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Respiratory Symptoms, Ventilatory Function and Health Related Quality of Life of Arc Welders in South West Nigeria

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Abstract

Introduction: Electric welding was introduced in about 1940 and the use of welding has increased in recent years, chiefly in the form of fusion welding. It is estimated that more than 1 million workers worldwide perform some types of welding as parts of their work duties. Though, there are about 60 different methods of welding, gas and arc welding are the types commonly practiced in the developing countries. Isah reported that the commonest type of welding in Benin City, Nigeria is the gas and electric arc welding. Other forms of welding include carbon arc welding, cold welding, flux core arc welding, gas welding, gas tungsten arc welding and laser beam welding, plasma arc welding and oxyacetylene welding. Welding is the process in which metal or other thermoplastic are joined together by the application of heat or pressure, or both with or without the use of filler metal.

In arc-welding, heat is generated by striking an arc between an electrode and the base metal. The temperature is about 4000°C when the pieces fuse together. Many arc welding processes are automatic or semi-automatic, but it is also carried out manually, the process is known as manual metal arc or open arc welding. Most conventional arc-welding is done manually by means of a covered (water) consumable electrode held in an electrode holder. These processes lead to the generation of fumes or particles which are dangerous especially to the respiratory system if inhaled. The particles in these fumes are generally so small that they can reach the narrowest branches of the respiratory organs. Opinions about the respiratory effects of welding differ. Respiratory effects seen in welders have included chronic bronchitis, asthma and possible increase in lung cancers. Pulmonary infections are increased in term of severity, duration and frequency among welders. Reports have shown that pulmonary functions in the welders were found significantly altered with increasing length of exposure. Increasingly, it has been recognized that health status, especially HRQL is an important outcome of medical care. The degree to which health impacts on a person's ability to perform and derive fulfillment from activities of daily life based on the self-determined evaluation of satisfaction is referred to as HRQL. Chronic exposure to welding fumes and its attendant sequalae has a detrimental effect on the HRQL of affected welders. Though, the severity of disease is an important determinant of the individual health, individual perception and adaptation largely defines the overall Quality of Life. Moreover, since pulmonary function is chronically and irreversibly impaired in this group of workers, treatment should not be directed only towards improving the pulmonary function. In addition, because of the observation that symptom burden is more closely related to HRQL than to FEV1, increasing attention is now being given to HRQL as an important outcome of medical care. However, HRQL measures do not substitute for physiologic parameter, but can complement these by including aspects of health and disease that are directly perceived by the individual.

In Nigeria, there are few studies on respiratory symptoms and ventilator patterns in welders. Erhabor reported that the most frequent symptom among welders is cough compared with the controls and were also found to have significantly lower lung function parameters than controls. Few other studies were limited by inability to do chest radiograph. However, there are no indexed studies detailing or assessing the HRQL of arc-welders in Nigeria, necessitating the need for this study.

Rationale for Study: The International Labor Organization (ILO) has estimated that over 2 million people die every year from work related accidents and diseases and that over 300 million non-fatal accidents are recorded each year. This translates into more than 6,000 deaths and over 800,000 non-fatal accidents every day. In addition, ILO estimates that more than 160 million people suffer from

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occupational and work related diseases. In many developing countries such as Nigeria, statistics on occupational health hazards especially those with respiratory sequalae are limited. Occupational deaths and injuries take a heavy toll among the poor and least protected. Furthermore, literature has shown that welders in SSEs are least aware of health effects emanating from the activities and materials in their work environment. In Nigeria, there is an information gap on welding occupational hazards as well as prevalence of both acute and chronic respiratory diseases among welders. Such information is vital in understanding the extent of the problem and may be useful when designing intervention strategies targeted at promoting and upholding good health and safety standards in this important working group- hence the study.

Aims and Objectives: To determine the respiratory symptoms, ventilator function and Health-Related Quality of Life of Arc-welders.

- To describe the pattern of respiratory symptoms in arc-welders.
- To assess the pattern of ventilatory function in arc-welders and matched controls.
- To assess the Health-Related Quality of Life of arc-welders.
- To assess the determinants of Health-Related Quality of Life of arc-welders.

Keywords: Respiratory symptoms; Ventilator function; ILO; Quality of life; Lung cancer

Literature Review

Introduction

Electric welding was introduced in about 1940 and the use of welding has increased in recent years, chiefly in the form of fusion welding. It is estimated that more than 1 million workers worldwide perform some types of welding as parts of their work duties [1,2]. Though, there are about 60 different methods of welding, gas and arc welding are the types commonly practiced in the developing countries [3]. Isah et al. [4] reported that the commonest type of welding in Benin City, Nigeria is the gas and electric arc welding. Other forms of welding include carbon arc welding, cold welding, flux core arc welding, gas welding, gas tungsten arc welding and laser beam welding, plasma arc welding and oxyacetylene welding. Several long-recognized, well catalogued but less common pneumoconiosis which fall into the group in which the dust load is heavy but pulmonary function is minimal include the pneumoconiosis resulting from inhalation of iron in welding fumes [5].

Workforce overview

Workers represent half of the World's population and 70% of the global workforce lives in developing countries [6,7]. The highest percentage (%) of men in the workplace is among those aged 45 to 49 years (99.2%) compared to just 67% of women in this age group. More than 80% of those employed in Nigeria work in the informal sector [8]. The informal sector comprises of mainly of Small and Medium Enterprises (SMEs). Globally, the welding industry continues to be a critical component of manufacturing [9]. The recent growth of the small scale welding industry has been stimulated by increase in construction and manufacturing activities, over the past few years which have created a demand for products and services of the small scale welders [10].

Welding and welding methods

Welding is an ancient art that has been practiced since man begun to extract and refine iron [11]. Welding is the process in which metal or other thermoplastic materials are joined together by the application of heat or pressure, or both with or without the use of filler metal [12,13]. Welding types are classified based on the source of heat for melting the metal or filler. The three common sources of heat upon which classification is based are combustion of a fuel gas with associated air or oxygen to produce a flame, an electric arc produced by an electrode between the electrode and work piece, electric resistance offered to passage of current between two or more work piece. In arc-welding, heat is generated by striking an arc between an electrode and the base metal. The temperature is about 4,000 degree Celsius when the pieces fuse together. Many arc welding processes are automatic or semi-automatic, but it is also carried out manually, the process is known as Manual Metal Arc Welding (MMAW) or open arc welding [14]. MMAW is the most commonly used welding method in the electric arc welding category and is also the most commonly used welding method in SSEs for reasons that the cost of equipment and maintenance is low compared to other methods [15,16]. MMAW equipment is very portable and only moderate skills are required to use the equipment. Although, MMA welding may be more preferable by the small scale welders, it is associated with greater risks of exposure to welding health hazards in comparison to other welding methods. It also produces fumes that contain more chemical elements in more than the trace amount. These fumes are largely from the vaporized and decomposed filler and coating. The process of welding using MMA is slower compared to other methods; the welder may have to spend more time working on the work piece, thereby increasing their exposure time to fumes and gases [17]. These fumes or particles are dangerous especially to the respiratory system if inhaled [18]. The particles in these fumes are generally so small that they can reach the narrowest branches of the respiratory organs [19] (Figure 1).

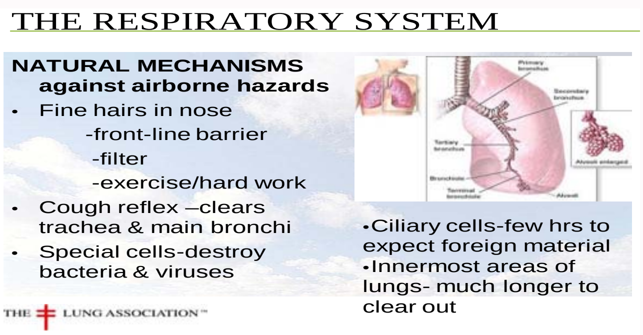

Figure 1: The respiratory system.

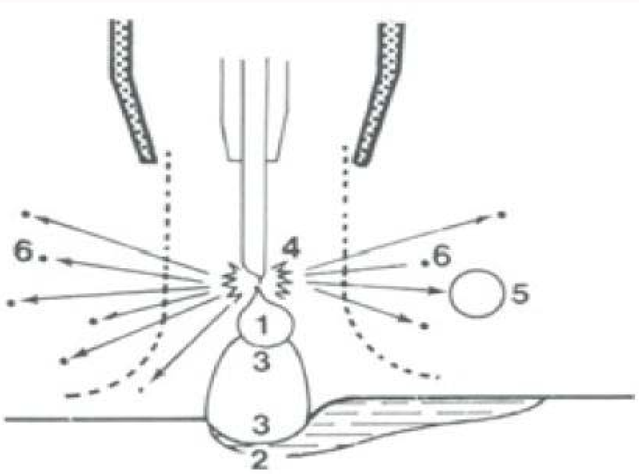

Figure 2: Sources of fume gas metal arc welding. 1) Droplet at of wire or during transfer, 2) Weld pool, 3) Electrode spots and anode, 4) Exploding wire, 5) Large particles, 6) fine metal droplets ejected by wire explosion.

Pathogenesis

Generation of fume and gases: Fume particles consist mainly of oxides. Oxides are formed when the melted metal is vaporized in the arc and then condenses and oxidizes with the surrounding air. Figure 2 shows conceivable sources of fume. In gas metal arc welding, it is the filler metal which is the main source of fume while the base metal contributes very little. The composition of the fume depends on the volatility of the alloying substances in the wire. The metal vapor found in the arc contains high level of the most volatile of these substances. In addition, in welding with oxidizing gases, volatile oxides are also formed and incorporated in the vapor. When the vapor comes into contact with the surrounding air, fume is formed through condensation and oxidation. The composition of welding fume corresponds more or less directly with the chemical composition of the wire. Spatter is a major factor in the formation of welding fume. The many small particles of spatter cause the total area from which vaporization takes place to increase. In addition, some of the spatter is also small that it can remain suspended in air and is thus considered fume particles.

During welding, the main causes of gas formation are the extremely high temperature and ultraviolet radiation emitted by the arc. Nitric oxide, NO, and Nitrogen dioxide are formed from oxygen and nitrogen in the surrounding air. When they come in contact with the hot arc with the hot base metal, the following reactions take place,

$N_2+O_2=2NO$

$2NO+O_2=2NO_2$

Ozone, O_3 is formed from the O_2 in the air as follows,

$3O_2$------- $2O_3$

The ultraviolet radiation from the arc decomposes the oxygen molecules into free oxygen atoms. These atoms react with other oxygen molecules and form ozone molecules. Most of the ozone forms in close proximity to the arc. The ozone is carried away from the arc in the hot plume of fume and gases which rise from the welding spot and this can be hazardous to the welder (Figure 3). The welding workers have a highest exposure to welding fumes. The content of the welding fumes depend both on the metal welded and on the welding process involved [20]. The deposition of inhaled particles is primarily dependent on particles size of solid substances and is best described in forms of an aerodynamic diameter. All particles with an aerodynamic diameter in excess of 10 um are deposited in the nose and pharynx. Particles between 3 um and 10 um in diameter can be deposited throughout the tracheobronchial tree where they initiate bronchoconstriction and coughing. Particles between 0.1 um and 0.3 um are mostly deposited within the alveoli. Smaller than 0.1 um remain in the air stream and are exhaled [21]. Most particles in the welding fume are extremely <0.5 um in diameter.

Figure 3: Rising plume of fume and gases from weld spot.

Pathogenesis/Pathophysiology: The deposition of dust in the lungs depends on the size and geometric and aerodynamic properties of the particles [22]. The pathogenesis is due to its exasperating, sensitizing and irritating properties. The physical properties include particle size and density, shape and penetrability, surface area, electrostatic charge and hygroscopicity. Among the more important chemical properties influencing the respiratory tract response is the acidity or alkalinity of the inhaled agent [23]. In addition, Campbell and Schonell [24] have reported that, in occupational lung disease, the inhaled particles produce a variety of reactions in the respiratory tract which depend upon the nature of the inhaled matter; the size, shape and concentration of the particles, the degree and duration of exposure, the site of the reaction and the individual workers susceptibility.

Hazardous agents associated with welding processes

In welding process, different agents are produced which are hazardous to human health such as-

- Gases: Acetylene, carbon monoxide, oxides of nitrogen, ozone and tungsten.
- Metals: Arsenic, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, nickel, silver, tin and zinc [25].
- Physical agents: Electricity, hot environment, vibration, UV radiation, ionizing radiation, noise and visible light [26].

Various factors influence emissions of welding fume in addition to the welding method, these include welding parameters(current, voltage, shielding gas, and shielding gas flow), base and filler metal, coating or contaminant on surface of plate.

Route of exposure

Inhalation is the primary, but not only route of exposure. Workers can also be exposed to welding related metals through ingestion and skin contact. This needs to be taken into account when evaluating worker exposure as welders eating with dirty hands or eating or drinking contaminated food or liquid can ingest a significant dose of the metal particles they are exposed to.

Aerosol deposition and clearance

The human lung has a large surface area, which for an average size person is approximately half a doubles tennis court thus maximizing the approximation of capillaries and alveolar tissue [27]. Whereas this design optimizes gas exchange, it also has the intrinsic risk of exposing the delicate alveolar tissues to potentially noxious particles that may be present in the ambient air.

Principle of deposition: The fraction of inhaled particles that deposits (as opposed to being exhaled), is called the deposition fraction [28]. The likelihood that a particle will deposit in a particular airway depends on the interaction of 3 factors: the physical characteristics of the particle (e.g. mass, shape), the gas flow in which the particle is transported (the patient breathing pattern [29], and any velocity impacted to the particle by a propellant), and the airway anatomy (especially the presence of airway obstruction [30]. In general, the greater the mass, the faster the velocity, and the narrower the airway, the greater the predisposition of the particle to deposit by a process called the inertial impaction. Particles that fail to deposit in proximal airways by inertial impaction can deposit in peripheral airways and alveoli by a process called gravitational sedimentation. Therefore for a given velocity, the greater the aerodynamic mass of an aerosol, the shorter the time it will remain suspended in the air stream. Gravitational sedimentation is the main mechanism by which particles (0.5 um to 5.0 um in diameter) deposit in the peripheral regions of the lung. Sedimentation is critically dependent on the patient breathing pattern [29]. If there is a breath hold by exhalation, particles are more likely to sediments; without a breath hold, particles are more likely to be exhaled rather than deposited. It has also been suggested that alveolar volume may affect deposition fraction (large airspaces require more time for sedimentation). Very small particles (<0.2 um) can deposit by diffusion. Particles between 0.2 um and 0.5um in diameter tend to be too small to deposit efficiently by sedimentation and yet too large to deposit efficiently by diffusion and tend to be exhaled rather than deposited in the lung [31].

Clearance

Mucociliary clearance: Mucus is transported proximally by the rhythmic beating of the cilia to the pharynx where it is swallowed by a process called mucociliary clearance [32]. The percentage of ciliated respiratory epithelial cells is highest in the trachea and lobar bronchi and decreases progressively in more distal airways. Secretary cells are also more numerous in proximal airways. Goblet cells produce thick carbohydrate-rich secretions, while other cells produce more serious secretions. Diseases such as chronic bronchitis and bronchiectasis are associated with increased number of goblet cells in more distal airways. Mucociliary clearance impairment can also be due to changes in the quantity and composition of airway secretion. When the mucociliary apparatus is significantly impaired, secretions can be cleared predominantly by cough. Mucociliary clearance in healthy subjects is usually completed within 24 h of deposition.

Alveolar clearance: Particle solubility affects clearance in alveoli. Soluble particulates may be absorbed through thin membrane of the peripheral airspaces [33]. Insoluble particulates, however, tend to be phagocytosed by alveolar macrophages. Their metal content influences the free radicals generating properties of the particles and can promote inflammation especially as the particle is delivered to the lysosomes. Lysosomes have a very low pH designed to kill microorganisms but the low pH may promote solubility of transition metals such as ferrous iron and therefore be pro-inflammatory. Inhaled dose is important and excessive exposure can lead to overloading of the alveolar macrophages which can be pro-inflammatory even with relative non-particulate.

Dust accumulation in the lungs is determined by deposition and clearance. The biologic response depends upon the amount and duration of the accumulation and the nature of the dust. Tissue responses to organic dusts depend on the particle size and the biologic activity of the dust, which in turn depends on its surface chemical and physical properties [31]. Parenchymal responses include nodular fibrosis, diffuse fibrosis and macula formation with focal emphysema. For any given dust exposure, the severity of the tissue reaction appears to be related to the cumulative lung dust burden.

Symptoms

Welding is associated with various inherent occupational hazards [34-37]. These hazards may lead to acute and chronic health effects. Acute health effects are those that usually occur rapidly as a result of short term exposure to hazards and are of short duration. Chronic effects on the other hand generally occur as a result of long term exposure to hazards and are of long duration [38].

Respiratory symptoms: Respiratory illness is the most commonly reported health hazard of welding. Respiratory effects seen in welders have included metal fume fever, bronchitis, asthma, and possible increase in lung cancers.

Metal fume fever: This is the most frequently observed respiratory illness of welders. A relatively common febrile illness of short duration that may occur during and after welding duties. The condition is caused by the inhalation of freshly formed zinc oxide fumes. It occurs most frequently among welders joining or cutting through galvanized zinc coated steel or other zinc alloys [39]. Metal fume fever is characterized by its acute onset (approximately 4 h after exposure) and often simulates a flu-like illness. These symptoms include thirst, dry cough. A sweet or metallic taste in the mouth, chills, dyspnoea, malaise, muscle ache, headaches, nausea, and fever. The illness is self-limiting and usually resolves in 24 h to 48 h after onset. Even though the aetiology of metal fume fever is known, the mechanism by which inhaled metal oxides commonly present in welding fumes induce the illness has not yet been determined. Blanc suggested that pulmonary responses of inflammatory cells may play a large role in metal fume fever. There are many respiratory problems that may be associated with welding that vary from acute responses such as that seen in metal fume fever usually associated with zinc oxide inhalation to less common cases of hypersensitivity pneumonitis and chronic sequalae such as welding-related pneumoconiosis [40].

Respiratory infections: Acute upper or lower respiratory tract infections have been shown to be increased in terms of severity, duration, and frequency among welders [41]. Chemical irritation, in particular exposure to metal fumes, of the airway epithelium is a suspected cause of the increased incidence of respiratory infections [42].

Several studies have reported an excess of mortality in welders due to pneumonia. Beaumont observed a 67% excess of pneumonia deaths in welders. The elevated occurrence of pneumonia was associated with elevated exposure to nitrogen dioxide and ozone. Coggon analyzed 3 sets of occupational mortality data for England and Wales for the periods 1959 to 1963, 1970 to 1972 and 1979 to 1990, and found a significant increase in mortality for pneumonia among welders.

Occupational asthma: Occupational asthma is caused by the inhalation of specific sensitizing agents in the workplace and it is distinguished from non-occupational asthma by an older age of onset, lack of seasonal variation in symptoms and an improvement of symptoms when away from work. Occupational asthma may develop as a consequence of exposure to certain types of welding. In welding, high concentrations of chromium and nickel in the fumes are considered responsible for airway sensitization [42]. A possible association between welding and occupational asthma remains mostly uncertain. Many of the studies performed are difficult to compare because of differences in worker populations, workshop settings, welding techniques, and duration of exposure. Frederich et al. [23] indicated that occupational asthma has not been definitely proven to be caused by inhalation of welding fumes. They concluded that given the prevalence of asthma in the general population, and the large number of full-time welders, there is likely an infrequent occurrence of asthma in welders. Many studies have been performed to examine this association. Meredith et al. [28] evaluated new cases of asthma reported for all occupations during 1989 and 1990. Three cases (0.3%) of occupational asthma were identified in workers exposed to welding fume, and 20 cases (1.8%) in workers exposed to other welding fumes. Asthma was diagnosed in 124 of 246 new cases of occupational lung disease reported in a survey by Contreras. There are many agents in the workplace that can induce asthma or cause substantial deterioration in pre-existing asthma. It has been estimated that 5% to 15% of adult-onset asthma can be attributed to occupational exposure [43]. Hence, adult patients, especially those with new-onset asthma must be investigated with regard to occupational risk factors for disease. Keskinen et al. [44] in 1980 reported a significant increase in cases of occupational asthma caused by fumes from manual metal arc.

Chronic bronchitis: In surveys of full-term welders, an increase in the prevalence of symptoms of chronic bronchitis is the most frequent problem associated with respiratory hazard [29]. One factor affecting the ability to detect chronic bronchitis in welders is the prevalence of cigarette smoking in welders and chronic bronchitis caused by smoking in control population. A number of studies have been performed to evaluate the prevalence of chronic bronchitis in full-time welders. In a study of 156 Danish welders and 152 controls from the same plant, no statistical difference in the rate of chronic bronchitis was seen when comparing the welders with the control group. Even more studies have been performed that indicate that welding fumes may induce chronic bronchitis in full-time welders regardless of cigarette smoking. In addition, there appears to be an increased prevalence of chronic bronchitis among welders who smoke cigarette. An early study evaluated the rate of chronic bronchitis among 100 welders and 100 control subjects in a US shipyard Hunnicutt et al. [45]. The prevalence of symptom of chronic bronchitis among smoking welders was 79% when compared with 36% for smoking controls and was 41% among non-smoking welders *vs.* 5% among non-smoking control subjects.

Groth and Lyngebo [40] studied the effect of welding fumes on respiratory symptoms. The welders showed a significantly higher prevalence of chronic bronchitis, 21% *vs.* 9% in the control group. Erkinjuntii-pekkanen et al. [46] reported that chronic bronchitis was more common among welders (24%) than non-welders (5%). Several studies have also documented a high prevalence of symptoms of chronic bronchitis and other work related respiratory symptoms in current welders.

Pneumoconiosis: Doig and Mclaughlin [7] first observed welder's siderosis in the radiographs of welders with no evidence of exposure to silica or coal dust, thus establishing this condition as a distinct entity. When some subjects from their original study were followed up for an additional 9 years, it was observed that the chest opacities had completely resolved in another whose exposure to welding fumes was greatly reduced. Welder's pneumoconiosis has generally been determined to be benign and not associated with respiratory symptom based on the absence of pulmonary function abnormalities in welders with marked radiographic abnormalities.

Roesler and Witowitz described the case of a welder with interstitial lung fibrosis that was attributed to iron oxide deposits in the lungs. He had worked as a welder for 27 years mostly in confined spaces with inadequate ventilation. After 8 years as a welder, he developed tuberculosis, which was successfully treated with chest radiograph returning to normal. By 10 years, he had developed siderosis with respiratory symptoms. His condition was attributed to exposure to high levels of welding fumes in confined spaces. Buerke et al. [43] found interstitial pulmonary fibrosis after long term severe exposure to welding fumes in poorly ventilated workplaces. In a survey of actively employed electric arc-welders in Britain in 1978, 7% had some degree of pneumoconiosis [44]. This was corroborated by Hull and Abraham [47], that chronic exposure to high concentration of fumes during aluminum arc welding causes a severe pneumoconiosis.

Lung cancer: Welding fumes have not been definitely shown by epidemiology studies to be a cause of lung cancer. Several studies have indicated an excess risk of lung cancer among welders. In 1990, the International Agency for Research on Cancer (IARC) concluded that welding fumes were possibly carcinogenic to human [48].

In review of early epidemiology studies, Parto concluded that the association between welding fume exposure and bronchogenic carcinoma had not been adequately investigated. The studies reviewed indicated 30% to 40% excess lung cancer mortality among all welders [49]. In more recent studies, Hansen evaluated the cancer incidence in a historical cohort of 10,059 metal workers in Denmark. An increased incidence of lung cancer among all welders was not statistically significant, but non-welding metal workers identified as having ever been employed either as welder or by a welding company had a significantly increased incidence of disease.

Non respiratory symptoms: Non respiratory symptoms such as neurological and dermatological effects have been reported [50,51]. Erhabor et al. [52] reported that, the most frequent symptoms found among welding workers were eye irritation (95.43%), rhinitis (50.09%) and skin irritation (43.19%).

Principle of management of pneumoconiosis

The clinician is faced with 2 main tasks when evaluating a case of pneumoconiosis. First to assess the nature of the disease process, including its site(airways, parenchymal or pleural) and its extent, and to determine whether it has decreased the individual's performance in particular for his or her current job (evidence of impairment or disability).

Assessment of impairment is based on symptoms and measurement of pulmonary function. Pneumoconiosis may be associated with apparently normal lung function or with a predominantly obstructive, restrictive or mixed pattern of dysfunction. In the individual case, interpretation of results in terms of lung function profile is usually done by the use of reference or predicted values. These may however be misleading given that those who undertake dusty occupations on the average have higher initial spirometry and lung volumes than the general population, on who most predicted values are based [53]. Thus, it is not appropriate to minimize the functional significance of pneumoconiosis on the grounds of apparently normal lung function. Second, is the need to determine whether there has been environmental or occupational exposure of duration, intensity, and characteristics sufficient to account in full or its part for the patient's present condition. For this task, the key tool is the occupational history which can be completed with the addition of the often extensive knowledge that the workers can provide concerning his occupation, the materials handled, and the process involved. Because pneumoconiosis is a reaction to retained dust, it may appear and progress after exposure has ceased [54]. Hence, the importance of a complete exposure history. On occasions, it may be necessary to establish occupational exposure on the basis of analysis of biologic materials e.g. sputum, broncho-alveolar lavage etc for the putative dusts or its breakdown products. This is particularly so in cases in which the exposure is remote and the exposure history is incomplete or unreliable.

Preventive measures for welding occupational hazards

Identification of hazards before undertaking any work process is always recommended in the control of hazards in any work setting to aid selection of the most suitable preventive measure. In welding, elimination may involve the removal of the risk factor by robotization of the process - this technique is not well developed yet [55].

Other methods of prevention include engineering controls i.e. local exhaust ventilation; administrative controls i.e. work-rest schedule and safe work procedures. Personal Protective Equipment (PPE) can be used by exposed worker as means of prevention of exposure to hazards when no other approach is feasible or when the degree of safety achieved by other option is considered inadequate [56]. With regards to welding PPE, protection is required to prevent hazardous exposures from head to toe. For eye and face protection, a welding helmet, hand shield, and goggles are required. Respirators or face masks protect the respiratory system. Exposed skin can be protected by means of fire/flame resistant clothing and aprons, safety boots and insulated gloves. Use of PPE entails reliance on active cooperation and compliance by the worker. In addition, for PPE to be effective, it is important to ensure that the workers know the right type of PPE to be used and that it is used in the correct way for the period when the worker is exposed to harmful substances or situations [57].

Occupational health and safety act (OHS)

Occupational health programmers were first introduced in Nigeria during the time the country was a British Colony [58]. This initiative led to legislation that included Labor act of 1974, the factories act of 1987 and the Workman's Compensation Acts 2004. Other Acts are Labor Act 1990 and 2004 of the law of the Federation of Nigeria. Nevertheless, these Acts are not been enforced in Nigeria as evidence from the reports of unhealthy exposure to risks of workers and employers in various Organization.

Lung function test

Over the last decades, numerous studies have addressed the effects of welding fumes on the pulmonary function of welders. Spirometry is the recommended objective test performed to identify abnormalities in lung volumes and air flow [59]. It is used in conjunction with physical assessment, history taking and chest X-ray to exclude or confirm particular types of lung diseases. The assessment of pulmonary or lung function with a spirometer has become common practice in patient setting and industry. It is now regarded as an integral component of any respiratory surveillance programmed. These tests measure the air volume that can be inhaled or expelled either forcefully or under normal condition. Pulmonary function test has assumed a key role in epidemiological studies, investigation, incidence, natural history and causality of environmental lung disease [60,61]. However, these measurements are not always sensitive enough to observe early signs of lung pathology, and irreversible damage may occur before measured reductions in pulmonary function are detailed [62]. Variable results have been observed in the many studies evaluating the effects of welding fumes on lung function. Some studies were conducted in carefully controlled work environments, others during actual workplace conditions, and some in laboratories. Thus, the severity of exposure to welding fumes varied widely due to differences such as welding processes and materials used, duration of exposure, ventilation of the exposure area, and duration of time between welding and lung function measurement. Mur et al. [63] demonstrated that welders who worked in confined spaces had reduced lung function when compared with those who worked in well-ventilated within the same workshop. Many studies also have tried to determine whether welders may experience acute asymptomatic transient decrement in pulmonary function on an everyday basis as a result of usual inhalation exposures. Spirometry is a safe test with minimal associated risks and there are few contra-indications to its performance. Although, the spirometry measures many physiologic parameters such as FVC, and FEV1, both FVC and FEV1 are expressed in liters at body temperature (37 degree Celsius) and the ambient pressure saturated with water vapor. After acceptable studies are obtained, interpretation can proceed using a systematic approach. Using the FVC, FEV1, and FEV1/FVC, an obstructive, restrictive, or normal pattern is determined.

Factors affecting ventilatory function

Values from ventilatory function tests obtained from normal subjects vary from place to place and also with the same population under varying circumstances. This clearly shows that many independent variables such as sex, height, weight, environment, ethnicity and race affect ventilator function [64,65]. Schoenberg et al. [66] showed that the Forced Vital Capacity (FVC) increases with age up to 24 years then remains stable until 35 years and thereafter declines. During aging, there is progressive decline in respiratory function due to factors such as loss of respiratory muscle strength, increased stiffness of the chest wall, reduced elastic recoil of the lung and diffusion capacity which ultimately may result in hypoxemia at rest. Height correlates positively with peak expiratory flow rate and forced vital capacity in both children and adults [67,68]. Femi-Pearse et al. [69] showed statistically different Spirometry values between Africans and Caucasians. Onadeko et al. [70] in a study showed that peak flow readings correlated well with weight up to 40 kg. However, this correlation does not persist in obesity as the peak flow rate reduces with weight. Similar finding was obtained by Abid Ali who worked on adolescents in Northern Nigeria [60]. Ele [61] assessed

Forced Vital Capacity (FVC) and Forced Expiratory Volume in one second (FEV1) in 245 healthy Nigerian Ibo males aged 12 to 23 years. Analysis showed strong correlation between anthropometric factors (age, height, weight) and spirometric measurement. In the young adult group (18 to 23 years), FEV1 did not correlate so strongly with weight, however, the pulmonary functions in the welders were found significantly altered. Kierst et al. [71] showed that FEV1 reduced with increasing length of exposure in welding industry. Khanzadeh [72] observed the different parameters of pulmonary function test between control and welding workers and reported that in the mean of the FEV1, FEV1/FVC, PEF were significantly decreased in welders compared with control. Chinn et al. [73] showed among welders, the effect of fumes was greatest in those who admitted not using protective measures and such workers experienced work related deterioration in FEV1. Erkinjuntti-Pekkanen et al. [46] reported that welders without respiratory protection or local exhaust ventilation while welding had a slight non-significant greater annual decline (88.8 ml) in FEV1 than non-welders, who had a slight non-significant annual increase (34.2 ml). In addition, they showed that, welders without respiratory protection or local exhaust ventilation while welding had a greater annual decline both in FEV1 and FVC, than welders with protection. Nakagate observed the obstructive changes in pulmonary function, to be related to level of cumulative exposure to welding fumes in male Japanese arc-welders after controlling for age and sex. Erhabor et al. [52] reported that the arc-welders were found to have characteristically lower lung function parameters than controls.

Chest imaging/Radiograph

Chest radiographs are the cornerstone of surveillance for pneumoconiosis in the workplace. It remains the accepted method for surveillance and assessment because of its wide availability, acceptable cost and radiation dose and the standardization of its reading. In certain percentage of welders, who have been employed for 10 to 15 years particularly in confined spaces, radiographic changes take place in the lungs. These changes are mainly small nodular opacities ranging from 0.5 mm to about 5 mm diameters, throughout the entire length.

Health-related quality of life (HRQL)

Health-related quality of Life has emerged globally as an important measure in research and clinical practice [74]. Quality of life has been defined as a multi-dimensional concept reflecting individual general health including psychological, social, and physical conditions [75]. Quality of life is more comprehensive than a patient's health status and it includes aspects that are generally affected by health conditions or services.

The World Health Organization (WHO) defines Health-Related Quality of Life as the way individuals perceives themselves within their own culture and value systems. Health-Related Quality of life is used to indicate the aspect of the environment that may, or may not be affected by health or treatment. It is determined by an interplay of several factors including (but not limited to) occupation, job satisfaction, income, marriage, family challenges etc. It is a process that is similar to a structured clinical history, although the end product is not a clinical impression but an objective measurement that can be used for scientific purposes [76]. Landmark progress has been made in the treatment and evaluation of patients with respiratory diseases like asthma, chronic obstructive lung diseases; using the traditional outcome measures like mortality, number of hospital admission [77]. However, these end points do not provide a complete picture of the experience of patients with these conditions. Health status instruments do not have a strong correlation with physiological measures such as FEV1 or imaging results like chest X-ray [78]. This is not necessarily a limitation but rather it shows that different individuals with the same physiological limitations will experience different effects on their health status [76]. There are a number of instruments used to measure quality of life [74,75]. They are broadly divided into general and disease specific questionnaires. General health questionnaires are designed to assess in a broad sense, the impact of disease on health while specific questionnaires are designed to detect the impact of specific disease on health.

Other generic measures include SF-36; Sickness Impact Profile (SIP); Nottingham Health Profile (NHP); Quality of Wellbeing (QWB); World Health Organization Quality of Life (WHOQOL-BREF).Disease specific questionnaires include St Georges Respiratory Questionnaire (SGRQ); COPD Assessment Test (CAT); Chronic Respiratory Questionnaire (CRQ) etc. SF-12 is a well validated health status measure used in health survey for both general and various populations with different diseases. An objective assessment of patient's Health-Related Quality of Life represents the functional effects of an illness and its consequent therapy on a patient as perceived by the patient.

Health-Related quality of life measures are however, not a substitute for disease outcomes but adjunct to them. It has been administered successfully in general population surveys in the US and other countries. The standard SF-12 question focuses on the preceding weeks [77]. The SF-12 survey contains categorical questions (e.g. yes/no) that assess limitations in role functioning as a result of physical and emotional health. The survey also contain Linkert response formats including those that are on a three-point scale (e.g. limited a lot, limited a little, not limited at all) that assess limitations in physical and physical role functioning. In addition, a five-point scale (e.g. not at all, a little bit, moderately, quite a bit and extremely) that assess pain, and a five-point scale that assesses overall health (excellent, very good, fair, and poor) are included. The SF-12 also contains a six-point scale (e.g. all of the time, most of the time, a good bit of the time, some of the time, a little of the time, none of the time) that assesses mental health, vitality, & social functioning.

Methodology

Location of study (study area)

The study was conducted in Ile-Ife, an ancient Yoruba City in South-Western Nigeria in Osun State. Ile-Ife is about 218 km (135 miles) North East of Lagos. Administratively, Ile-Ife has 2 local Governments and the population according to the 2006 National Census, is put at 167,254 and 188,027 respectively. Ile-Ife inhabitants are primarily town dwelling farmers.

Study design

The study is a cross-sectional descriptive study on arc-welders in Ile-Ife, Nigeria.

Sample size

Sample size was calculated using the formula for estimating a single proportion at a specified precision.

$$n = \frac{Z\alpha^2 pq}{2d^2}$$

n = minimum sample size

Z = normal Standard Deviation set at 1.96 corresponding to 95% confidence interval

P = proportion of target population estimated to have a particular characteristic

(Prevalence of respiratory symptoms in arc-welders), this was taken to be 50.09% [52].

q=1-p=confidence level that the estimate is the distance d of the proportion of interest

d = degree of accuracy desired (precision). This was taken as 10%.

Therefore, $n=1=1.96 \times 1.96 \times 0.509 \times (1-0.509)/0.1 \times 0.1 = 96.00\%$.

Therefore, 96 welders with an additional 10% of the population to allow for any attrition. Total of 106 welders were used for the study.

Sampling technique

Study participants were recruited using a multi-stage sampling technique. Workers with 5 years and above of practice were recruited for the study based on their different zones. There are about 8 different zones. Each zone having a membership of 20 to 30. Four zones will be randomly selected from the 8 zones till the sample size is complete. The control population was drawn from workers in the Maintenance Unit of Obafemi Awolowo University, Ile-Ife who had no previous exposure to welding fume. They will be matched in age and sex with the study cases.

Study population

Two hundred and two individuals (202) were recruited i.e. one hundred and three (103) welders and ninety nine (99) healthy controls.

Inclusion criteria

- Arc-welders whose main occupation is welding.
- Workers must be currently engaged in the art.
- Willingness to participate.
- Ability to demonstrate sufficient proficiency in performing the tests necessary to assess ventilatory function.
- Welders with 5 and above years of practice.

Exclusion criteria

Subjects with the following were excluded

- Workers with pre-existing respiratory diseases like asthma, COPD.
- Workers with past history of pulmonary tuberculosis.
- Current smokers and past smokers.

Ethical approval

- Ethical approval was obtained from the Ethics and Research Committee of the Obafemi Awolowo University Teaching Hospitals Complex, Ile-Ife before the study was commenced.
- Informed consent of the individuals for the study was obtained.

Data collection

Subjects enrolled into the study were assessed using the following:

- Modified Medical Research Council UK Respiratory questionnaire was used to obtain demographic information about the patient as well as respiratory symptoms.
- Health-Related Quality of Life of welders was evaluated using the Short Form-12, a generic quality of life tool [79].
- Spirometry was done to assess lung function in the study population.
- A PA-View chest radiograph of subject with respiratory and/or abnormal lung function test was taken.

Procedure

Questionnaires were administered using structured interview method.

Modified medical research council (MRC) respiratory questionnaire: A modified version of the Medical Research Council (MRC) questionnaire was used to obtain information on socio-demographic characteristics and respiratory symptoms of the subjects and dyspnoea severity score ranges from 0 to 4 [21].

Health-related quality of life (HRQL): Health-Related Quality of Life was evaluated using the Short Form-12, a generic quality of life tool [80]. S-F 12 is one of the scales used in measuring quality of life. It is a general concept scale. It contains 12 items from the original S-F 36 across all dimensions [22]. The 12 items include the self-assessment of health; physical functioning; physical role limitation; mental role limitation; social functioning; mental health and pain. These 12 items selected for inclusion can reproduce at least 90% of the variance in the physical and mental subscales of the SF-36 [81].

The 12 items yield the 8 dimensions of the S-F 36, but with fewer levels and less precise scores. SF-12, therefore displays greater floor and ceiling effects compared to SF-36. The SF-12 is suitable for self administration, computerized administration or administration by a trained interviewer. It can be administered in 5 min to 10 min with a high degree of acceptability and data quality. The data obtained with the SF-12 has been developed, tested and validated by Quality Metric Incorporation. SF-12 has been used in numerous populations and with good test- and retest reliability. A Yoruba translated version of SF-12 questionnaire was used for participants who are literate in Yoruba language and prefers the Yoruba version. The SF-12 was scored using the recommended Medical Outcome Study (MOS) software program that creates two summary scores, Mental health score (MCS 12), and physical health (PCS 12). The scores were represented as t- scores that are linear transformations within a mean of 50 and SD of 10 in the general population [75]. All subscales scores were transformed to 0-100 scale with the higher score indicating less dysfunction, impairment, or pain consistent with the recommended procedure for scoring.

Lung function test: Lung function of the subjects was assessed according to the American thoracic society guideline 85 using a standardized Spirometer (Spiro-lab III) manufactured by Micro Medical USA. The Spirometer uses a turbine sensor, which is sensitive and temperature, pressure or gas density do not affect its measurements. Hence, it does not require calibration. Subjects were instructed to refrain from undergoing vigorous exercise for 1 h, eating a large meal for at least 2 h before the test. Subjects height was measured without shoes to the nearest centimeter using a wall mounted Stadiometer on a flat surface while weight was measured to the nearest 0.1 kilogram using a portable weight scale after zero calibration check. Body Mass Index (BMI) was calculated as a ratio of measured weight to the square of the measured height (kg/m^2).

The Spirometry was performed with the subjects seated on a comfortable chair with no arm rest. They were instructed initially on the process of doing a Spirometry test with emphasis on the importance of having lips sealed around the mouthpiece, how to avoid tongue occlusion or obstruction during the manoeuvre. Also they were taught on how to achieve maximal effort by inhalation to total lung capacity before uninterrupted forced exhalation. Subjects that showed obstructive ventilatory pattern were assessed 10 min to 20 min after inhalation of 400 μg of salbutamol using a metered dose inhaler with a spacer device.

The spirograms were accepted if they meet the following ATS/ERS acceptability criteria:

- They are free from artifacts, glottis closure, early terminations, leaks or non-maximal efforts.
- The back extrapolated volume less than 5% of the FVC or 0.15 L, whichever is greater.
- When the spirograms show satisfactory exhalation duration of >6 sec or by manual pattern recognition of at least a plateau in the volume-time curve.

The highest of the 3 spirograms which met the acceptability criteria was chosen for measurement of the following parameters:

- **Forced expiratory volume in 1 second (FEV1)** which is the maximal volume of air exhaled during the first second from total lung capacity during a forced manoeuvre.
- **Forced vital capacity (FVC)** which is the maximum volume of air that can be delivered by a maximal forced exhalation after a full inspiration.
- **Ventilatory ratio** which is the ratio of FEV1/FVC multiplied by 100.

Chest radiograph: A PA-View chest radiograph of each eligible subject was taken. Standard CXR was reported in liaison with a Consultant Radiologist in accordance with International Labor Organization (ILO) Chest X-Ray Grading. The ILO is a specialized agency of the United Nation that seeks to promote social justice and internationally recognized human and labor rights [82]. Since 1950, the ILO has periodically published guidelines on how to classify radiographs for pneumoconiosis. The purpose is to describe and codify radiographic abnormalities of pneumoconiosis in a simple, systematic, and reproducible manner aiding interaction, comparisons of data, epidemiology, screening and surveillance, clinical purposes and medical research.

The classification system includes the Guidelines and two sets of standard films [25]. The Standard films represent different types and severity of abnormality and are used for comparison to subject films during the classification process. The system is oriented towards describing the nature and extent of features associated with different pneumoconiosis including coal workers pneumoconiosis, silicosis and asbestosis. It deals with parenchymal abnormalities (small and large opacities), pleural changes and other features associated or sometimes confused, with occupational lung diseases.

The Reader first graded the film quality; then categorized small opacities according to shape and size. There were 4 technical grades:

1. Good,
2. Acceptable, with no technical defect likely to impair classification,
3. Acceptable, with some technical defects but still adequate; and
4. Unacceptable.

Quality defects included over- or under-exposure, under-inflation, artifacts, improper positioning, and others.

The size of small round opacities was characterized as p (up to 1.5 mm), q (1.5 mm to 3 mm), or r (3 mm to 10 mm). Irregular small opacities were classified by width as s, t, or u (same sizes as for small rounded opacities). Lung zones of each lung were mentally subdivided by the Reader into 3 evenly spaced zones: Upper, middle, and lower. The zones in which the small parenchymal opacities appear were recorded. Profusion (frequency) of small opacities was classified on a 4-point major category divided scale (0-3), with each major category divided into three, giving a 12-point scale between 0/- and 3/4. Large opacities were defined as any opacity greater than 1cm that was present in a film. These were classified as category A (for one or more large opacities whose combined dimension did not exceed 5 cm), category B (for one or more large opacities whose combined dimension exceeded 5 cm but did not exceed the equivalent area of the right upper lung zone), or category C (size was greater than category B). Pleural abnormalities were also assessed with respect to location, width, extent, and degree of calcification. The Reader then commented on any other abnormal features of the chest radiograph or other relevant information.

Data analysis

The data was analyzed using the Statistical Package for Social Science (SPSS) IL, Chicago Version 17. Descriptive tools; frequency tables, mean, standard deviation and charts were employed to describe the age distribution, gender, socio demographic characteristics and clinical characteristics (the pattern of respiratory symptoms) among respondents. Continuous data were presented in means and standard deviation while categorical data were presented using proportions and frequencies. An unpaired t-test analysis was used to compare the ventilatory function and Health-Related Quality of Life of arc-welders with matched controls. In order to determine the independent predictors of Health-Related Quality of Life of arc-welders, a linear multivariate regression analysis was done, while adjusting for possible confounding variables such as age, sex, socio-economic status and smoking. 5% probability level was accepted as significant.

Results

Socio-demographic characteristics of the welder and control groups

A total of 202 subjects were recruited for the study, 103 welders and 99 controls, all fulfilling the inclusion and exclusion criteria for subjects and controls respectively. The mean age of the welder subject group (n=103) was 32.90 ± 8.54, and the mean age of the control group (n=99) was 34.27 ± 10.03. Fifty-two welders were between 30 and 45 years (50.5%) while 44 controls were above 45 years (45.5%). Most welders and controls were married, 64.1% and 71.7% respectively. Forty six percent (46.6%) of the welders had primary school education compared to 43.4% of the controls. Thirty-five (35.4%) of the controls however had secondary education. Most of the respondents were of Yoruba ethnicity and Christians (Table 1).

Occupational history of welders

Table 2 shows that 49 (47.6%) of the respondents had duration of

Table 1: Socio - demographic characteristics of welder and control groups.

Variable	Welder (%) N=103	Control (%) N=99	x^2	p - value
Age (in years)				
Less than 30	16 (15.5)	12 (12.1)	2.37	0.306
30 - 45	52 (50.5)	43 (43.4)		
Above 45	35 (34.0)	44 (44.5)		
Mean Age ± SD				
Marital Status				
Single	17 (16.5)	10 (10.1)	3.01	0.39
Married	66 (64.1)	71 (71.7)		
Separated	11 (10.7)	7 (7.1)		
Widowed	9 (8.7)	11 (11.1)		
Educational Status				
None	13 (12.6)	5 (5.1)	5.27	0.153
Primary	48 (46.6)	43 (43.4)		
Secondary	32 (31.1)	35 (35.4)		
Tertiary	10 (9.7)	16 (16.2)		
Ethnic Group				
Yoruba	96 (93.2)	88(88.9)	2.27	0.518
Igbo	3 (2.91)	6 (6.1)		
Hausa	2 (1.94)	1 (1.0)		
Others	2 (1.94)	4 (4.0)		
Religion		.		
Christianity	79 (76.7)	84 (84.9)	3.5	0.174
Islam	19 (18.4)	14 (14.1)		
Others	5 (4.9)	1 (5.0)		

Table 2: Occupational history of welders under study.

Variable	Frequency N=103	Percentage
Length of Experience (in years)		
Less than 10	21	20.4
10 - 19	49	47.6
20 and above	33	32
Average hours spent per day at workshop		
Below 6	12	11.6
6 - 10	56	54.4
Above 10	35	34
Type of PPE use		
Glasses	86	83.5
Face Mask	17	16.5
Frequency of PPE use		
Always	29	28.2
Occasionally	74	71.8
Types of materials wedded at workshop		
Iron only	48	46.6
Iron and Steel	55	53.4
Type of welding workplace		
Open	86	83.5
Confined	5	4.8
Both	12	11.7
Eat during work		
Yes	99	96.1
No	4	3.8
Have bath after day's work		
Yes	71	68.9
No	32	31.1

Table 3: Comparison of some health symptoms of the welders and control groups.

Variable	Welder (%) N=103	Control (%) N=99	x^2	p - value
Cough				
Not at all	75 (72.8)	90	11.2	0.004
Occasionally	21 (20.4)	6		
Often	7 (6.8)	3		
Phlegm				
Not at all	56 (54.4)	64	2.69	0.26
Occasionally	33 (32.0)	27		
Often	14 (13.6)	8		
Fever				
Not at all	57 (55.3)	65	2.84	0.241
Occasionally	41 (39.8)	32		
Often	5 (4.9)	2		
Wheeze				
Not at all	83 (80.6)	89	7.46	0.024
Occasionally	16 (15.5)	5		
Often	4 (3.9)	1		
Weight loss				
Not at all	76 (73.8)	85	3.92	0.067
Occasionally	22 (21.4)	13		
Often	5 (4.8)	1		
Chest Pain				
No	77 (74.8)	86	8.56	0.014
Occasionally	19 (18.5)	11		
Often	11 (10.7)	2		

exposure between 10 and 19 years, 33 (32%) of them had duration of exposure for more than 20 years while only 21 (20.4%) of the welders had less than 10 years of exposure.

Fifty-six (54.4%) of the welders spent between 6 and 10 h at work, 35 (34.0%) of them spent more than 10 h and 12 (11.6%) less than 6 h. Eighty-six welders (83.5%) used eye goggle as personal protective equipment during welding operation while only a few 17 (16.5%) of them used face masks. However, 74 (71.8%) reported occasional use of PPE as compared to 29 (28.2%) who used it always. Fifty-five (53.4%) of the welders worked on both steel and iron, 48 (46.6%) only worked on iron. Amongst the welders, 86 (83.5%) had open workplace, 12 (11.7%) had both open and confined workplace while 5 (4.8%) had confined workplace. Greater number of welders 99 (96.1%) used to eat at or during work, while 4 (3.8%) did not (Table 2).

Symptoms between welders and controls

In Table 3, 28 welders (27.2%) had cough compared to 9 (8.74%) of the matched controls, 21 (20.4%) of the welders occasionally had it

Table 4: Body mass index and blood pressure of the welder and control groups.

Variable	Welder (%) N=103	Control (%) N=99	x^2	p - value
BMI (Kg/m²)				
Underweight (Less than 18.5)	6 (5.8)	1 (1.0)	6	0.114
Normal weight (18.5 - 24.9)	81 (78.6)	86 (86.9)		
Over weight (25.0 - 29.9)	14 (13.6)	8 (8.1)		
Obese (30 and above)	2 (1.9)	4 (4.0)		
BP (Systolic)				
Normal (<140)	82 (79.6)	91 (91.9)	6.2	0.013
Abnormal (≥ 140)	21 (20.4)	8 (8.1)		
BP (Diastolic)				
Normal (<90)	78 (75.7)	90 (90.9)	8.3	0.004
Abnormal (≥ 90)	25 (24.3)	9 (9.1)		

Table 5: Physical and chest examinations of the welder and control groups compared.

Variable	Welder (%) N = 103	Control (%) N = 99	x^2	p – value
PHYSCIAL EXAMINATION				
Pallor				
Yes	12 (11.6)	3 (3.0)	4.27	**0.039***
No	91 (88.4)	96 (97.0)		
Central Cyanosis				
Yes	15 (14.6)	4 (4.0)	6.56	**0.020***
No	88 (85.4)	95 (96.0)		
Digital Clubbing				
Yes	4 (3.9)	0 (0.0)		0.122**
No	99 (96.1)	99 (100.0)		
Weight loss				
Yes	16 (15.5)	6 (6.1)	4.67	**0.031**
No	87 (84.5)	93 (93.9)		
CHEST EXAMINATION				
Respiratory Rate				
Normal	83 (80.6)	90 (90.9)	4.38	**0.036**
Abnormal	20 (19.4)	9 (9.1)		
Inspection				
Normal	95 (92.2)	98 (99.0)	3.94	**0.047***
Abnormal	8 (7.8)	1 (1.0)		
Percussion				
Normal	86 (83.5)	88 (88.9)	1.23	0.267
Abnormal	17 (16.5)	11 (11.1)		
Auscultation				
Normal	80 (77.7)	91 (91.9)	7.89	**0.005**
Abnormal	23 (22.3)	8 (8.1)		

*Yates' Corrected Chi Square; **Fisher Exact

while 3 (2.9%) often had it. Of the 9 (8.74%) controls who had cough, only 3 (2.91%) had it often. The cough was productive of phlegm in 47 (45.6%) of the welders compared to 35 (23.4%) of the controls while 14 welders (13.6%) and 8 (7.8%) of the controls often produced sputum respectively. Fever was present in 46 welders (44.7%) compared to 34 (33.1%) of the controls who had fever. Wheeze was reported in 20 welders (19.4%) compared with 6 (5.82%) of the controls. Weight loss was also reported in 27 (26.2%) of the welders in contrast with 14 (13.6%) in the controls. Thirty welders (29.2%) had chest pain out of which 19 (18.5%) had it occasionally and 11 (10.7%) had it often. This was in contrast to what was obtained in the controls with 13 (12.2%) having chest pain of which 2 (1.9%) and 11 (10.3%) had it often and occasionally respectively. Wilcoxon test results showed that only in cough, wheeze, and chest pain, the differences were significant (p<0.05) (Table 3).

Body mass index and blood pressure of the welder and control groups

Table 4 shows that 6 welders (5.8%) were underweight in contrast to 1 (1.0%) of the controls. A large proportion of both the welders and the controls (78.6% vs. 86.9%) had normal Body Mass Index. Four of the controls (4.0%) were obese compared with 2 (1.9%) of the controls. The study showed that 21 welders (20.4%) and 25 welders (24.3%) had abnormal systolic and diastolic blood pressures respectively while only 8 (8.1%) and 9 (9.1%) of the controls had both abnormal systolic and diastolic blood pressure. The differences in the systolic and diastolic blood pressures were statistically significant (p<0.05) (Table 4).

Physical and chest examinations of the welder and control groups compared

In Table 5, more abnormalities were detected on the general physical examination in the welders than the controls. Pallor was seen in 12 welders (11.6%) and 3 (3.0%) of the controls. central cyanosis in 15 welders (14.6%) compared to 4 (4.0%) of the controls, weight loss was found in 16 welders (15.5%) and 6 (6.1%) of the controls while 4 welders (3.9%) had digital clubbing and none of the controls had such. In the chest examination, 83 welders (80.6%) of the welders had normal respiratory rate while 20 welders (19.4%) had abnormal respiratory rate compared to 90 (90.9%) of the controls having normal respiratory rate and only 9 (9.1%) with abnormal respiratory rate. Abnormal findings on inspection were seen in 8 welders (7.8%) and 1(1.0%) of the controls, on percussion; 17 welders (16.5%) and 11 (11.1%) of the controls while on auscultation 23 welders (22.3%) and 8 (8.1%) of the controls. The differences in the general physical examination findings such as pallor, central cyanosis, weight loss, and chest examination on inspection and auscultation were statistically significant (Table 5).

Ventilatory function between welders and the controls

Table 6 shows the lung function of the welders and controls. The arc welders recorded significantly reduced lung function parameters when compared with the controls. The mean of FEV1 in liter was 4.49 ± 1.12 for the welders and 4.91 ± 1.66 for the controls. The means of FEV1 (% predicted) in both the welder and control groups were 85.23% and 87.91 respectively. The means of FVC in liters were 4.37 and 4.88 for the welders and the controls respectively, while the means of FEV1/FVC (% predicted) were 74.4 for the welders and 76.6 for the

Table 6: Ventilatory function in Arc – welder and the control groups.

Variable		Welder (%) N=103	Control (%) N=99	t	p - value
FEV_1 (L)	Mean ± SD	4.49 ± 1.12	4.91 ± 1.66	2.2	**0.036**
FEV_1 (%)	Mean ± SD	85.23 ± 6.18	87.91 ± 6.26	3.1	**0.003**
FVC (L)	Mean ± SD	4.37 ± 0.98	4.88 ± 1.24	3.3	**0.001**
FEV_1/FVC (%)	Mean ± SD	74.41 ± 4.08	76.64 ± 5.84	3.2	**0.001**

t: Independent t test; L: Liters; FEV1: Forced Respiratory Volume in one second; FEV1 (%): FEV1 as percent predicted; FVC: Forced Vital Capacity

Table 7: Lung impairments in Arc -welders and control group.

Lung impairment	Welder (%) N=103	Control (%) N=99	x^2	p - value
Obstructive pattern	39 (37.9%)	12(12.1%)	17.73	<0.0001
Restrictive pattern	47(45.6%)	18(18.2%)	14.3	<0.0001
Normal lung function	17(16.5%)	69(69.6%)	64.5	<0.0001

Table 8: Chest X-ray features of the welder and control groups.

Variable	Welder (%) N=103	Control (%)	x^2	p - value
Parenchymal Abnormalities				
Yes	13 (12.6)	4 (4.0)	0.028	**0.028**
No	90 (87.4))	95 (96.0)		
Primary (n = 13)				
P	9 (69.2)	3 (25.0)	0.79	0.674
Q	2 (15.4)	1 (25.0)		
R	2 (15.4)	0 (0.0)		
Zone (n = 13)				
Upper	1 (7.7)	1 (25.0)	1.4	0.498
Middle	2 (15.4)	0 (0.0)		
Lower	10 (76.9)	3 (25.0)		

Table 9: Age and educational status as determinants of health related quality of life of welders.

Variable	Health – Related QoL			x^2	p – value
	Good (%) N=57	Poor (%) N=46	Total N=103		
Age (in years)					
Less than 30	6 (37.5)	10 (62.5)	16	13.27	**0.001**
30–45	23 (44.2)	29 (55.8)	52		
Above 45	28 (80.0)	7 (20.0)	35		
Educational Status					
None	4 (30.8)	9 (69.2)	13	40.67	**<0.0001**
Primary	14 (29.2)	34 (70.8)	48		
Secondary	29 (90.6)	3 (9.4)	32		
Tertiary	10 (100.0)	0 (0.0)	10		

controls. Differences in all the parameters measured were statistically significant ($p<0.05$).

Lung impairments in Arc-welders and control group

The pattern of lung function abnormality is presented in Table 7 which showed that 47 (45.6%) of the subjects had restrictive lung defects as compared to 18 (18.2%) of the controls. Thirty-nine (37.9%) of the subjects had obstructive defects as compared to 12 (12.1%) of the controls. Seventeen (16.5%) of the welders had normal lung function while 69 (69.6%) of the controls had normal lung function. These findings were statistically significant ($p<0.001$).

Chest X-ray features of the welder and control groups

The result showed that 13 (12.6%) welders had parenchymal abnormalities consistent with pneumoconiosis as compared to the controls with only four (4.0%). The parenchymal abnormality were mainly small opacities in 9 welders (69.2%) in contrast with 1 (25.0%) in the control group. Lobar involvement was mainly lower in 10 welders (76.9%) as compared to 3 (25.0%) in the controls (Table 8 & Figure 4).

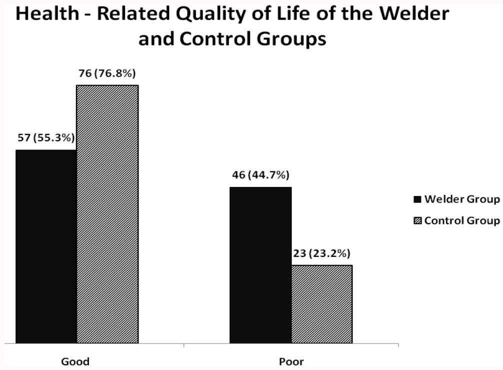

Figure 4: Bar chart showing Health related quality of life between Welders and the Controls.

Age and educational status as determinants of health related quality of life of welders

Table 9 shows that 28 (80.0%) of the subjects above 45 years had good HRQL as compared to 7 (20.0%) who had poor HRQL, 23 (44.2%) of subjects between 30 and 45 years had good HRQL as compared to 29 (55.8%) who had poor HRQL and 6 (37.5%) of the subjects of less than 30 years had good HRQL as compared with 10 (62.5%) who had poor HRQL. Also, 4 (30.8%) of the subjects with no formal education had good HRQL as compared to 9 (69.2%) with poor HRQL. Fourteen (29.2%) subjects who had primary education had good HRQL as compared to 34 (70.8%) with poor HRQL. Similarly, 29 (90.6%) of subjects with secondary education had good HRQL as compared with only 3 (9.4%) with poor HRQL. All the subjects who had tertiary education had good HRQL. The differences in both age and level of education were statistically significant.

Relationship of occupational history and Health-Related Quality of Life of welders

Table 10 shows that subjects with the following parameters had good HRQL; (a) 10 to 19 years of exposure, (b) welder who spent 6 h to 10 h at work, (c) welded only iron in an open workplace, (d) who always use their personal protective equipment, (e) who did not normally eat during work and (f) who normally had their bath after the day work. All parameters tested were statistically significant with the exception of the type of materials welded and type of working place.

Logistic regression (odd Ratio) showing the determinants of health related quality of arc-welders under study

Table 11 represents the logistic regression showing the determinants of Health related quality of life of welders. Subjects above 45 years of age and those between 30 and 45 years were seven (7) times and approximately two (2) times respectively better than subjects with less than 30 years.

Those subjects who had primary education had almost the same HRQL as those with no formal education while those welders with secondary education were four (4) times more likely to have better HRQL than those with no formal education. The welders with more than 20 years of exposure and between 10 and 20 years of exposure were four (4) times likely to have better HRQL than those with less than 10 years of exposure.

Table 10: Relationship between occupational history and health related quality of life of welders.

Variable	Health – Related QoL			x^2	p - value
	Good (%) N=57	Poor (%) N=46	Total N=103		
Length of Experience (in years)					
Less than 10	6 (28.6)	15 (71.4)	21	7.7	**0.021**
10-19	30 (61.2)	19 (38.8)	49		
20 and above	21 (63.6)	12 (36.4)	33		
Average hours spent per day at workshop					
Below 6	7 (58.3)	5 (41.7)	12	9.9	**0.007**
6–10	38 (67.9)	18 (32.1)	56		
Above 10	12 (34.3)	23 (65.7)	35		
Type of PPE use					
Glasses	43 (50.0)	43 (50.0)	86	4	**0.045**
Face Mask	13 (76.5)	4 (23.5)	17		
Frequency of PPE use					
Always	22 (75.9)	7 (24.1)	29	7.5	**0.006**
Occasionally	34 (45.9)	40 (54.1)	74		
Types of materials wedded at workshop					
Iron only	30 (62.5)	18 (37.5)	48	1.9	0.172
Iron and Steel	27 (49.1)	28 (50.9)	55		
Type of welding workplace					
Open	52 (60.5)	34 (39.5)	86	5.8	0.055
Confined	1 (20.0)	4 (80.0)	5		
Both	4 (33.3)	8 (66.7)	12		
Eat during work					
Yes	54 (54.6)	45 (45.4)	99		0.626**
No	3 (75.0)	1 (25.0)	4		
Have bath after day's work					
Yes	45 (63.4)	26 (36.6)	71	6	**0.014**
No	12 (37.5)	20 (62.5)	32		

**Fisher Exact

Discussion

Small Scale Enterprises (SSE) account for a large portion of the manufacturing activities in the developing countries [52]. Welding is a common industrial process but one with the potentials to be extremely harmful and detrimental to the health of welders [83]. One of the main risk factors to which welders are exposed is welding fumes and gases. The main disorder caused by such exposure include respiratory disorders [84,85]. Pneumoconiosis resulting from inhalation of iron in welding fume is a long-recognized, well catalogued but less common type in which the dust load is heavy but pulmonary reaction minimal [86]. Principles of management of pneumoconiosis have included lung function test, an integral part of diagnosing and managing patients with respiratory diseases. However, these end points do not fully represent the wide spectrum of disease burden in this form of pneumoconiosis when not used in conjunction with the clinical, occupational history and chest radiograph. The International Labor Organization (ILO) standard films for the descriptive interpretation of the radiologic appearance of diffuse parenchymal lung were originally developed for epidemiologic studies of occupational lung disease [82]. Chest radiograph is the corner stone of surveillance for pneumoconiosis in this less form of pneumoconiosis may actually help in predicting the overall outcome in this group of workers. The welding activities being associate with exposure to welding fume and gas and the observations that respiratory symptoms burden, lung impairments are closely related to Health-Relate Quality of life (HRQL); increasing attention is now being given to HRQL as an important outcome of medical care [74].

Socio-demographic & clinical characteristics

In this study, the mean age of the welders was 32.90 ± 8.54. This was slightly lower when compared to that of the controls (34.27 ± 10.03). In this study, 52 (50.5%) of the welders were between the ages brackets of 30 to 45 years. This finding was comparable to earlier works by Erhabor et al. [52] that reported a mean age of 32.5 ± 9.68. However, this is in contrast to the finding that the highest percentage of men (99.2%) in the work place is among those aged between 45 and 49 years [8]. The age difference might be explained by the low level of educational status in the developing countries and the acquisition of skills through apprenticeship is common in this age group.

Studies from different regions of the world have reported similar age profile [86,87]. In this study, largest proportion of the welders, 48 (46.6%) had primary school education thus corroborating the fact that most of the respondents received their apprenticeship and thereby

Table 11: Logistic regression (Odd Ratio) showing the determinants of health -related quality of life of Arc – welders under study.

	OR (95% Confidence Interval)	P
Age (in years)		
Less than 30	1	
30–45	1.32 (0.37–4.87)	0.634
Above 45	6.67 (1.153–31.08)	**0.002**
Educational Status		
None	1	
Primary	0.93 (0.21–4.32)	0.911
Secondary	21.75 (3.28–177.31)	<**0.001**
Tertiary		
Length of Experience (in years)		
Less than 10	1	
10–19	3.95 (1.16–13.95)	**0.012**
20 and above	4.38 (1.17–17.14)	**0.012**
Average hours spent per day at workshop		
Below 6	1	
6–10	1.51 (0.35–6.35)	0.527
Above 10	0.37 (0.08–1.71)	0.143
Type of PPE use		
Glasses	1	
Face Mask	3.25 (0.89–12.94)	**0.045**
Frequency of PPE use		
Always	1	
Occasionally	0.22 (0.07–0.61)	**0.001**
Have bath after day's work		
Yes	1	
No	0.35 (0.13–0.89)	0.014

rely on their masters for information on the job hazards. This finding was consistent with that of Adewoye et al. [88]. Poor knowledge of imminent dangers of welding will lead to poor utilization of safety gadgets, by the welders even when they possess such. Majority of the controls (58.4%) had secondary education, this is not unexpected, and considering the fact that a substantial number of them are civil servants and are expected to have a higher level of education than the welders. There were no significant differences in age, marital status, ethnic group, religion and level of education in the welders and controls.

Pattern of respiratory symptoms

Our study showed that respiratory symptoms were significantly more prevalent among the welders than the controls ($p<0.05$). Various studies in the industrialized countries have also reported an increase in respiratory symptoms usually of the acute type. These symptoms depend on the degree of exposure of fumes released during welding [89,90]. This study is comparative to a study done by Erhabol et al. [52] on 44 arc-welders in Modakeke, a suburb of Ile-Ife in Nigeria, which showed that the welders had more respiratory symptoms compared to the controls. Another review of 119 welders and 90 controls, matched for age and height as well as smoking history showed that there were more significant respiratory symptoms in the welders than the controls [91]. Our data were in agreement with Kernig et al. [92] who reported higher frequencies of respiratory symptoms in welders. They concluded that age and smoking were the main etiological factors, and that they enhance the effects of welding fumes. Arc welding is known to release gases, which are toxic respiratory irritants. The commonest respiratory symptom as shown by this study was cough with sputum production, 47 (45.5%). This seem plausible because accumulation of welding particles in small airways can increase mucus production and lead to stagnation of secretion [93]. Although, prevalence of phlegm, fever and weight loss was higher among the welders, these differences were not statistically significant (Table 3). This finding was not in tandem with the finding from a study of 156 Danish welders and 152 controls from the same plant, where no statistical difference in the rate of chronic bronchitis was seen when compared with the control group [94]. In addition Antiipoika indicated that welders were not at a greater risk of developing serious respiratory ailments than the controls. Other studies have also shown increased prevalence of acute upper and lower respiratory tract infections [41]. Chemical irritations in particular exposure to metal fumes of the airway epithelium are a suspected cause of increased incidence of respiratory infections [42]. Oxhoj et al. [95] in Sweden in 1990 investigated 119 Shipyard welders who had welded for 5 years or more and 90 clerks who had never welded as controls. The respiratory symptoms such as cough, wheeze and dyspnoea were more prevalent in welders than in controls, which are also reflected in this study. The authors concluded that these could be attributable to deposition of welding fumes in the small airways and alveoli.

Occupational characteristics of welders

Length of experience (Years): In this study, 49 (47.6%) of the welders had duration of exposure between 10 and 19 years. This suggests an association between the length of employment and lung impairments in arc welders. Excessive exposure can lead to overloading of alveolar macrophages which can be pro-inflammatory even with relative non-particulate [33]. This finding was consistent with the finding of Erhabor et al. [52] who reported the mean number of years of 44 arc welders studied as 13 years. All the subjects who developed the obstructive pattern of lung disease had it after 9 years of employment as contrasted to those with restrictive lung disease of less than 9 years. Similar study by Sultan et al. [86] also showed that a duration of more than 9 years was associated with a significant reduction in spirometric patterns relative to their controls, whereas, those workers between 5 and 9 years and those of occupational exposure of less than 5 years did not show a significant reduction in lung function parameters. It also showed a strong association with a dose response effect, between welding years and decreased MVV, FEV1, and FVC. This trend may suggest gradually accumulating lung pathology in welding workers. Increasing welding years may affect physical function, general health thus reducing quality of life. From our study, we found out that a large proportion of the welders, 56 (54.4%) spent between 6 and 10 h at work.

Type of personal protective equipment (PPE) and its use: This study showed that the commonest PPEs used by the welder group were eye goggles 86 (83.5%) and face mask 17 (16.5%). This may be due to level of education of the subjects studied and lack of knowledge and understanding of health hazards of welding. These findings were consistent with that of Adewoye et al. [88], which showed that most welders used eye goggle (80.3%). However, the finding in this study is comparatively higher than what was obtained from similar studies by Sabitu et al. [85], where 60.9% of the welders interviewed reported the use of eye goggles and by Isah et al. [4] in Benin City, Nigeria where

35.9% of welders interviewed reported the use of eye goggles. The use of face mask was reported low, 17 (16.5%) in this study which may be due to poor knowledge of hazard associated with non- or irregular use of face mask among the respondents and kind of training they received as almost all of the welders in the developing countries were trained through hands of apprenticeship [88]. The use of face mask reduces the inhalation of welding fumes that may result in the development of respiratory diseases. Further study by Chen et al. [96] reported that face mask was sufficient in blocking the inhalation of particles but was not efficient in blocking gases found in welding fumes.

Types of welding materials and working places: Results from this study showed that majority, 55 (53.4%) of the welders welded both iron and steel as compared to 48 (46.6%) who welded only iron. This disparity might be due to increase use of steel now in developing countries in building constructions. The study also revealed that amongst the welders, largest proportion, 86 (83.5%) had open workplaces. It has previously been shown that welders who worked in open workplaces had no significant decrease in lung function [97]. Those welders working in well ventilated areas showed no obstructive signs or radiological abnormalities, relative to welders working in poor ventilated areas [98]. In addition, welding years and the use of PPEs were found to be factors influencing HRQL of welders [96].

Physical and chest examination findings of welder and control groups

In this study, pallor was seen in 12 (11.6%) of the welders compared with 3 (3.0%) controls. Central cyanosis was present in 15 (14.6%) of the welders relative to 4 (4.0%) of controls. Four (3.9%) had digital clubbing. None of the control had this. A higher prevalence of bronchial breath sounds (abnormal auscultation) was found in welders, 23 (22.3%) compared to 8 (8.1%) controls. All associations were statistically significant except for the digital clubbing.

Lung function

Pulmonary function testing is an integral part of diagnosing and managing patients with respiratory diseases. Several studies had been done to evaluate some specific group of workers or patients. However, the use of the lung function to assess the adverse effects of long-term exposure to welding fume is inconsistently reported. Osim et al. [99] assessed the lung function of some Nigeria bank workers; Okpapi et al. [100] evaluated the respiratory symptoms and lung function among textile workers at Kano textile mills, Kano, Nigeria. Other studies on lung function were that of Ozoh and Egbagbe et al. [101] also studied the prevalence of respiratory symptoms and lung function of flour mills workers in Ilorin, North Central Nigeria. The results of the present study established a statistically significant reduction in the mean value of FVC (%), FVC (L), FEV1 (%), FEV1 (L) and FEV1/FVC in the welders compared with controls ($p<0.05$) Table 6. This finding is consistent with the finding by Erhabor et al. [52] in a study of 44 arc welders in Modakeke, Nigeria that showed that welders were found to have characteristically lower lung function parameters when compared to controls. Akbarkhaaden [102], 50 observed the different parameters of pulmonary function test between welders and controls and reported that FEV1, FEV1/FVC were significantly decreased in welders compared with controls. Stern et al. [50] reported that FEV1 and FVC were also reduced in the welders. A previous study showed no significant differences between the ventilatory function test results of welders and controls [103]. This might be explained by the presence of absences and respiratory symptoms. Ekijuntii-Pekkanen et al. [46] reported that welders who smoked had a significantly greater annual decline (88.8 ml) in FEV1 than non-smoker welders who had a slight non-significant annual decrease (34.2 ml). In addition, they showed that welders without respiratory protection or local exhaust ventilation while welding had a greater annual decline both in FVC and FEV1 than welders with protection. These findings confirm the findings of others, that, welding fume adversely affects lung function parameters of welders relative to controls. The low FEV1 may indicate obstructive lung disease or reduction in the lung volumes and might be due to exposure to welding fumes and duration. Our study has also shown that restrictive ventilatory pattern was seen more in the study subjects, 47 (45.6%) compared with 39 (37.9%) that had obstructive ventilatory pattern. The reason for this may be as a result of parenchymal responses which include nodular fibrosis, diffuse fibrosis, and macule formation with focal emphysema. This finding was corroborated by the finding of Erhabor et al. [52] that also showed restrictive pattern as predominant ventilatory defect noticed among the welders, 18 (40.9%) of them had the restrictive pattern of the ventilatory defect as compared to 10 (22.7%) with obstructive pattern. They also found that all the subjects who developed the obstructive pattern of lung disease had it after 9 years of employment as contrasted to those with restrictive lung disease. It was concluded in their study that the early effects of exposure to arc welding is to produce a restrictive lung disease, although later a mixed pattern, may emerge. In this present study, 18 (18.2%) of the controls had restrictive ventilatory pattern. This finding was comparatively higher than that of Erhabor et al. [52] where none of the controls had restrictive disease.

Chest X-ray features of welders and controls

Chest radiographs are the corner stone of surveillance for pneumoconiosis in the work places. Pneumoconiosis is a common and serious occupational disease in Nigeria. It is mainly diagnosed through the use of chest X-ray. The diagnosis of pneumoconiosis is a complex procedure and it requires a certain level of expertise [104]. Durg and McLaughlin in 1936 were the first to describe abnormal radiographic findings in the lungs of arc welders and suggested that the shadows might be caused by the deposition of iron oxides in the lung. Exposure to welding fume may alter the pathologic picture, including a more complicating fibrotic reaction [105,106]. In our study, 13 (12.6%) of the welders had parenchymal abnormalities consistent with pneumoconiosis as compared to the controls with only 4 (4.0%). These findings mostly belonged to category 1, type p. None of the welders had developed nodulation. This finding is not in keeping with the finding of Spacilova. They examined the 37 arc welders; 23 of them had worked for part of the time inside closed cistern under some of the most hazardous working conditions in Praque where MAC for inert dust was greatly exceeded. Thirty (81.1%) of the study subjects were in category 1 but type s and t. Only 4 (10.8%) developed nodulation type m, n, category 2 after an average 25 h of welding. This study also showed a predominant lower lobe involvement in 10 (76.9%) of welders (Table 8) [107-110].

Health-related quality of life (HRQL)

Previous studies showed that the SF-12 has a good reliability and validity [102]. Our study showed that increasing age and higher level of education were associated with good HRQL in the welders and that the welders had a poor HRQL compared to the controls. Previous study by Qinj et al. [106] also revealed that the welders had poor (lower scores of SF-12) HRQL compared to the controls which was reflected in our study. HRQL may be influenced by multiple factors [111-115]. This study has shown age and level of education to be statistically significant. It was also reported in this study that welders above 45 years of age had better HRQL, 28 (80.0%) compared to those between 30 and 45 years, 23(44.2%) and those less than 30 years, 6 (37.5%). Tertiary education was found to be associated with good HRQL [116-120]. In exploring these factors further, our results showed that the length of experience; average hours spend per day at work; frequency and type of PPEs use, and having bath after the day's work were associated with good HRQL. However, factors such as types of material welded, types of welding workplace and eating at work were also associated with good HRQL but not statistically significant. These findings were consistent with the finding of Qinj et al. [106]. Multivariate logistic regression was used to determine the independent predictors of HRQL in arc welders. Factors such as age above 45 years, length of experience (years) of more than 20 years and between 10 and 19 years, use of face mask were significantly associated with good HRQL [121,122].

Conclusions

- This study had demonstrated that welders exposed to welding fumes and gases have predominant lower respiratory tract symptoms.
- The study also showed that the commonest respiratory symptom among the welders is cough and sputum production.
- The study also showed that all the Spirometric indices (FEV1, FVC, and FEV1/FVC) were significantly reduced in the welders compared to controls.
- Health related quality of life of arc-welders is significantly associated with age, duration of exposure, educational status, average hours spent at work, and the use of Personal Protective Equipments (PPEs).

Recommendations

- Arc-welders should have a pre-occupational lung function assessment to identify workers at risk/or with pre-existing respiratory impairments.
- Arc-welders should have periodic testing during their welding years to detect pulmonary disease in its earliest stages when corrective measure measures are likely to be beneficial.
- Arc-welders should use the appropriate Personal Protective Equipment (PPE) regularly.
- Further research is recommended to study and measure each particulate matters so as to determine the degree of the hazard.

Limitations of Study

- Inability to measure directly different particulate matters, fumes or gases inhaled by the subjects.
- A longitudinal study would have been preferred to a cross-sectional study to enable documentations of findings over time.

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