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Respiratory Disorders, Pulmonary Function And Radiological Abnormalities Among Workers Exposed To Welding Fumes At Shuaiba Industrial Area In The State Of Kuwait

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1.Abstract

1.1. Introduction: The welding process produces visible smoke that contains harmful metal fume and gas by-products. Results of previous researches on effects of welding emissions on respiratory health were equivocal.

1.2. Aim: To study the prevalence of respiratory symptoms and diseases, and to investigate the changes in lung function and radiological abnormalities among welders.

1.3. Method: This cross-sectional study was conducted in the Shuaiba industrial area, Kuwait. Two hundred and thirty-five welders and 155 unexposed workers were interviewed by the British Medical Research Council questionnaire, workers underwent measurements of lung functions, and chest X rays were performed and interpreted, according to the ILO classification of pneumoconiosis.

1.4. Results: exposure to welding fumes significantly increased the prevalence of chronic cough in the early morning, it was 1.74 times fold higher compared with unexposed workers.Chronic bronchitis was more encountered, but the result was not statistically significant.
Metal fume fever was experienced by 23.4% of the studied welders, the majority reported one or two attacks per year, and attacks usually lasted for one or two days. Frequency of sick leaves were significantly higher among welders (35.74%) compared with unexposed workers (14.19%), and were mainly due to respiratory diseases, followed by musculoskeletal disorders, and injuries. Lung function indices (LFIs) investigated in this study (FVC, FEV_1, $FEV_1\%$, PEFR, $FEF_{75\%}$, $FEF_{50\%}$, and $FEF_{25\%}$) showed significant decrements in welders after adjusting for age, height, weight, and smoking, moreover, increase in duration of exposure to welding fumes was significantly associated with decrease in lung functions after allowing for the effect of confounders. Findings suggestive of pneumoconiosis were observed in this study.

1.5 Conclusion: welding fumes had significant adverse effects on the respiratory system of welders and the level of protection for exposed workers should be increased.

2. Keywords:
Welding, respiratory symptoms, pulmonary function test, pneumoconiosis.

3. Introduction

Welding is considered the most hazardous occupation and is increasing dramatically in both developed and developing countries. The welding process produces a mixture of particulate and non-particulate chemical hazards [1,2]. Most of the fumes created from the welding process have particles less than 2μm in aerodynamic diameter, which have the ability to penetrate lungs and be deposited in terminal bronchioles and alveoli [3]. Occupational exposure to welding fumes may cause acute and chronic respiratory health effects. Acute respiratory effects ranged from airway irritation to asphyxia and pneumonitis [4]. Metal fume fever was frequently reported by welders, presented with a systemic febrile illness lasting 4-6 hours that may appear during or after welding work. Pneumonitis was previously diagnosed in welders after inhalation of irritant gas or gas particulate mixture that produces acute inflammation

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of lung parenchyma [5]. Respiratory infections have been shown to be increased in terms of severity, duration, and frequency among welders [2,5]. Furthermore, the increased risk of pneumonia among welders was observed in some studies [6,7]. Chronic respiratory disorders such as chronic bronchitis, occupational asthma, pneumoconiosis, lung cancer, and reduction of pulmonary function were reported by some research groups [8]. Benign pneumoconiosis was usually attributed to chronic exposure to iron oxides during the welding process [9]. Exposure to welding fumes was reported by some researchers to be associated with acute transient reduction in pulmonary function, especially through shift working without a local exhaust system [10]. Although adverse respiratory health effects of welders have been suggested by several research groups, yet findings have not been conclusive. Thus, this study was conducted to detect the prevalence of respiratory symptoms and respiratory diseases among welders. In addition, we intended to investigate the changes in lung function and radiological abnormalities among welders.

4. Methods

This cross-sectional comparative study was conducted at the Shuaiba Industrial area, Kuwait. Study population (n=235) included all welders who fulfilled study inclusion criteria i.e. on job for at least six months, not exposed to respiratory hazardous agents other than welding fumes, no previous exposure to respiratory hazards, and free from chronic respiratory diseases and / or systemic diseases that affect the respiratory system. The comparison population included 155 workers, not exposed to welding fumes or other respiratory hazards.

Tools for data collection included:

A self-structured interviewing questionnaire, to obtain data about sociodemographic and workplace characteristics

British Medical Research Council "BMRC" questionnaire for respiratory symptoms [11], diseases and smoking habit. According to smoking habit workers were classified into 3 categories [12]:

- Smokers: who still smoked at least one cigarette daily for as long as one year.
- Ex-smokers: those who had given up smoking for at least six months prior to the date of
- examination.
- Non-smokers: who had never smoked or smoked less than one pack per month or 20 packs in their whole lif.

Workers in the first category (smokers) were further categorized according to their smoking index SI (which was calculated by multiplying the number of cigarettes smoked per day by long life duration of smoking in years) into[12]:

-light smokers: SI is less than 200.
-moderate smokers: SI ranges from 200 to 400.
-heavy smokers: SI is more than 400.

c) General medical examination, and a local examination of the chest.

d) Forced expiratory spirometry, was carried out by a computerized flow volume spirometer Master Screen IOS, which can produce both volume time and flow volume curves [13]. The spirometer was calibrated daily with a one-liter syringe. The spirometer used and the maneuvers met the recommended standardization cited by the American Thoracic Society [14]. The results of the best 3 acceptable forced expiratory maneuvers were recorded, provided that there was good reproducibility between the best 3 trials, i.e. the variability between them must be less than 5% for the FVC and FEV_1 indices and 10 % for the PEFR index. The highest of the 3 trials was recorded as the final value [15]. The following lung function indices were recorded for each worker in the study: FVC, FEV_1, FEV_1/FVC %, PEFR, $FEF_{75\%}$, $FEF_{50\%}$, and $FEF_{25\%}$. *e)* Standard full size postero-anterior chest radiographs taken at full maximal inspiration. Chest radiographs were interpreted according to the ILO classification of pneumoconiosis [16].

The SPSS/Pc+ software program version 25 was used for both data entry and statistical analysis of the data [17]. Statistical analysis of the results included both descriptive and analytic techniques. Descriptive statistics including mean, standard deviation, percentage and frequency were used to describe personal characteristics and different respiratory symptoms among the study groups. Analytic measures included, two sample t- test and Chi square test. A correlation matrix was used to assess the degree of association between different variables including lung function indices and other independent variables. Those variables having significant correlation with lung function indices and other dependent variables were selected for further analysis through multiple regression technique. A logistic regression model was used to describe respiratory symptoms and test differences in their prevalence between the studied groups after adjusting for age, smoking habit, and exposure. A level of $P \leq 0.05$ was considered to be statistically significant.

4.1. Ethical Clearance:

The overall study objectives and procedures were discussed with those responsible in the Shuaiba industrial area and occupational medical center before getting their approval to carry out the study. Approval of the Medical Ethics Committee of Alexandria Faculty of Medicine and the Ethical Research Committee at Ministry of Health of Kuwait were obtained. A verbal consent to share in the study was obtained from the participating workers. All collected data were dealt with great confidentiality.

5. Results

All subjects participating in this study were males and most of the welders and unexposed workers were Indians. Welders in this study were significantly younger, shorter, and less obese than unexposed workers. Mean smoking index was significantly higher among unexposed workers compared with controls. Thus, multifactorial statistical methods were used to control for the confounding effects of age, height, weight, and smoking habit (Table 1).

Table 1: Distribution of studied welders and unexposed workers according to personal characteristics

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Variable	Welders n=235 No.	%	Unexposed workers n=155 No.	%	Test of significance (p-value)
Age					
▯ 20-	54	22.98%	25	16.13%	
▯ 30-	129	54.89%	60	38.71%	X^2=25.13
▯ 40-	41	17.45%	47	30.32%	
▯ 50-60	11	4.68%	23	14.84%	0.000
Min-Max	22-60-		23-59		
Mean± SD	34.77±7.39		39.00±9.05		
Nationality					
▯ Indian	214	91.06%	82	52.90%	X^2 =75.99
▯ Egyptian	11	4.68%	25	16.13%	
▯ Others	10	4.26%	48	31.97%	0.000
Smoking habits					X^2=2.984
▯ Nonsmoker	168	71.50%	107	69.03%	
▯ Ex-smoker	11	4.68%	14	9.03%	0.225
▯ Smoker	56	23.82%	34	21.94%	
Smoking index					X^2=5.885
▯ Light	52	92.86%	27	79.41%	0.053
▯ Moderate	4	7.14%	4	11.77%	
▯ Heavy	0	0.0%	3	8.82%	
					t = -2.346
Min-Max	1-400		1-1400		
mean± SD	1.071±0.259		1.294±0.629		<0.000
Height (m)					t= 2.89
Min- Max	1.51-1.85		1.50-1.86		
Mean ± SD	1.66 ± 0.06		1.68 ± .07		0.03
Weight (Kg)					t= 4.375
Min- Max	48.0-102.0		44.0-135.0		
Mean ± SD	71.21±9.93		77.00±16.18		0.00

Studying current workplace characteristics revealed that (Table 2), job duration of welders ranged from 6 months to 25 years with a mean of 5.183 years, and their daily exposure to welding fumes ranged between 5-11 hours. Most of the welders worked in open space, and they all used PPE.

Table 2: Distribution of studied- welders according to workplace characteristics

Workplace characteristics	**Welders n= 235** No.	%
Job duration in years		
▯ <5	136	57.87%
▯ 5-	71	30.21%
▯ 10-	19	8.10%
▯ 15-	8	3.40%
▯ 20-25	1	0.42%
Daily exposure hours		
▯ 2-	25	10.64%
▯ 5-	150	63.83%
▯ 9-11	60	25.53%
workplace setting		
▯ Open space	168	71.49%
▯ Confined space	40	17.02%
▯ Both	27	11.49%
Ventilation		
▯ Local exhaust	3	1.28%
▯ General	22	9.36%
▯ Natural	168	71.49%
▯ More than one types	42	17.87%

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Use of personal protective equipment (PPE)		
Frequency of using PPE		
▯ Occasionally	2	0.90%
▯ All the time	233	99.10%
Total	235	100.0%

Flux cored arc welding was the most common method used by 40.9% of the studied welders (Figure1). Most of the welders (61.27%) used steel alloys, (13.20%) used iron alloys, and (25.53%) used alloys made from several different combinations of metals (Figure2).

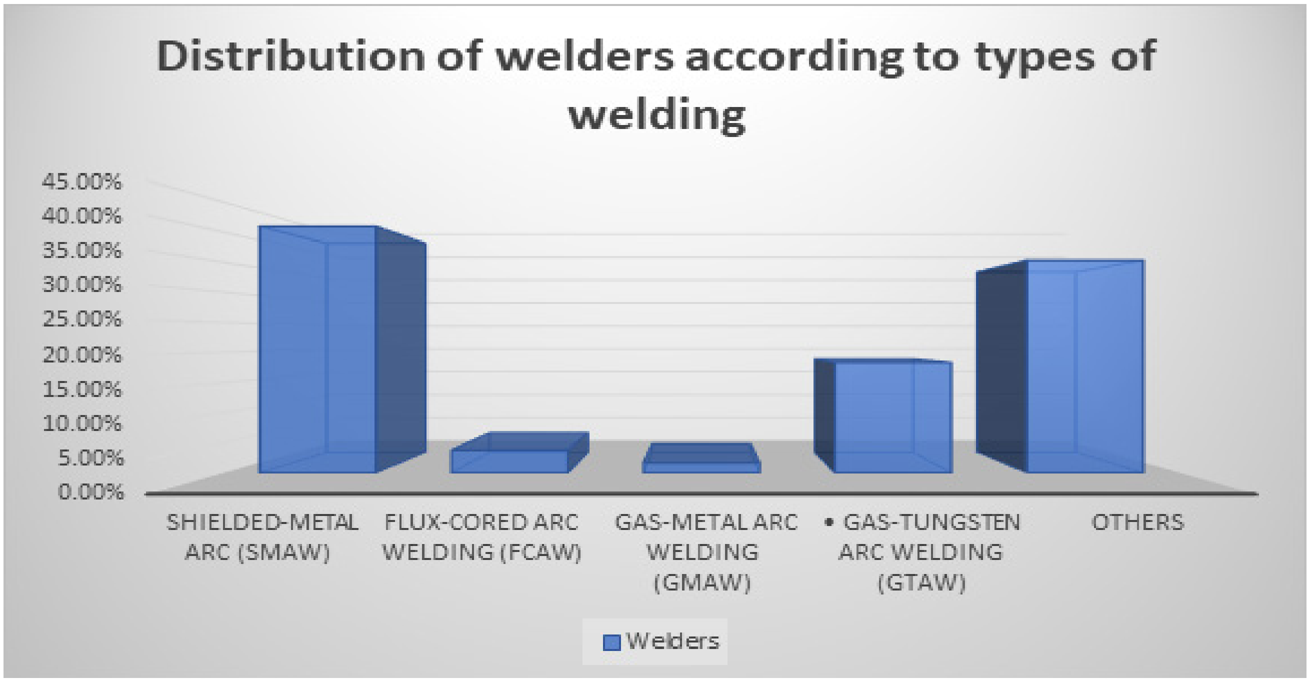

Figure 1: Distribution of studied welders according to types of welding

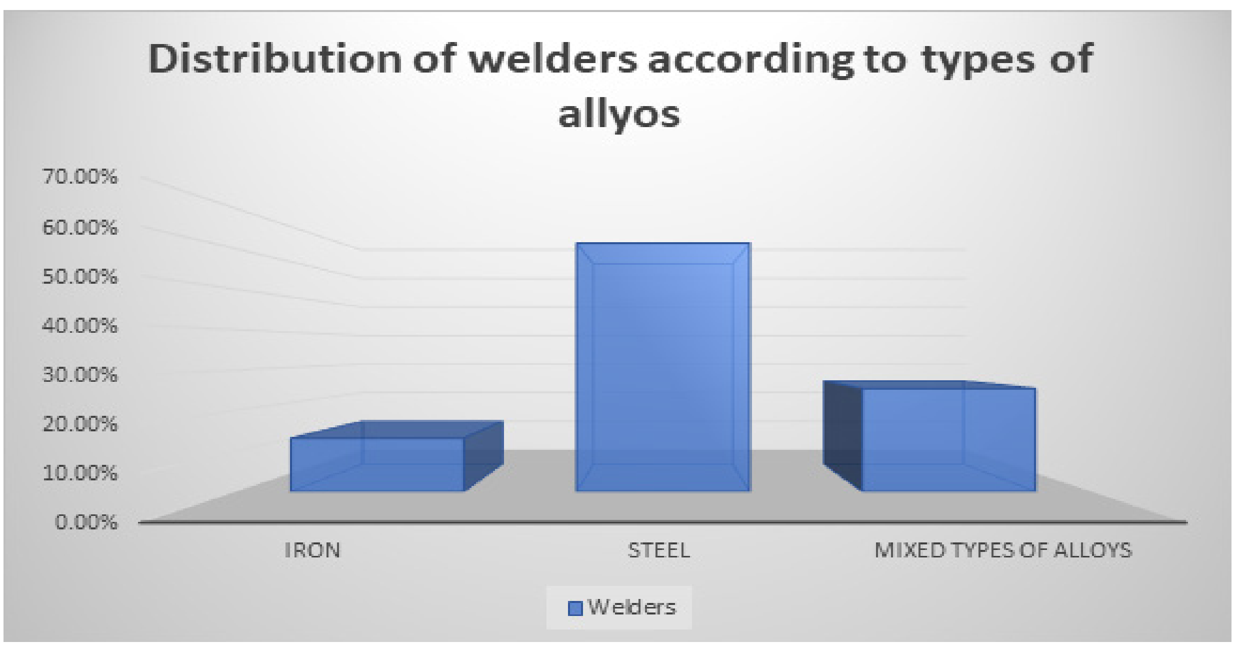

Figure 2: Distribution of studied welders according to types of welding alloys

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Regarding sick leaves, its frequency was significantly higher among welders (35.74%) compared with unexposed workers (14.19%). Sick leaves were mainly due to respiratory diseases, followed by musculoskeletal disorders, and injuries (Figure 3).

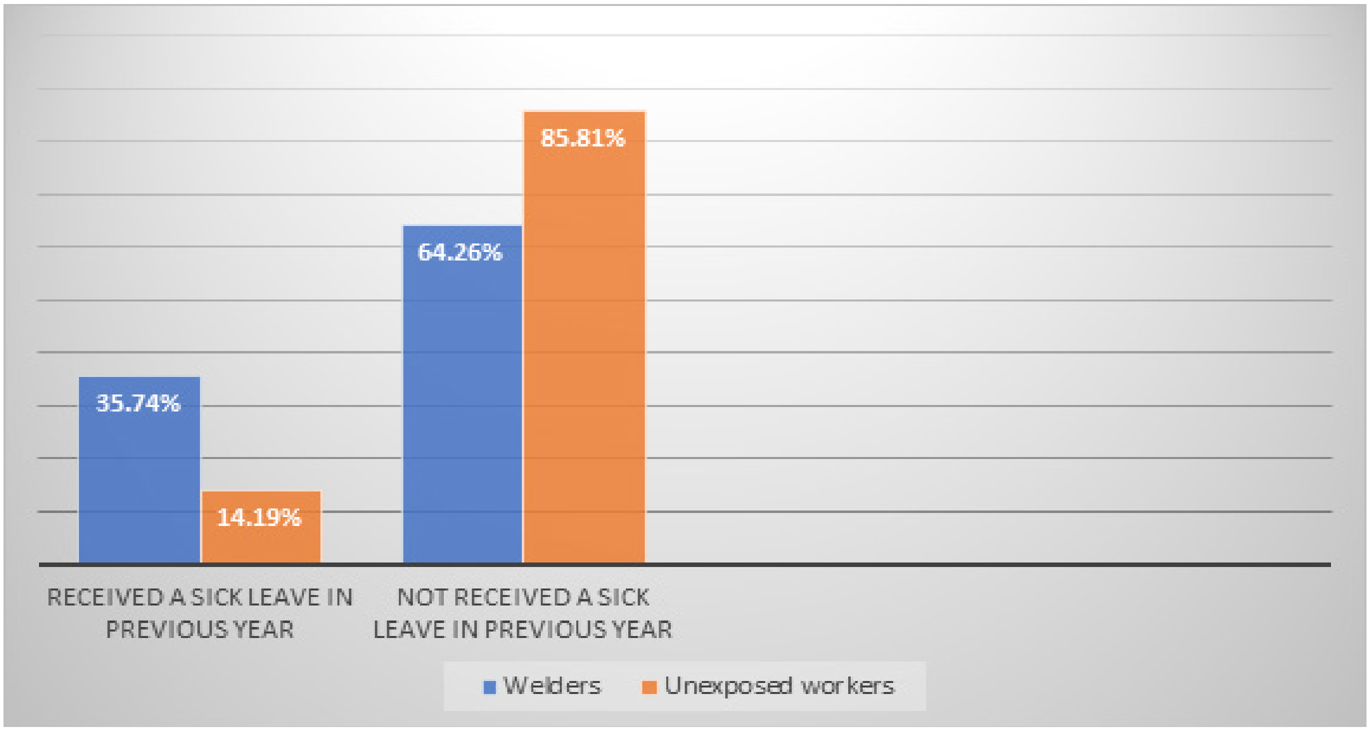

Figure 3: Distribution of studied welders and unexposed workers according to sick leaves

Table 3, and 4 show that chronic cough in the early morning was significantly more encountered among welders compared with unexposed workers. After allowing for the effect of smoking, chronic cough among welders was significantly1.065 times fold higher among welders compared with unexposed workers. Although, phlegm production and wheeze were more prevalent among welders compared with unexposed workers, yet, the relationship was not statistically significant.

Table 3: Distribution of studied welders and unexposed workers according to respiratory symptoms

Respiratory symptoms	Welders n=235				Unexposed workers n=155				Test of significance p-value
	Yes		No		Yes		No		
	No.	%	No.	%	No.	%	No.	%	
Cough in early morning in winter	28	11.90%	207	88.10%	7	4.52%	148	95.48%	6.259 0.012
Chronic cough	5	2.13%	230	97.87%	1	0.65%	154	99.35%	0.405
Phlegm production in early morning in winter	19	8.09%	216	91.91%	6	3.87%	149	96.13%	2.675 0.096
Chronic phlegm production	5	2.13%	230	97.87%	1	0.65%	145	99.35%	0.405
Wheeze	2	0.9%	233	99.1%	2	1.30%	153	98.70%	0.178 0.651

Table 4: Logistic regression model describing respiratory symptoms among studied population after allowing for the effect of smoking

Independent variable	Cough in early morning		chronic phlegm		Wheeze	
	B	Exp(B)	B	Exp(B)	B	Exp(B)
Constant	-2.696	---	-2.177	---	-4.234	---
Exposure (yes, no)	1.065	2.902*	0.031	0.970	0.322	1.380
Smoking (yes, no)	0.551	1.736*	1.235	0.291	1.585	4.878

*Significance

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Regarding respiratory diseases, prevalence of chronic bronchitis and asthma were not significantly different between welders and unexposed workers. Metal fume fever was experienced by 23.4% of the studied welders, most of the welders who suffered MFF (89.10%) had one or two attacks per year, and attacks usually lasted for one or two days. About 10% of the welders experienced three to six attacks of MFF per year (table 5).

Table 5: Distribution of studied welders and unexposed workers according to respiratory disease

Respiratory disease	Welders n=235		Unexposed workers n=155		Fisher Exact p-value
	No.	%	No.	%	
Bronchial asthma					0.352
Yes	2	0.90%	3	1.90%	
No	233	99.10%	152	98.10%	
Chronic bronchitis					0.162
Yes	5	2.13%	0	0.0%	
No	230	97.87%	155	100.0%	
Metal fume fever			-	-	-
Yes	55	23.40%			
No	180	76.60%			
• Duration of attack (days)					
1	24	43.63%			
2	26	47.27%			
3	5	9.10%			
• Frequency of attacks per year					
1-2	49	89.10%			
3-6	6	10.90%			

Table 6 revealed regression models for different lung function indices (LFI) as dependent variables and exposure (yes=1 and No=0) as independent variable, while allowing for the effects of age, weight, height and smoking (as confounders). The mean values of FVC, FEV_1 and $FEV_{1\%}$ for welders was significantly lower than the unexposed group (β: -5.106, -3.171, 102.364, respectively, and p: 0.019, <0.000, <0.000, respectively). These findings were consistent with obstructive impairment. Mean value of PEFR was significantly lower in welders compared to unexposed subjects (β: -3.323, p: 0.808). The mean value of $FEF_{50\%}$ and $FEF_{25\%}$ (indices of medium and small sized airway caliber) was significantly lower in welders compared to the unexposed subjects (β: -0.046, and 0.308, respectively and p: <0.000, and <0.000 respectively).

Impairment of lung function was duration dependent, where after allowing for confounders, increased duration of exposure to welding fumes was significantly associated with decease in FVC (β:-4.912 p:0.022), FEV_1 (β: -2.955, p: 0.002), decrease in PEFR (β: -3,212, p: 0.647), and decrease in $FEF_{50\%}$ and $FEF_{25\%}$ (β: 0.518 ,and 0.519respectively, p: 0.002 , 0.005respectively) as shown in table 7.

Table 6: Correlation regression relationship between exposure to welding fumes and lung function indices (LFI) after allowing for age, height, weight, and smoking

LFI	(constant)	Height/ m	Weight/kg	Age	Smoking	Exposure (1: yes,0:no) β	p
FVC	-5.106	5.824	0.000	-0.027	0.202	-0.145	0.019
FEV_1	-3.171	4.184	0.001	-0.026	0.001	-0.182	<0.000
FEV_1%	102.364	-11.782	0.004	-0.092	-0.676	-1.931	<0.000
PEFR	-3.323	7.356	0.003	-0.024	0.224	-0.039	0.808
$FEF_{75\%}$	-2.139	5.798	0.006	-0.022	0.136	-0.243	0.122
$FEF_{50\%}$	-0.046	2.687	0.005	-0.028	0.003	-0.532	<0.000
$FEF_{25\%}$	0.308	0.991	0.000	-0.024	-0.014	-0.245	<0.000

Table 7: Correlation regression relationship between duration of exposure to welding fumes and lung function indices (LFI) after allowing for age, height, weight, and smoking

LFI	(constant)	Height/ m	Weight/kg	Age	Smoking	Exposure (years) β	p
FVC	-4.912	5.747	0.001	-0.024	0.197	-0.017	0.022
FEV_1	-2.955	4.105	0.002	-0.022	0.135	-0.019	0.002

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FEV_1%	104.691	-12.641	0.016	-0.048	-0.741	-0.207	0.001
PEFR	-3.212	7.299	0.003	-0.023	0.224	-0.009	0.647
$FEF_{75\%}$	-1.743	5.626	0.007	-0.015	0.129	-0.034	0.072
$FEF_{50\%}$	0.518	2.499	0.008	-0.017	-0.016	-0.051	0.002
$FEF_{25\%}$	0.519	0.935	0.001	-0.019	-0.023	-0.020	0.005

Radiological abnormalities in this study indicated 4 chest x-rays with pneumoconiosis (Figure 4) and were confirmed by high resolution computed tomography (Figure 5). Increased bronchovascular markings were demonstrated in chest x-rays of (91.9%) of the studied welders. Calcified hilar lymph nodes were found in 23 chest x-rays (Figure 6). Random findings of 4 cases of bronchiectasis, 5 cases of atelectasis, 1 case of pneumonia and 1 case of pneumonitis were described.

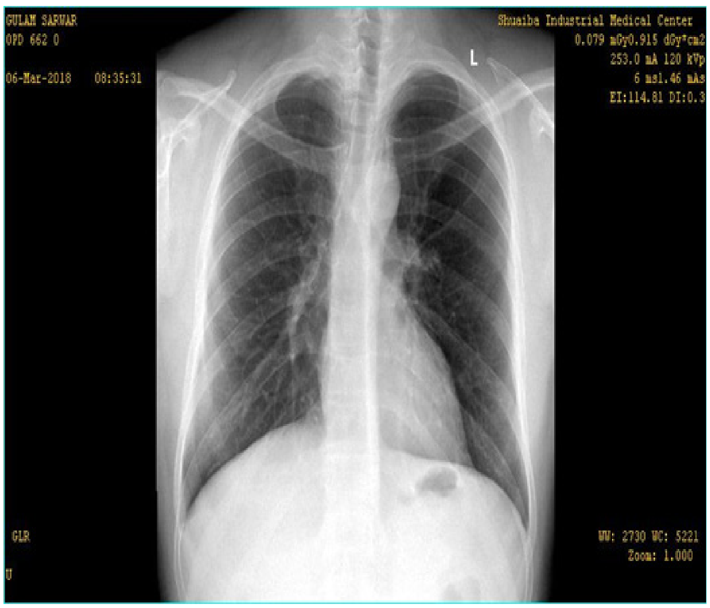


Figure 4: Plain chest x-rays postero-anterior view shows bilateral macro and micronodular infiltration (1/1 profusion grade, size t) with minor atelectasis in right middle lobe.

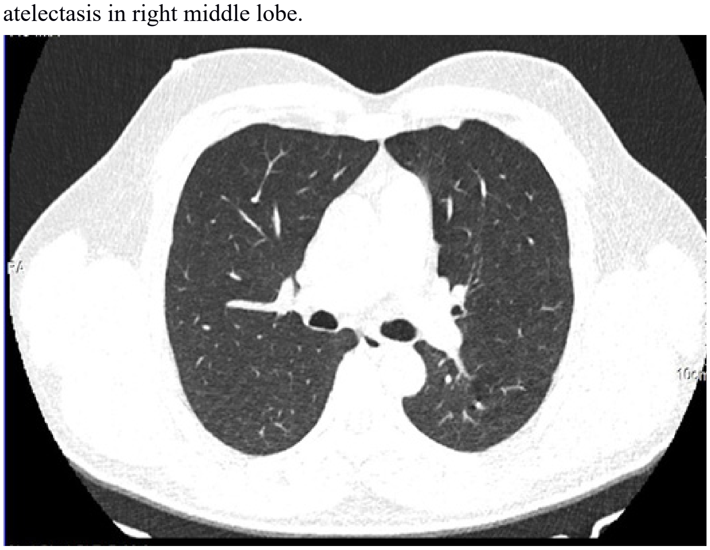
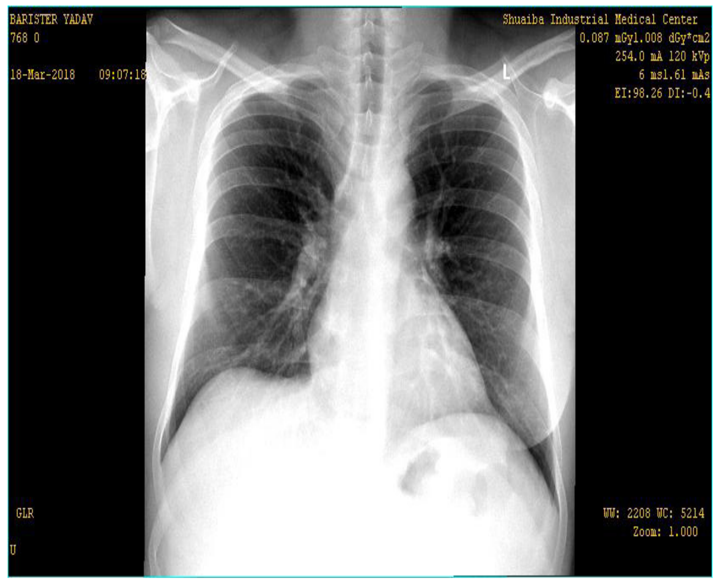


Figure 5: High Resoultion Comupted Tomographic Scan (HRCT) of the chest shows multipe small reticulonodular opacities with fine fibrotic strands bilaterally

Figure 6: Plain Chest x-ray postero-anterior view shows increased bronchovascular markings and calcified hilar lymph nodes.



6.Discussion

There are conflicting data in literature regarding welding fume exposure and respiratory effects. Thus, the present study was conducted to address such controversial issue. This study revealed that the frequency of sick leaves was significantly higher among welders compared with unexposed workers and were mainly attributed to respiratory causes followed by musculoskeletal problems. Similarly, Fawer et al, in a study conducted on British welders, concluded that absences were significantly higher among welders than matched controls, and attributed to respiratory diseases. Furthermore, welders had higher average annual sick leave duration and average sick leave length due to respiratory disease than controls[18]. On the other hand evidence from a longitudinal study conducted on 222 welders in Netherlands stated that musculoskeletal problems was the main cause of sick leave which accounted for 44% of all work days lost [19].

This study clearly demonstrates that exposure to welding fumes has led to significant increase in the prevalence of chronic cough in the early morning. On the contrary, phlegm production, wheeze, and shortness of breath showed no significant differences between welders and their referents. Moreover, after allowing for the effect of smoking, there was no

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significant relationship between the type of alloy (iron, steel, mixed) used by the studied welders and the occurrence of chronic cough in the early morning. In agreement with the results of this study, Rangkooy et al, in 2016 evaluated respiratory symptoms in 60 welders and 40 non-welders in a steel industry. All workers that participated in the study were relatively young and persistent cough was more prevalent in welders than non-welders [20]. Similarly Hayden et al. who studied respiratory symptoms among welders in the three largest factories in West Midlands, UK, found no difference between welders and controls regarding phlegm production wheeze, and shortness of breath. [21]. Moreover, a study conducted in Finland showed no significant difference between 157 welders and 108 controls regarding the prevalence of respiratory symptoms[22].

This study did not confirm an association between exposure to welding fumes and increased prevalence of chronic bronchitis nor asthma. Coinciding with the results of this study, findings of a Denmark epidemiological study showed no significant difference in the occurrence of chronic bronchitis between welders and controls[23].Similarly, when Zober and Weltle studied the respiratory effects of arc welding workers who had an average of 21 years work experience in Germany. Chronic bronchitis was confirmed only among welders who smoked[24]. Moreover, Sferrazza and Beckett found through literature review no evidence of occupational asthma caused by welding fumes exposure[8]. On the other hand, in a study conducted on Korean shipyard welders, the prevalence of COPD was 15%, and findings of the study supported an association between welding fume exposure and increased risk of COPD[25]. Another study by Al-Otaibi, who investigated the respiratory health of welders compared to non-exposed workers in Saudi Aramco company in 2018, found that chronic bronchitis was significantly more prevalent among welders compared to the unexposed matched group after excluding the effect of smoking[26]. Similarly, a cross sectional study conducted in a container yard, Sri Lanka; Jayawardana, and Abeysena have indicated that chronic bronchitis was significantly higher among welders (27%) than in controls (7%) with an odds ratio of 4.6[27]. Moreover, Hannu, et al, confirmed the relation between long term exposure to stainless steel welding fumes and the development of occupational asthma, and the mean duration of exposure before the onset of asthma symptoms was 18 years[28].

Insignificant results in this study regarding the prevalence of chronic bronchitis and bronchial asthma among welders, may be attributed to the fact that most of the welders who participated in this study were relatively young; their age ranged between 20 and 40 years old, and their job duration was less than 10 years. On the other hand, most of the studies that detected asthma were prospective cohort studies, as asthma caused by exposure to welding fumes requires a long period of time to detect bronchial obstruction and hyperresponsiveness. The present study demonstrated that Metal Fume Fever (MFF) was experienced by 23.40% of the studied welders, most of the welders who suffered MFF (89.10%) had one or two attacks per year, and attacks usually lasted for one or two days. Coinciding with the results of this study, El-Zein et al. in 2005 detected MFF symptoms among 39.2% of welding apprentices [29]. Moreover, at the Victorian Poison information Centre, Australia they received calls between June 2005 and December 2010 to detect the exposure and symptoms of metal fume fever. It has been noticed that 95% of calls were symptoms of metal fume fever occurring on Mondays within 24 hours of metal fume exposure in welders using steel and iron alloys. Welders admitted that they had 1-3 attacks per year, and attributed it to poor safety practices and control measures in the workplace [30].

The variability in the reported prevalence of Metal fume fever may be due to the misdiagnosis of MFF with upper respiratory tract infection or influenza, as there is no specific test available for diagnosing metal fume fever. Thus, a detailed occupational history is mandatory. In the present study, multiple regression analysis was used to allow for the effects of confounding variables while examining the relationship between exposure to welding fumes and lung function. The present study revealed significant reduction in the mean values of FVC, FEV_1, and FEV_1%. Thus, a mixed restrictive and obstructive pattern was suggested. PEFR and maximum flow rates at 50% and 25% of FVC were recorded and found to be significantly slower in welders compared with unexposed workers. Thus, medium and small sized airways were mainly narrowed. This is consistent with the irritant nature of the welding fumes. Moreover, lung function impairment was also dependent on duration of exposure on the job. There was no significant relationship between type of alloy used by welders and impairment of lung function parameters.

Coinciding with the results of this study, Rangkooy et al, in 2016 found a significant reduction in FVC, FEV_1, $FEF_{75\text{-}25\%}$ and FEV_1/FVC ratio, among welders in the steel industry when compared to a non- welders' group [20]. Similarly, an Iranian cohort study in 2011, conducted on 43 welders and 129 office workers at an automobile assembly factory found that mean values of FVC, FEV_1, FEV_1%, and PEFR were lower in welders than office workers, results were not statistically significant, but after adjusting for age and smoking habits , exposure to welding fumes was significantly associated with FEF25-75% reduction. In addition, work duration was significantly associated with decrease in FEV_1, FEV_1%, and FEF25-75% [31]. Another study by Kilburn et al, who investigated 145 welders from a West Coast shipyard, Los Angeles, reported a significant decrease in FEF25-75% predicted values compared with controls [32]. Epidemiological studies by Cotes, et al, Chinn, et al, and Ozdemir, et al, have stressed the role of smoking in the impairment of lung functions among welders [33-35]. Roach LL in 2018 stated that smoking in combination with welding fume exposure had a negative impact on pulmonary functions of young healthy workers[36]. On the other hand, some studies reported no significant relationship between exposure to welding fumes and impaired pulmonary functions. An early study by McMillan GH, and Heath J. found that pulmonary function of welders and matched controls at the beginning and end of a shift showed no significant differences [37]. Similar findings were reported by Antti-Poika and coworkers who indicated no significant differences in pulmonary functions (FVC,$FEV_{1,}$ EFV_1%) among 157 electric arc welders and 108 controls with same age and smoking habits [22].Sjogren and Ulfvarson estimated that FVC and FEV_1 in three welder groups and their respective reference groups showed no significant differences. In addition, welders with long exposure period did not show increase in pulmonary function impairment [38]. Findings of a Turkish study conducted on 110 welders and 55 controls, indicated that the mean pulmonary function variables FEF75, FEF50, and FEF25 showed no significant differences between welders and controls [39].

Radiological abnormalities among welders were confirmed in this study, where increased bronchovascular markings were demonstrated in chest x-rays of (91.9%) of the studied welders which may be attributed to welding fumes and smoking. Moreover, 23 CCRs showed calcified hilar lymph nodes, and random findings of 4 cases of bronchiectasis and 5 cases of atelectasis were described. Calcified hilar lymph nodes were suggestive of old tuberculosis as x-rays belonged to Indian welders, and it was concluded by the World Health Organization (WHO) that India had the highest burden of tuberculosis; where the total incidence in 2017 was 2.74 million[39].In addition, chronic lung infections such as tuberculosis T.B is considered a risk factor for developing bronchiectasis [40]. Although the causes of atelectasis are not associated with occupational exposures to welding fumes[41]. Similar to the results of this study, Han D. et al., in 2000, while investigating pneumoconiosis in Korean welders, they described twelve cases of bronchiectasis and two cases of atelectasis in CT scans of the 85 studied arc welders [42].On the contrary to the results of the current study, most of the previous epidemiological studies suggested no association between exposure to welding fumes and the presence of bronchiectasis, atelectasis, and calcified lymph nodes.

The current study revealed radiological abnormalities suggestive of pneumoconiosis in 4 chest x-rays (1.7%) of welders, and the diagnosis was confirmed by high resolution CT scanning. Coinciding with this finding, the appearance of lung opacities on chest x-ray was first reported in asymptomatic welders in 1936, 1938 and 1948[43-45]. Attfield and Ross, in 1978 conducted a study on 661 electric arc welders. they demonstrated small rounded opacities of profusion 0/1 or more in chest x-rays of 7% of the welders. There was a positive correlation between grade of profusion and duration of exposure to welding fumes. Radiological findings had no evidence of large opacities nor progressive massive fibrosis [46]. A Cross sectional study by Zober, et al in Germany conducted on welders exposed to welding fumes for at least eight years showed high prevalence (27%) of small round opacities of the size ‘p’ in the chest x-rays. Working in confined space was significantly associated with the increased prevalence of small round opacities [24]. Furthermore, Buerke et al. concluded that development of interstitial pulmonary fibrosis in German welders was associated with long term exposure to high concentration of welding fumes and poorly ventilated workplaces [47].

Furthermore, most of the studies suggested that welder’s pneumoconiosis is benign associated with asymptomatic respiratory symptoms and normal pulmonary functions [48-50]. In addition, Buerke, et al. studied the development of siderosis in 2003 among 150 welders in Germany. They concluded that pulmonary siderosis was associated with long-term exposure to high concentration of welding fumes with poor working conditions [51]. Moreover, Doig and McLaughlin recognized chest opacities that had been completely resolved in one welder who had left the trade and partially resolved in another welder whose welding exposure was reduced [45].

Another report by Lim KH, et al in 2000, described a case report of a 33 years old welder in Malaysia with 14 years welding experience, presented with small rounded opacities distributed throughout both lungs in chest x-ray. High resolution computed tomogram (HRCT) confirmed the diagnosis of siderosis which showed fine nodules and reticular shadows in the basal segments in both lower lobes [52]. A case report by Khalid et al, in 2009 was for a 64-year-old African American welder with 25 years welding experience his chest x-ray showed bilateral reticular-nodular opacities in lower lung fields. High resolution computed tomogram (HRCT) exhibited multiple small reticulonodular opacities. The diagnosis of siderosis was established by transbronchial biopsy which showed dense nodular interstitial fibrosis containing clusters and sheets of macrophages having cytoplasmic iron pigment. The patient had medically resolved after one-month job retirement [53]. Thus, this study provided strong evidences about the association between chronic exposure to welding fumes and the increased frequency of chronic cough in the early morning. Moreover, impairment of lung functions, and pneumoconiosis were confirmed. The development of control and risk-assessment strategies to reduce welding hazards is mandatory.

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