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Research Article

Exposure to Wood Smoke Accentuates Risk of Respiratory Diseases: A Case of Charcoal Workers in a Developing Nation, Sub-Sahara Africa

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Abstract

Background: Wood smoke is emitted during charcoal production and has components similar to those of oil fumes; thus it inflames the respiratory tract and induces respiratory diseases with repeated and continuous inhalation. Estimating the risk of lung diseases among charcoal workers became more expedient since they are exposed to a gamut of toxic pollutants.

Methods: The study was conducted among 65 charcoal workers and 130 suitably matched controls in a semi-urban community in Niger-Delta, Nigeria by adopting a cross-sectional analytic design. A modified MRC questionnaire and portable spirometer were employed for data collection. Data was analysed with SPSS version 22 and odds ratio was applied to estimate the magnitude of association between being a charcoal worker and respiratory problems.

Results: All symptoms suggestive of tuberculosis were present majorly among charcoal workers and the association between being a charcoal worker and symptoms were significant ($p < 0.001$). About a tenth of charcoal workers separately had tuberculosis and asthma but these were absent among controls; and the association between these lung diseases and exposure to wood smoke was significant ($p < 0.001$). Chronic obstructive airway disease detected by spirometry was recorded among 26 (17.6%) of charcoal workers with majority having moderate disease.

Conclusion: Charcoal workers have increased risk for lung diseases such as tuberculosis, asthma and COPD thus policies on preventive measures need to be formulated and instituted for their lifelong health benefit.

Keywords: *Wood Smoke; Respiratory Diseases; Charcoal Workers*

Introduction

The production of wood charcoal dates back to several centuries ago when it was a major energy supply in most parts of Asia and Europe. Its use was very popular in the 'Bronze age' because it provided energy that was useful in refining and amalgamation of iron, tin and bronze, thus many of the industries in that era required it for its high energy value - a gram of charcoal releases twice the energy a gram of wood can generate [1]. Even in the nineteenth century some first world countries continued to use charcoal as a prominent fuel for powering the manufacture of metals including ornamentals. In these settings, charcoal has largely been replaced by 'cleaner fuels' such as fossil fuel, nuclear energy, hydroelectric power etc. However, in many parts of the developing world it is still being used for the production of metals and it is a major domestic fuel in sub-Sahara Africa [2].

Wood smoke is emitted during charcoal production and has components similar to those oil fumes; thus it inflames the respiratory tract and induces respiratory diseases following repeated and continuous inhalation [3-5]. In addition, a significant proportion of the world's population who consume biomass for cooking meals and heating homes are exposed to inhaling contaminated air from domestic combustion of this essential energy source. Moreover, bush burning and wildfire also expose people to wood smoke thus occupational groups such as fire fighters, are also at risk of suffering harmful health effects on their respiratory system [6,7].

Evidence from studies conducted in South America, Asia and Nigeria suggest that individuals exposed to wood smoke have increased risk for lung diseases [8-11]. The danger of inhaling wood smoke is further exemplified by reports from a study conducted by the United States Environmental Protection Agency in which burning 4.5 kilograms of wood generated toxic substances much more than 30 sticks of cigarettes [12]. The damage that inhalation of wood smoke causes to human health cumulatively snowballs into other diseases not directly related to the toxic chemicals in wood smoke, probably due to defects in the mucociliary action of the respiratory tract or an excessive mucus production which invariably increases susceptibility to respiratory infections [13]. Thus, estimating the risk of lung diseases among charcoal workers has become more expedient, since they are exposed to a gamut of toxic pollutants, with the hope that this study will provide baseline data to substantiate the need for formulation of policies for the prevention of the hazard of exposure to wood smoke from charcoal production.

Methods

The study was carried out in a semi-urban community in Niger-Delta, Nigeria by adopting a cross-sectional analytic design to draw attention to the risk of lung diseases among charcoal workers. All consenting charcoal workers excluding biomass users and smokers were group-matched for age and sex with controls (two controls to one charcoal worker) who recruited from traders in a municipal market using a simple random sampling method by balloting. Controls who declined from giving consent, had previous work-related exposure to wood smoke, domestic users of biomass and smokers were not included in the study. A total of 65 charcoal workers and 130 controls who satisfied the eligibility criteria participated in the study however, 8 charcoal workers and 3 controls had to withdraw from the study as they could not satisfactorily perform the spirometric manoeuvres despite repeated coaching, and encouragement.

Presence of respiratory disorders was determined based on respiratory symptoms, history of previous illness and spirometry. A modified Medical Research Council (MRC) Questionnaire was applied to interview respondents on respiratory symptoms and history previous respiratory disorders [14]. Diagnosis of chronic obstructive lung diseases was based on a forced expiratory ratio of less than 70% and predicted forced expiratory volume in the first second of ≤ 80% with severity categorised as mild (predicted FEV1 ≤ 80%), moderate (predicted FEV150 - 79%), severe (predicted FEV1: 30 - 49%) and very severe (predicted FEV1 < 30%).

Collected data was analysed with SPSS version 22; and categorical data was expressed in percentages while odds ratio was applied to estimate the magnitude of association between exposure to wood smoke and respiratory illness. Smokers and biomass users were excluded in the final analysis that illustrated prevalence of respiratory diseases.

Ethical approval was obtained from the Health Research Ethics committee of Delta state University Teaching. Participation in the study was entirely voluntary and informed consent was obtained from each respondent before being enlisted for the study.

Results

A total of 65 charcoal workers and 130 controls; 13 participants had to withdraw in the course of the study and they have no results apart from age and sex, thus the response rate for other results was 93.3%. Over a quarter (27.2%) of all participants was aged 20 - 29 and there are more females than males (64.6% vs. 35.4%). The age and sex distribution of participants were not significantly dissimilar between charcoal workers and controls ($p > 0.05$) (Table 1).

Variables*		Traders and charcoal workers		Total
		Charcoal Workers (n = 60)	Controls (n=130)	
Age	20 - 29	18 (27.7)	35 (26.9)	53 (27.2)
	30 - 39	10 (15.4)	36 (27.7)	46 (19.9)
	40 - 49	19 (29.2)	20 (15.4)	39 (23.6)
	50 - 59	10 (15.4)	26 (20.0)	36 (18.5)
	≥ 60	8 (12.3)	13 (10.0)	21 (10.8)
		X^2 = 7.660; p = 0.105		
Sex	Male	21 (22.8)	48 (36.9)	69 (35.4)
	Female	44 (77.2)	82 (63.1)	126 (64.6)
		X^2: 0.404; p < 0.525; OR: 10.2 (CI: 0.41 - 1.60)		

Table 1: *Socio-demographic characteristics.*

All symptoms suggestive of tuberculosis were present majorly among charcoal workers and the association between being a charcoal worker and symptoms were significant (p < 0.001). At a tenth of charcoal workers had tuberculosis and asthma respectively but no controls reported having had these medical conditions; and the association between these lung diseases and exposure to wood smoke was significant (p < 0.001). Chest illness in the last three years and a excessive sputum production were only present among charcoal workers (p < 0.017) (Table 2). A significantly higher proportion of charcoal workers had Obstructive lung function defect (33.3% vs. 9.4%) and COPD (36.8% vs. 15.4%); and they were more than three times as likely as non-exposed controls to have these respiratory complications (p = 0.001). However, charcoal workers were as likely as their controls to have restrictive lung function defect though the association between the two groups and restrictive lung defect was significant (p = 0.687) (Table 3). Severity of chronic obstructive airway disease detected by spirometry was recorded among 26 (17.6%) of charcoal workers with majority having moderate disease (Table 2).

Variables*		Traders and charcoal workers		Total
		Charcoal Workers (n = 57)	Traders (n = 127)	
Likely symptoms of Tuberculosis				
Weight loss	No	51 (89.5)	127 (100.0)	178 (96.8)
	Yes	6 (10.5)	0 (0.0)	6 (3.2)
		X^2 = 10.684	p = 0.001	OR:N/A
Drenching night sweats	Yes	8 (14.0)	2 (1.6)	10 (5.4)
	No	49 (86.0)	125 (98.4)	174 (94.6)
		X^2: 10.172; p: 0.001; OR: 12.21 (CI: 2.09 - 49.75)		
Unexplained fatigue	Yes	13 (22.8)	3 (2.4)	16 (8.6)
	No	44 (77.2)	124 (97.6)	168 (91.4)
		X^2: 16.713; p < 0.001; OR: 10.2 (CI: 3.32 - 44.88)		
Chest pain with cough	No	51 (89.5)	127 (100.0)	178 (96.7)
	Yes	6 (10.5)	0 (0.0)	6 (3.3)
		X^2 = 10.684	p = 0.001	OR:N/A
History of respiratory disease				
Pulmonary tuberculosis	No	51 (89.5)	127 (100.0)	178 (96.7)
	Yes	6 (10.5)	0 (0.0)	6 (3.3)
		X^2 = 10.684	p = 0.001	OR:N/A
Asthma	No	51 (89.5)	127 (100.0)	178 (96.7)
	Yes	6 (10.5)	0 (0.0)	6 (3.3)
		X^2 = 10.684	p = 0.001	OR:N/A
Pneumonia	No	55 (96.5)	127 (100.0)	182 (98.9)
	Yes	2 (3.5)	0 (0.0)	2 (1.1)
		X^2 = 1.657	p = 0.168	OR:N/A
Other symptoms/conditions				
Excessive phlegm production?	No	53 (93.0)	127 (100.0)	180 (97.8)
	Yes	4 (7.0)	0 (0.0)	4 (2.2)
		X^2 = 5.694; p = 0.017; OR: N/A		
Any chest illness in 3 years	No	53 (93.0)	127 (100.0)	180 (97.8)
	Yes	4 (7.0)	0 (0.0)	4 (2.2)
		X^2 = 5.694; p = 0.017		OR:N/A

Table 2: *Risk of respiratory diseases among study participants.*

**All biomass users as well as smokers were excluded; OR: Odds Ratio; N/A: Not Applicable*

		Charcoal workers and controls		Total
Variables		**Charcoal Workers**	**Controls**	
Severity of COPD	Mild	7 (26.9)	8 (40.0)	15 (32.6)
	Moderate	19 (73.1)	11 (55.0)	30 (65.2)
	Very severe	0 (0.0)	1 (5.0))	1 (2.2)
		X^2 = 2.828	p = 0.243	
Obstructive lung function defect	Present	19 (33.3)	12 (9.4)	31 (16.8)
	Absent	38 (66.7)	115 (90.6)	153 (83.2)
		X^2 = 12.048; p = 0.001; OR: 3.87 (1.63 - 9.43)		
COPD	Present	26 (36.8)	20 (15.4)	46 (24.6)
	Absent	31 (63.2)	110 (84.6)	141 (75.4)
		X^2 = 13.551; p < 0.001; OR: 3.49 (1.66 - 7.33)		
Restrictive lung function defect	Present	31 (63.2)	65 (51.2)	96 (52.2)
	Absent	26 (36.8)	62 (48.8)	88 (47.8)
		X^2 = 0.162; p = 0.687; OR: 1.14 (0.58 - 2.24)		
Restrictive-obstructive lung function defect	Present	6 (10.5)	10 (7.9)	16 (8.7)
	Absent	51 (89.5)	117 (92.1)	168 (91.3)
		X^2 = 0.349; p = 0.578*; OR: 1.38 (0.39 - 4.44)		

Table 3: *Lung function defect and chronic obstructive pulmonary disease.*

*OR: Odds Ratio; *Fischer's exact*

Discussion

Charcoal workers and their controls were similar in their demographic characteristics and are thus comparable in factors that may introduce a confounding effect in the risk of lung diseases among them. In this study charcoal workers persistently experienced an increased risk for tuberculosis as evidenced by the higher prevalence of chest pain associated with cough, drenching night sweats and weight loss; in addition the odds of some symptoms were high among the exposed group. And, the fact that the association between these symptoms and wood smoke exposure was significant substantiates the assertion of higher probability of pulmonary tuberculosis occurring in these workers especially because wood smoke weakens pulmonary defence against infective organisms [15,16].

Pulmonary tuberculosis is usually endemic and highly prevalent in Nigeria, a country with one of the highest burden of the disease. Nevertheless, the fact that that one-tenth of charcoal workers had disease in the absence of same in the controls makes it plausible that the risk of infectious lung diseases predominates with exposure to wood smoke. The above claim is given credence by the prevalence of pneumonia among these workers and further highlights the untoward risk of inhaling wood smoke and its link with respiratory disease [17].

Asthma being obstructive lung impairment was recorded among a tenth of the workers, a finding that suggests charcoal workers may be prone to repeated exacerbation of this underlying health condition and portends a danger to their health and future survival [18].

Wood smoke-exposed workers were more likely than their unexposed controls to develop COPD and obstructive lung defect. This finding does not differ that reported from China, where wood smoke has been implicated as a likely cause of COPD [19]. Similarly in India, Mexico and Nigeria the risk of COPD increases with exposure to wood smoke [8,11,20]. Nonetheless, the results of this study did not demonstrate the wood smoke is associated with a higher severity of COPD as majority of charcoal workers with COPD had moderate disease.

The foregoing therefore suggests that obstructive lung function pattern may be the prevailing respiratory disorder among these workers even though a higher proportion had restrictive rather than obstructive lung function defect. A mixed picture of restrictive and obstructive lung function defects is not unlikely in this group of patients and this probably accounts for the apparently absolute presence of lung function defects in all workers. Thus, exposure to wood smoke portends danger to the respiratory function of charcoal workers and this finding would be contributory to evidence that could inspire policy formulation for establishing preventive measures for these workers.

Conclusion

Workers exposed to wood smoke had a higher risk for infectious and non-infectious lung diseases than their controls. Risk for pulmonary tuberculosis, COPD and obstructive lung function defect predominated among charcoal workers however some participants had restrictive in addition to a mixed pattern of lung function defect. Thus, policies on preventive measures need to be formulated and instituted for their lifelong health benefit.

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