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ABSTRACT

Objective: **To investigate the occupational effects of Arc-welding on small scale welders in Modakeke, Ile-Ife, Nigeria.**
Design: **A community-based, cross-sectional study.**
Setting: **A semi-urban area Modakeke, Ile-Ife, Nigeria.**
Population: **A semi-urban area with a population of about 300,000 (three hundred thousand).**
Study population: **Forty four Arc-welders in Modakeke, Ile-Ife and fifty age and sex-matched controls working in the Maintenance Department of Obafemi Awolowo University, Ile-Ife, Nigeria.**
Intervention: **Structured questionnaires adapted from the Medical Research Council, UK respiratory questionnaire with some modifications were administered to all subjects and controls. Physical examination and lung function tests were also carried out on all subjects and controls.**
Main outcome measures: **Occupational-related symptoms of welders and controls were compared. Ventilatory function of welders and controls were also compared using the Student's 't'-test. Chi-square was adopted to test the strength of relationship between smoking and lung function abnormalities.**
Results: **The most frequent symptoms found among the subjects were eye irritation (95.43%), rhinitis (50.09%) and skin irritation (43.19%). The arc-welders were found to have characteristically lower lung function parameters than controls ($p<0.05$). Ten (22.7%) of the subjects had obstructive lung disease compared to four (8%) of the controls; while 18 (40.9%) of the subjects had restrictive lung disease. Their lung abnormalities had no relationship to their smoking history.**
Conclusion: **Workers exposed to arc-welding are at risk of occupational-related symptoms and chronic lung disease. Adoption of protective devices and monitoring of welders' breathing zones for toxic levels of gases and fumes are necessary to reduce the risk associated with arc-welding.**

INTRODUCTION

Welding is a generic term referring to the union, by various processes, of pieces of metal at joint faces. The use of welding has increased in recent years, chiefly in the form of fusion welding. However, newer methods of welding are replacing the old methods in industrialised nations. In arc-welding, an electric current flows between electrode and the pieces of metal to be welded. The temperature is about 4000°C when the pieces fuse together. Most conventional arc-welding is done manually by means of a covered (water) consumable electrode held in an electrode holder.

Fumes given off when certain coated or treated metals are welded may be dangerous, especially to the respiratory system(1). In view of this, precautions are required for protection from hazards of ozone, carbon-monoxide and phosgene.

Investigations into occupational health problems of workers in diverse fields have been conducted at various times in our environment(2,3); however, studies on arc welding in Nigeria are scarce. The main objective of the present study was to determine the influence of welding on the pulmonary function of arc welders in Modakeke, Ile-Ife and to suggest measures aimed at preventing chronic lung disability in this group of workers.

MATERIALS AND METHODS

Arc-welders working in Modakeke, a sub-urb of the ancient city of Ile-Ife, Nigeria, were recruited for the study. To be included in the study, workers must have had no respiratory disorders prior to employment and they must have been directly involved in the process of arc-welding. The workers were notified through their union leader and a date was fixed for the study; this date coincided with their monthly membership union meeting. Forty four arc-welders were finally selected for the study. This was a convenient sample size because it represented 95% of the total work force of welders in Modakeke.

The control group consisted of fifty adult males resident in Ile-Ife. Their line of duty was general maintenance work at the

Obafemi Awolowo University Maintenance Unit. None of the controls had any history suggestive of chronic respiratory disease. None of them were smokers at the time of the study; however two of them had been light-smokers who had stopped smoking for over two years.

A questionnaire was employed in obtaining the necessary data. The section dealing with respiratory illness was adapted from the Medical Research Council (MRC) respiratory questionnaire(4), with some modifications. Questions asked related to demographic data, occupational history and personal habits such as smoking. Smokers were defined as those who smoked at least one cigarette a day or its equivalent in other tobacco products; while ex-smokers were those who had ceased smoking for at least six months before the study. Non-smokers were those who never smoked or had smoked not more than one cigarette in their lifetime. Four trained research assistants carried out the interview in both English and the local language. The permission of the local ethical committee was obtained before the commencement of the study.

Physical examination and lung function tests were carried out at the worksite of both the arc-welders and the controls. Measurements of the standing height and weight were taken without shoes and with light clothing. Spirometric measurements were performed using the vitalograph wedge spirometer (Vitalograph Ltd., Buckingham). At least three curves (meeting the American Thoracic Society standard) were required from each subject for analysis. The best spirogram was used to obtain the Forced Vital Capacity (FVC) and the Forced Expiratory Volume in one second (FEV_1). All were corrected to body temperature and pressure saturated with vapour (BPTS). Peak Expiratory Flow (PEF) was measured using the Wright Peak Flow Meter (Clement Clarke, UK). The highest value attained after three attempts was recorded.

Analysis: Evaluation of the pattern of lung function abnormality was based on the American Thoracic Society statements on lung function testings. Subjects whose ventilatory ratio were less than 70 per cent (FEV/FVC%<70%) were categorised as having an obstructive pattern of lung function. Those whose vital capacity (VC) were reduced as suggested by their predicted FVC values of less than 80%(6) and whose ventilatory ratio were normal or raised (FEV/FVC%>70), were categorised as having a restrictive ventilatory defect.

The results were given as means (±SD). The means of the lung functions were compared with the controls using the Student's t-test. Chi-square was also adopted to test the strength of relationship between smoking and lung function abnormalities. A significant level was put at a 'p' value of less than 0.05 ($p<0.05$). The data were processed with the use of Statistical Package for Social Sciences 9.0 (SPSS) and Microsoft Excel Windows 2000.

RESULTS

The demographic characteristics and smoking habits of the subjects and controls are shown in Table 1. The age of the subjects ranged between 15 and 56 years with a mean of 32.52±9.68; while that of the control group ranged between 20 and 58 years with a mean of 28.92±9.13. Though the age difference of the subjects was slightly higher than that of the controls, the observed difference was not statistically significant.

The height of the subjects ranged between 1.47 and 2.7 metres with a mean of 1.72±0.56; while the mean height of the control group was 1.71±0.0054, with a range of 1.50 and 1.89 metres. However, the observed difference was not statistically significant.

Table 1

Characteristics of Arc-welders and control group

	Subjects n=44	Control n=50	P value	Statistical analysis 't' test
Age (year) mean ± SD	32.52±9.68	28.92±9.13	0.067	P>0.05
Height (m) mean ±SD	1.72±0.56	1.71±0.054	0.95	P>0.05
Weight (kg) mean ±SD	58.74±9.76	61.6±5.72	0.08	P>0.05
Smoking habits:				
Non-smokers	36	43		
Ex-smokers	8	7		
Current smoker	0	0		

The weight of the subjects ranged between 38kg and 80kg; while the mean was 58.74±9.76kg. In the case of the control group, the weights ranged between 47kg and 73kg while the mean was 61.6±5.72kg. The observed difference in the weight was not statistically significant ($p>0.05$). The occupational-related symptoms recorded among the subjects and controls are shown in Table 2. Of the 45 arc-welders, 42 (95.45%) reported eye symptoms, 26 (50.09%) had rhinitis, 19 (43.18%) had skin irritation while 13 (29.55%) had cough with sputum. Other symptoms complained of included dizziness and back pain. The effect of arc-welding on occupational-related symptoms was found to be statistically significant ($\chi 2 = 41.69$, df = 7, $p = 0.00$). Most of the symptoms were found among the arc-welders when compared to the controls.

Table 2

Occupational-related symptoms in Arc-welders

Symptoms	No. of workers affected n=44	No. of controls n=50	P value	Statistical analysis ($\chi 2$)
Cough with sputum production	13 (29.55%)	7(14%)		
Rhinnitis	26 (59.09%)	0		
Chest pain	5 (11.36%)	3(6%)		
Chest tightness	1 (2.27%)	0	0.00	P<0.05
Eye irritation	42 (95.45%)	0		
Skin irritation	19 (43.18%)	0		
Dizziness	10 (22.27%)			
Back pain	10 (22.27%)	0		

Table 3 shows the lung function of the welders and controls. The arc-welders recorded significantly reduced lung function parameters when compared with controls. The pattern of lung function abnormality is presented in Table 4. Ten (22.7%) of the subjects had obstructive lung defects as compared to only four (8%) of the controls. Eighteen (40.9%) of the subjects had restrictive defects as compared to none of the controls.

Table 3

Ventilatory functions or subjects and controls

	Subjects n=44	Control n=50	P value	Statistical tests
PEFR	413.30±74.9	525.2±66.9	0.001	P<0.05
FEV_1 (L/min)	2.47±0.52	3.05±0.74	0.001	P<0.05
FVC	3.09±0.77	3.49±0.82	0.025	P<0.05
FEV/FVC	82.11±16.83	82.42±10.07	0.004	P<0.0

Table 4

Lung impairments in arc-welders and control group

Lung impairment	Subjects n= 44	Control n=50	P value	Statistical tests ($\chi 2$)
Restrictive pattern	18 (40.9%)	0	0.028	P<0.05
Obstructive pattern	10 (22.7%)	4 (8%)		
Normal lung function	16 (26.4%)	46(92%)		

Table 5

Length of employment and lung function impairment of arc-welders

Length of service (yrs)	Obstructive disease n=10	Restrictive disease n=18
<9 years	0	10 (55.6%)
≥10 years	10 (100%)	8 (44.4%)

The effect of duration of arc-welding on lung function abnormalities is presented in Table 5. The mean number of years in employment was 13 years. Eighteen (40.9%) of the subjects had restrictive lung abnormality, out of which 10 (22.7%) of them had the abnormality within the first nine years of employment. The remaining eight (18.2%) subjects had the abnormality after nine years of employment. The effect of early exposure of arc-welders on restrictive lung abnormality was subjected to statistical analysis and was found to be statistically significant ($\chi 2$= 6.25, df= 1, p = 0.012). However, in the case of obstructive lung defect all the subjects affected developed the abnormality after nine years of employment.

Table 6

Smoking and lung function impairment of arc-welders

Smoking status	Obstructive n=10	Lung disease n=18	Restrictive lung disease
Non-smokers	8 (80%)	15 (83.33%)	
Ex-smokers	2 (20%)	3 (16.67%)	

The effect of smoking on lung function impairment was studied. As shown in Table 6, of the 10 subjects with obstructive lung disease, eight (80%) were non-smokers while two (20%) were ex-smokers. Similarly, out of the 18 subjects with restrictive lung disease, 15 (83.33%) were non-smokers while only three (16.67%) were ex-smokers. The results show that the relationship existing between smoking and lung function abnormalities recorded among the subjects was quite weak for obstructive ($\chi 2$ = 0.35, df=1, p=0.554) and for restrictive lung disease ($\chi 2$=1.36, df=1, p=0.243)

Most of the subjects were not using personal protective devices such as gas mask, eye protectors and aprons during the work processes. The workshops of most of the welders were located by the road-side and their workspaces were poorly ventilated.

DISCUSSION

Small-scale industries account for a large portion of the manufacturing activities in the developing countries(7). Arc welding is a common practice in most of the developing countries; however there are few studies that have looked into the potential hazards of this form of welding. Various studies in the industrialised countries have reported an increase in respiratory symptoms, usually of the acute type. These symptoms depend on the degree of exposure to fumes released during welding(8,9).

A survey of 209 arc-welders and 109 controls showed evidence of differences from controls in FEV_1 of 200 millilitres in smokers and 350 millilitres in non-smokers(10). Another review of 119 welders and 90 controls matched for age and height as well as smoking history, showed that there were more significant symptoms in the welders and a slight elevation in both closing volume and lung capacity(11). This shows a predominantly small airway disease. Another study of 83 stainless steel welders, and 29 mild steel welders, indicated that decrements in flow rates and possibly in Carbon Monoxide Diffusing Capacity (DLCO) occurred in relation to length of exposure to manual metal arc-welding which is a relatively high-fume process(12). Other comparisons between arc-welders and controls from the same plant, but not welding, show a high level of respiratory symptoms in both groups; but no major lung function test differences between them(13). Hayden *et al*(14) compared 258 welders and age matched controls. They showed no difference in pulmonary function; however, there were more work absences and respiratory symptoms among the welders. In a subset of 186 of the welders, there were significant differences in the lower part of the Maximum Expiratory Flow Volume (MEFV) curves between the welders and controls with the same smoking history. Non-smoking welders were not abnormal in this respect. In this study, the arc-welders reported high levels of occupational related symptoms when compared to controls. Highest of these were eye irritation and rhinitis; other symptoms included skin irritation, cough and sputum production. Arc-welding is known to release gases, which are toxic respiratory irritants; and exposure to ultraviolet radiation emanating from welding arcs lead to skin irritation and in some cases, dermatological diseases(15).

Our findings are in accordance with those of Oleru and Ademiluyi(15) in their study on acute and long-term exposure in welding and thermal cutting operations in Nigerians. They reported a high rate of occupational-

related symptoms in their welders; predominantly, eye and skin irritations. Also, our previous study on gas welders(4) showed prevalence of occupational-related symptoms of which eye irritation was the most frequent complaint. In our current study, the arc-welders were found to have characteristically lower lung function parameters when compared to control. Restrictive lung pattern was the predominant ventilatory defect noticed among the welders. Eighteen (40.9%) of them had the abnormality while ten (22.7%) of them had the obstructive pattern of the ventilatory defect. It is noteworthy from this study that the pattern of lung disease is influenced by years of employment. All the subjects who developed the obstructive pattern of lung disease had it after nine years of employment, as contrasted to those with restrictive lung disease. It appears that the early effects of exposure to arc-welding is to produce a restrictive lung disease; although later a mixed pattern, may emerge. We intend to follow up these patients for a few more years in order to conclusively determine the long-term effect of exposure to arc-welding. None of the controls had restrictive disease, but four (8%) had obstructive disease. These changes cannot be accounted for by smoking. There were very few ex-smokers among the welders and controls. Most of them were light smokers who smoked for a very short duration. However, this study is in contrast to our previous work on gas welders where only four (8.8%) had obstructive disease and three (6.67%) had restrictive disease. Most of our subjects either did not use any protective devices or used them infrequently. Many of the workers complained of the hot and humid conditions which made it difficult for them to use personal protectors such as respirators and aprons which are usually uncomfortable under these conditions. The costs of these protectors are also out of reach of the average welder. Some of these workers worked in confined spaces, thereby increasing their risk of inhaling toxic doses of the fumes. Subjects exposed to toxic doses of fumes are known to develop abnormal lung defects of both the restrictive and obstructive patterns(16). However, subjects who are exposed to large doses of fumes and gases may develop lung function abnormalities earlier than expected. In our study, we could not quantify the degree of exposure of each of the subjects because there were no gas or particulate analysers. We hope to pursue this in future studies.

An efficient way of preventing health impairment from exposure to harmful agents in the working environment is to assess the hazards in the work place and to monitor the health effects on exposed persons(17). Owing to the shortage of funds and trained personnel, highly sophisticated procedures and monitoring techniques designed and developed in the industrial countries may not be applicable in the developing countries(17). Furthermore, many of the developing countries have not yet adapted environmental standards or legislation for the control of environmental exposure. Our study is limited by the fact that radiological examination and other measures of lung function, for example, diffusing capacity, total lung capacity and blood gases were not assessed; this was largely due to limited funds. We hope to do extensive tests as a follow up to this study in future as this would help to further ascertain the effects of long-term exposure to arc-welding on the respiratory health of Nigerian welders. Our study brings to focus the increasing hazards that workers in developing countries encounter on a daily basis. There is the need to educate these workers on work hazards; and for government to introduce means of monitoring possible toxic products at the worksite and enforcing safety measures. In most medical schools, there is inadequate coverage of occupational medicine. Most physicians have only a sketchy knowledge of how their patients' occupation and state of healthcare are related. This has led to poor reporting of occupational diseases in the developing nations. There is urgent need to review the undergraduate and postgraduate curriculum for medical students and doctors alike in order to bridge this gap.

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