05) as shown in Table 5. The hypothesis of no association between respiratory symptoms and duration of exposure was not rejected given that the Chi square ($\chi^2$) values for wheeze, cough, chest tightness and nasal irritation/sneezing against duration of exposure are 3.606, 4.075, 0.663 and 1.347 with corresponding p-values of 0.176, 0.130, 0.758 and 0.515 which are greater than 5% significance level.

**Table 5.** Association between Respiratory Symptoms and Duration of Exposure.

| | | Wheeze | | | Cough | | | Chest tightness | | | Nasal Irritation/ Sneezing | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Yes | No | Total | Yes | No | Total | Yes | No | Total | Yes | No | Total |
| Duration of Exposure | 1-3years | 10 | 19 | 29 | 13 | 17 | 30 | 7 | 22 | 29 | 15 | 14 | 29 |
| | 4-6 years | 8 | 17 | 25 | 15 | 6 | 21 | 6 | 19 | 25 | 13 | 12 | 25 |
| | Above 6 years | 12 | 9 | 21 | 12 | 12 | 24 | 7 | 14 | 21 | 14 | 7 | 21 |
| | Total | 30 | 45 | 75 | 40 | 24 | 75 | 20 | 55 | 75 | 42 | 33 | 75 |
| | $\chi^2$ | | 3.606 | | | 4.075 | | | 0.663 | | | 1.347 | |
| | P-value | | 0.176 | | | 0.130 | | | 0.758 | | | 0.515 | |

*Comparison of Pulmonary Function Indices between Gas Vendors and Non vendors*

The results of the findings of lung function test as indicated in Table 6 showed that the means of $FEV_1$, FVC and PEF were higher in the non-vendor group (FEV1: 3.594±0.702; FVC: 3.789±0.679; $FEV_1$/FVC: 0.390±0.971; PEF: 7.117±1.397) except $FEV_1$/FVC as compared with the vendor group ($FEV_1$: 1.925±0.637; FVC: 2.037±0.738; $FEV_1$/FVC: 1.009±0.124; PEF: 4.151±1.258). The assessment shows a significant decrease in the pulmonary function indices ($FEV_1$, FVC and PEF) of the vendors with the respective p-value of 0.001 which is less than 5% significance level with exception to $FEV_1$/FVC whose p-value is 0466.

**Table 6.** Pulmonary Function Assessment.

| Parameters | Vendor N | Vendor Mean | Vendor SD | Non Vendor N | Non Vendor Mean | Non Vendor SD | T- value | P- value |
|---|---|---|---|---|---|---|---|---|
| FEV1 (liters) | 75 | 1.925 | 0.637 | 75 | 3.594 | 0.702 | -15.255 | < 0.001** |
| FVC (liters) | 75 | 2.037 | 0.738 | 75 | 3.789 | 0.679 | -15.136 | < 0.001** |
| FEV1/FVC | 75 | 1.009 | 0.124 | 75 | 0.390 | 0.971 | 0.229 | 0.466 |
| PEF | 75 | 4.151 | 1.258 | 75 | 7.117 | 1.397 | -13.665 | < 0.001** |

Abbreviation: FEV1 = forced expiratory volume in one second, FVC = forced vital capacity, FEV1/FVC = FEV1, FVC ratio, PEF = peak expiratory flow, SD = standard deviation.

## Discussion

Acute inhalation of liquefied petroleum gas (LPG) has been associated with death through respiratory system attacks (Ferkol and Schraufnagel, 2014).

In this study, a chronic exposure to LPG is considered. As indicated in Table 1, it is revealed that there is an increase in SBP (mmHg), DBP (mmHg) and BMI (kg/ m²) among the gas vendors.

These findings are in tandem with the works of Fedak *et al.*,2019; Quinn *et al.*, 2017; Pena *et al.*, 2015; Sirdah *et al.*, 2013 in terms of the rise in the SBP and DSP with significant difference compared with the control group.

The respiratory symptoms such as wheeze, cough, nasal irritation/sneezing and chest tightness were found to be prevalent in LPG exposed group as indicated in Table 2. The prevalence was found to be highest in nasal irritation/sneezing followed by cough, wheeze and chest tightness. These findings agree with the works of Kaur-Sidhu *et al.*, 2019, and Nazurah bt Abdul Walud, Balalla and Koh, 2014 that vendors exposed to LPG are at higher risk of health-related symptoms.

A significant association between the prevalent respiratory symptoms (nasal irritation/sneezing and cough) and the vendors of LPG was recorded as shown in Table 3. These findings provided enough evidence that revealed that nasal irritation/sneezing and cough are common among LPG vendors than non-vendors of LPG. The studies of Kaur-Sidhu *et al.*, 2019, Nazurah bt Abdul Walud, Balalla and Koh, 2014 only showed a significant association between cough and the exposed group compared to this particular study that recorded a significant association between the exposed group and nasal irritation/sneezing in addition to cough.

This study could not provide sufficient evidence to show that respiratory symptoms are associated with age of the exposed group and duration of exposure as indicated in Table 4 and 5, respectively. That is to say, irrespective of the age group or duration of exposure, the exposed group would exhibit respiratory symptoms. Meanwhile, the study of Nazurah bt Abdul Walud, Balalla and Koh, 2014 showed that the respiratory symptom (cough) was significantly associated with duration of exposure for more than 10 years. In the current study as indicated in Table 6, significant differences were found in pulmonary function indices between LPG vendors and non-vendors (control) except FEV1/FVC.

Similarly, different studies have provided evidence of negative effects of health conditions including impaired pulmonary function as a result of indoor exposure to cooking gas (Kaur-Sidhu *et al.*, 2019; Svedah *et al.*, 2009; Willers *et al.*, 2006; Corbo *et al.*, 2001; Moran *et al.*, 1999 and Sirdah *et al.*, 2013).

The major implication of this study is the creation of awareness on the hazardous health effects of continuous and unchecked exposure to non-combusted LPG on vendors which include prevalence rate of respiratory symptoms and impaired pulmonary function indices. In addition, the study further provides evidence that could help in designing and implementing policy to protect and promote health of LPG vendors.

*Strengths and Limitations of the Study*

The study is able to establish that chronic exposure to LPG could be a major source of respiratory symptoms and reduced pulmonary functions among vendors but failed to identify and appraise the possible coexistence and interaction of two or more respiratory symptoms in each participant in the exposed group.

## Conclusion

In summary, the findings of this study revealed that the vendors of LPG are at higher risk of health-related symptoms (such as nasal irritation/sneezing and cough) and reduced pulmonary functions. It is recommended that this work could be improved by considering increase in sample size and assessing the possible coexistence and interaction of two or more respiratory symptoms in LPG vendors.

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