



DETERMINANTS OF OCCUPATIONAL HEALTH AND SAFETY IN THE FOCUS OF WELDERS

Kaynakçıların odağında iş sağlığı ve güvenliğinin belirleyicileri

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Abstract

The welding industry is known for having significant occupational health risks. For this reason, the occupational hazards of welders have been previously examined by many researchers in the literature. However, the traditional hazards-outcomes focused analyses do not show the big picture in which occupational health and safety (OHS) is neglected due to global competitive conditions. Therefore, it may be important to define the determinants of OHS that deepen inequalities, especially in developing countries. This study aimed to evaluate the relationship between OHS indicators and OHS determinants among welders in a developing country. In this descriptive study, the data were collected from 88 welders by telephone interview. Health outcomes were also confirmed from clinical records. In addition to the indicators of OHS, independent variables such as education level, sector, business size, union membership, security, wage, weekly working hours, etc were investigated in the study. According to the results, the work accident rate was higher in welders who started their careers as a child. Leading OHS indicators were found to be significantly worse in the working environments of those with low education, low wages, workers in the private sector and who are non-unionized. Additionally, a positive correlation was found between being unionised and high education level, high socioeconomic development (SED) level, business size, and working in the public sector. There was a negative correlation between union membership and weekly working hours. Since the concept of OHS is related to many factors, working life should be considered from a holistic perspective.

Keywords: Occupational health, OHS determinants, social determinants of health, labor union, welders.

Özet

Kaynak sektörünün önemli iş sağlığı riskleri taşıdığı bilinmektedir. Bu nedenle kaynakçıların mesleki tehlikeleri, literatürde birçok araştırmacı tarafından daha önce incelenmiştir. Ancak geleneksel tehlike-sonuç odaklı yaklaşım küresel rekabet koşulları gereği iş sağlığı ve güvenliğinin (İSG) ihmal edildiği büyük resmi göstermemektedir. Bu nedenle özellikle gelişmekte olan ülkelerde eşitsizlikleri derinleştiren İSG belirleyicilerinin tanımlanması önemli olabilir. Bu çalışma, gelişmekte olan bir ülkedeki kaynakçılar arasında İSG göstergeleri ile İSG belirleyicileri arasındaki ilişkinin incelenmesini amaçlamıştır. Tanımlayıcı nitelikteki bu çalışmada, veriler 88 kaynakçıdan telefon görüşmesiyle toplandı. Sağlık sonuçları klinik kayıtlardan doğrulandı. Çalışmada İSG'nin öncül ve ardıl göstergelerinin yanında, bağımsız değişken olarak; eğitim düzeyi, sektör, işletme büyüklüğü, sendika üyeliği, güvence, ücret, haftalık çalışma saatleri vb. sonuçlara göre çocuk yaşta mesleğe başlayan kaynakçılarda iş kazası oranı daha yüksekti. Öncül İSG göstergelerinin düşük eğitim düzeyine sahip olan kaynakçılarda, aylık maaşı düşük olanlarda, özel sektörde çalışanlarda ve sendikası olmayanlarda anlamlı derecede kötü olduğu görüldü. Ayrıca sendikalı olma durumu ile; yüksek eğitim düzeyi, doğum yerinin yüksek sosyo-ekonomik gelişmişliği (SEG), işletme büyüklüğü ve kamuda çalışma arasında pozitif yönde anlamlı bir korelasyon bulundu. Sendika üyeliği ile haftalık çalışma saatleri arasında negatif bir korelasyon vardı. İSG kavramı birçok faktörle ilişkili olduğundan çalışma yaşamının bütünsel bir bakış açısıyla ele alınması gerekmektedir.

Anahtar kelimeler: İş sağlığı, İSG belirleyicileri, sağlığın sosyal belirleyicileri, sendika, kaynakçı.

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Introduction

According to the World Health Organization (WHO), work is recognized as one of the social determinants of health (1). While work affects health in terms of workplace hazards, access to health services and income; people's job opportunities are also related to their environmental, individual and social characteristics. Therefore, it would be fair to say that work is both the driver and the consequence of inequalities at the same time (2).

Today, in the field of occupational health and safety (OHS), the relationship between work and health has traditionally been evaluated with linear risk models based on hazards and outcomes. It means that "pneumoconiosis may occur if dust is present". But this approach is insufficient to show the big picture behind the dust (3). For example, in developing countries, OHS laws, which are neglected due to the social, economic and political challenges associated with global competitive conditions, cover only a small part of the population (4, 5). In previous studies, it has been reported that occupational injuries are more frequent in small businesses where precarious employment is also more common (6, 7). Low union density in the workplace, possibly due to a lack of awareness, reduces the likelihood of reporting illness (7). It is estimated that 160 million children worldwide are involved in

child labour, with three times as many in rural areas (8). Based on all these arguments, it is important to define the determinants of OHS that deepen inequalities. This complex field should be handled with a holistic perspective, beyond just focusing on workplace hazards (3).

Regarding workplace hazards, the welding industry, which employs approximately 11 million people worldwide, is one of the focuses of occupational health professionals (9). Work accidents are frequently reported among welders (6, 10, 11). Exposures in the welding process are known to cause a wide variety of work-related diseases. Welding fumes, noise, and ultraviolet (UV) radiation are the main hazards and have been proven to cause respiratory diseases, hearing loss, cataracts and various cancers (12-17). Although many studies have been conducted on occupational hazards in this field, there are no studies on the determinants of welders' health to our knowledge.

For all these reasons, this study aimed to evaluate the relationship between welders' OHS indicators and OHS determinants, such as personal characteristics, living environment, working conditions and working relationships. The secondary purpose of this study was to describe the work-related health problems of welders in a developing country.

Material and Method

This descriptive study was designed as part of a cohort of cases followed in the occupational disease clinic of Dokuz Eylül University Hospital. The records of 2640 cases who applied to the outpatient clinic from 2013 to 2022 were reviewed retrospectively. According to the records, 95 cases whose profession was welding were called by phone. Five of the cases could not be reached because their phone numbers were not up-to-date. Two refused to participate in the study. A total of 88 welders

were included in the study with their informed consent. The response rate was 97.7% (88/90). Welders had been referred to the occupational diseases clinic for the following reasons: suspicion of radiological abnormality (41 cases), respiratory symptoms (22 cases), periodic hearing test abnormalities (11 cases), periodic laboratory test abnormalities (5 cases) and musculoskeletal complaints (10 cases). Ethical approval was obtained from the local ethics committee of Dokuz Eylül University

(No: 2022/21-10).

Data collection

Data on demographic characteristics, working conditions, labor relations, and working environments of the welders were collected by telephone interview. Health outcomes were also confirmed from clinical records. A data registration form was prepared by the researchers in line with the relevant literature, and a pre-test was applied.

Variables of the study

The outcomes of the study were leading and lagging indicators of OHS. Lagging OHS indicators are "failure-focused" indicators that measure events or outcomes which have already occurred. Leading indicators are a proactive approach that measures the performance of OHS activities, emphasizing the evaluation before illness, disability or death occurs (18).

- Lagging OHS indicators: In this study, the rate of work accidents and occupational diseases were taken as lagging indicators. By cross-checking the medical records and telephone questionnaires of the cases, the variable of having a work accident related to welding and being diagnosed with an occupational disease during their career was defined into categorical variables (yes/no).

- Leading OHS indicators: As the leading indicators, the engineering control and personal protective equipment facilities of the welders in the most current workplace were examined. Respiratory and hearing protection and Local Exhaust Ventilation (LEV) was used as a categorical variable (yes/no). All welders stated that they had access to eye protection as the most basic and common requirement. Therefore, this variable was not included in the binary analyses.

The independent variables of the research were age, gender, age at the start of welding career, sector (public/private), current wage (according to minimum wage), union membership, weekly working hours (more or less than 45 hours per week), etc., in addition to those described below.

- Education level: Graduation from high school or equivalent vocational school was categorized as high education level,

while others were categorized as low education level.

- Child Labor: According to the ILO methodology, starting the welding profession between the ages of 5-17 was categorized as child labor (8).

- Socioeconomic development (SED) level of the region of origin: It was defined as the SED level of the city where the welders were born and raised. The level of SED was determined based on the current Socioeconomic development index (SEDI) published by the Ministry of Industry(19). Provinces with SED indexes 1 and 2 were categorized as high-level and others as low-level.

- The size of the business was determined according to OECD criteria. Businesses with fewer than 250 employees were classified as small-medium-sized enterprises (SMEs) and those with more employees were classified as large enterprises(20). In descriptive statistics, subgroups of SMEs were also given as micro (1-9 employees), small (10-49 employees) and medium (50-249 employees).

- Insurance: Those whose insurance premiums were paid regularly and others (who were underpaid or informally employed without insurance) were categorized by grouping.

- Employment type: Welders were categorized by their employment contract: main company's staff, working for a subcontractor, or daily labor without any contract.

Statistical analysis

Descriptive statistics were presented as number, percentage, mean (\pm standard deviation), median (min-max) values. Pearson chi-square test was used to compare the ratios. Fisher's Exact test was used for >20% cell count with an expected value less than 5. The correlation of categorical variables was evaluated with tetrachoric correlation. The correlation coefficient was ± 0.2 to ± 0.4 weak, ± 0.4 to ± 0.6 moderate, ± 0.6 to ± 0.8 strong, ± 0.8 to ± 1 very strong correlation. Significance level was accepted as $p < 0.05$. Analyzes were performed with R version 4.2.0 (<https://www.r-project.org/>) and SPSS version 24 (Armonk, NY: IBM Corp).

Results

All 88 welders participating in the study were male. The mean age was 45.5 (± 8.04) and the median age was 45 (26-69). The median age of starting their welding career was 17 (7-49). Twenty-eight welders (31.8%) were educated at the high school level. Thirty-two of welders (36.4%) were from provinces with low SED. One third of the welders ($n=29$, %33) was working in SMEs. Considering the working conditions, the mean weekly working hours was 49 (± 10.55) and the median was 48 (8-105)

hours. Monthly wages of most of the cases ($n=61$, 69.3%) were less than twice the minimum wage. The unionization rate of the welders participating in the study was 33%. Three of the welders were working without insurance, and the six had underpaid insurance premiums. None of these 9 welders were labor union members. While 75 welders were the main staff of company, 11 worked for subcontractors and 2 worked as day laborers (Table 1).

Table 1: Characteristics of the cases included in the study and their working life.

	n(%)
Individual and social characteristics	
Male gender	88 (100.0)
Age, mean(SD)	45.5 (± 8.04)
Age at start of welding career, mean(SD)	19.6 (± 7.74)
Education level	
High school	28 (31.8)
Elementary school	60 (68.2)
SED level of province of origin	
Low	32 (36.4)
High	56 (63.6)
Working environment	
Working sector	
Public	11 (12.5)
Private	77 (87.5)
Size of the Business	
Micro and small	12 (13.6)
Medium	17 (19.3)
Large	59 (67.0)
Working conditions	
Working hours per week, mean(SD)	49 (± 10.55)
Shift work	19 (21.6)
Overtime work	49 (55.7)
Work at night	26 (29.5)
Weekly rest day ≥ 2 days	28 (31.8)
Wage	
≥ 3 MW	1 (1.1)
≥ 2 MW	26 (29.5)
\geq MW	60 (68.3)
$<$ MW	1 (1.1)
Labor relations	
Insurance	
Insurance premium paid regularly	79 (89.8)
Underpaid insurance premium	6 (6.8)
Employee without insurance	3 (3.4)
Employment type	
Staff of the main company	75 (85.2)
Working for a subcontractor	11 (12.5)
Daily work	2 (2.3)
Union Membership	29 (33.0)

MW: minimum wage, SED: Socioeconomic development

Photokeratitis (n=78, 88.6%), photodermatitis (n=61, 69.3%) and hearing loss (n=57, 64.8%) were reported most frequently as welding-related health

problems during their careers. In addition, musculoskeletal disorders were also quite high. Details of experienced health problems based on self-report are presented in Figure 1.

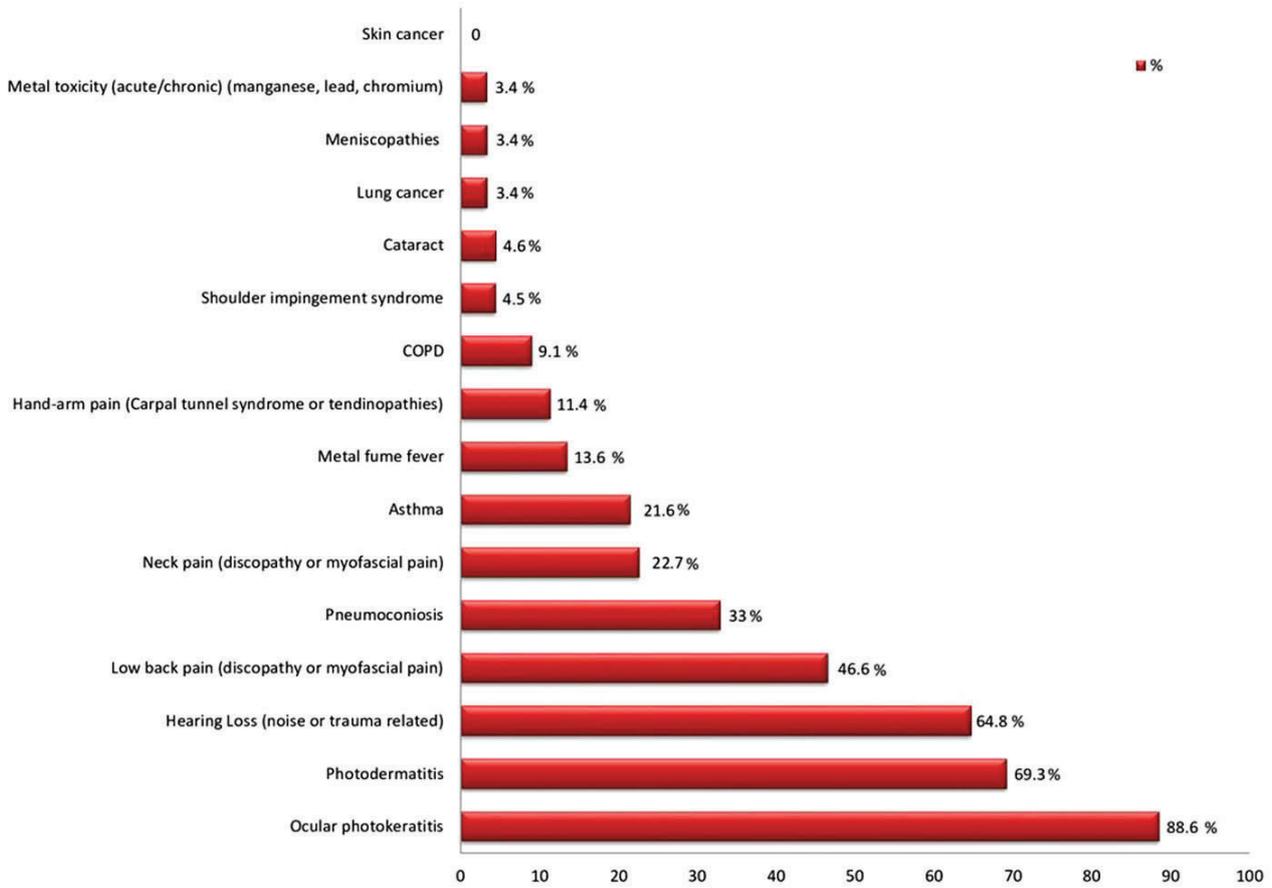


Figure 1: Self reported health problems associated with welding.

Engineering control for welding fumes (LEV) was only available in the workplace of 21 welders (23.9%). Only 5 welders had access to the respiratory protective welding mask. While personal protective equipment for UV-eye protection was provided to all welders, appropriate equipment for skin protection was not available in 46.6% (n=41). Sixty-eight percent (n=60) of welders had experienced a work accident during their working life and 60.2% (n=53) were diagnosed with occupational diseases.

Details of work accidents and occupational diseases are presented in Table 2.

Work accident rates were found to be higher in welders who started their career as a child ($p=0.004$). Leading OHS indicators were found to be significantly worse in the working environments of those with low education, low wages, workers in the private sector and non-unionized workers. The relationship between work-life components and OHS indicators is detailed in Table 3.

Table 2: Leading and lagging indicators of OHS (N Total= 88, 100%).

Lagging indicators	n (%)	Lagging indicators	n (%)
Work accident*	60 (68.2)	OHS protection measures	
Trapped by moving equipment	19 (31.7)	Engineering measure (LEV)	21 (23.9)
Eye injuries	19 (31.7)	Personal Protective Equipment	
Falls same or heigh level	10 (16.7)	Respiratory protection (SAR)	5 (5.7)
CUIB (cut in, under or between)	9 (15.0)	Welding mask (eye protection)	88 (100.0)
Falling objects	4 (6.7)	• SAR	5 (5.7)
Electrocution	1 (1.7)	• Helmet	56 (63.6)
Occupational disease*	53 (60.2)	• Hand shield or eye goggles	27 (30.7)
Pneumoconiosis	29 (33.0)	Hearing protection	35 (39.8)
Noise-induced hearing loss	32 (36.4)	• Earmuffs	5 (5.7)
Asthma	4 (4.5)	• Ear plugs	30 (34.1)
Tendinitis (CTS, impingement)	5 (5.7)	UV protection (skin)	47 (53.4)
Discopathy (cervical, lumbar)	2 (2.3)	• Whole body protection	22 (25.0)
Heavy metal toxicity	3 (3.4)	• Leather welding sleeve	25 (28.4)

*There may be more than one disease or injury in the same case.

CTS: carpal tunnel syndrome, LEV: portable local exhaust ventilation, SAR: Supplied-air respirator

Table 3: Relationship of work life components with OHS indicators.

	TOTAL	LAGGING INDICATORS		LEADING INDICATORS		
	N=88	Work accident n=60	Occupational disease n=53	lack of engineering measure (LEV) n=67	Lack of respiratory protection n=83	Lack of hearing protection n=53
Previously working as a child laborer						
Yes	48 (54.5%)	39 (81.3%)**	28 (58.3%)	36 (75.0%)	47 (97.9%)	29 (60.4%)
No	40 (45.5%)	21 (52.5%)	25 (62.5%)	31 (77.5%)	36 (90.0%)	24 (60.0%)
p		0.004	0.691	0.781	0.172	0.968
Education level						
Low	60 (68.2%)	40 (66.7%)	37 (61.7%)	51 (85.0%)**	59 (98.3%)*	39 (65.0%)
High	28 (31.8%)	20 (71.4%)	16 (57.1%)	16 (57.1%)	24 (85.7%)	14 (50.0%)
p		0.655	0.686	0.004	0.034	0.181
SED level of province of origin						
Low	32 (36.4%)	23 (71.9%)	22 (68.8%)	25 (78.1%)	31 (96.9%)	20 (62.5%)
High	56 (63.6%)	37 (66.1%)	31 (54.4%)	42 (75.0%)	52 (92.9%)	33 (58.9%)
p		0.574	0.217	0.741	0.649	0.742
Regularly paid insurance premium						
No	9 (10.2%)	7 (77.8%)	7 (77.8%)	8 (88.9%)	9 (100.0%)	8 (88.9%)
Yes	79 (89.8%)	53 (67.1%)	46 (58.2%)	59 (74.7%)	74 (93.7%)	45 (57.0%)
p		0.717	0.308	0.680	>0.999	0.081
Unionization						
Non-unionized workers	59 (67.0%)	43 (72.9%)	36 (61.0%)	47 (79.7%)	59 (100%)**	43 (72.9%)**
Unionized workers	29 (33.0%)	17 (58.6%)	17 (58.6%)	20 (69.0%)	24 (82.8%)	10 (34.5%)
p		0.177	0.829	0.269	0.003	0.001
Employment type						
Working for a subcontractor or daily working	13 (14.8%)	10 (79.9%)	7 (53.8%)	11 (84.6%)	13 (100%)	10 (76.9%)
Staff of the main company	75 (85.2%)	50 (66.7%)	46 (61.3%)	56 (74.7%)	70 (93.3%)	43 (57.3%)
p		0.538	0.611	0.725	>0.999	0.183
Size of the Business						
SME	29 (33.0%)	19 (65.5%)	17 (58.6%)	23 (79.3%)	29 (100%)	20 (69.0%)
Large enterprise	59 (67.0%)	41 (69.5%)	36 (61.0%)	44 (74.6%)	54 (91.5%)	33 (55.9%)
p		0.707	0.829	0.624	0.167	0.240
Working sector						
Private	77 (87.5%)	54 (70.1%)	46 (59.7%)	61 (79.2%)	76 (98.7%)***	49 (63.6%)
Public	11 (12.5%)	6 (54.5%)	7 (63.6%)	6 (54.5%)	7 (63.6%)	4 (36.4%)
p		0.316	>0.999	0.123	<0.001	0.106
Wage						
<2 MW	61 (69.3%)	42 (68.9%)	35 (57.4%)	52 (85.2%)**	60 (98.4%)*	39 (63.9%)
≥2 MW	27 (30.7%)	18 (66.7%)	18 (66.7%)	15 (55.6%)	23 (85.2%)	14 (51.9%)
p		0.839	0.412	0.003	0.029	0.286
Working hours per week						
> 45	56 (63.6%)	42 (75.0%)	37 (66.1%)	45 (80.4%)	56 (100%)**	37 (66.1%)
≤ 45	32 (36.4%)	18 (56.3%)	16 (50.0%)	22 (68.8%)	27 (84.4%)	16 (50.0%)
p		0.069	0.138	0.219	0.005	0.138

MW: minimum wage, SED: Socioeconomic development, SME: small-medium-sized enterprise ***p<0.001, **p<0.01, *p<0.05

After applying to the occupational disease outpatient clinic, 59.1% (n=52) of the welders had quit their jobs. The rate of quitting was significantly higher in those who were not unionized (p=0.001). Sixteen (30.8%) of those who quit their jobs did not receive their financial compensation rights. None of these cases were unionized. In addition, unionized workers had higher wages and security opportunities (p values

respectively; 0.003 and 0.027) and fewer weekly working hours (p=0.010).

A positive correlation was found between being unionized and high education level, high SED level, business size, and working in the public sector (correlation coefficients were respectively; r=0.53, r=0.45, r=0.80, r=0.81). The correlation map of work life components is presented in Figure 2.

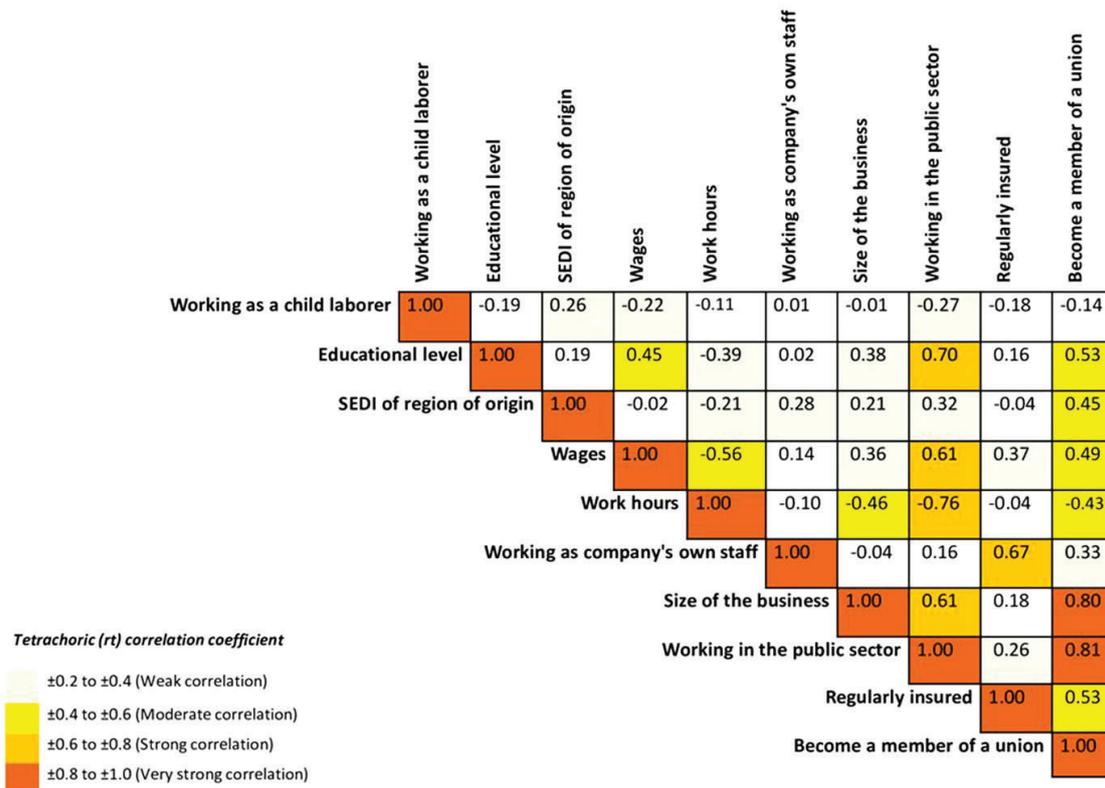


Figure 2: Correlation map of work life components.

Discussion

The study focused on a group of welders in a developing country and analyzed their OHS indicators and related factors. The study results showed that those with low education, low wages, long working hours, workers in the private sector and non-unionized workers had significantly worse, leading OHS indicators in their working environments. Those who had started their careers as a child experienced more work accidents. The results supported

the need for a holistic approach to the determinants of OHS, in line with the "sociomedical causality" emphasized by Rudolf Virchow nearly two centuries ago (21, 22). Previously, Flynn et al. mentioned undocumented migrant labor as a potential social determinant of OHS (23). Flexible and non-standard forms of employment have also been identified as a major social determinant of inequalities in Europe (24). Fujishiro et al. presented a framework that

highlights the limitations of the traditional exposure-outcome approach used in occupational health research. In this comprehensive framework, three social factors affecting health are referred: 1) laws and regulations that about work characterized by minimum wage, working hours, employment protection, workplace inspections, etc. 2) general social policies such as education, medical care, taxation, transportation, urban planning, and environmental protection 3) resources for working people such as health problems, job loss, temporary or long-term disability and caregiving responsibilities (3).

It was observed that two-thirds of the welders in the study were non-unionized, and 10% lacked regular insurance coverage. None of these workers, who worked without regular-insurance, was part of a union. In addition, the weekly working hours of the unionized welders were found to be significantly less. Unionized workers had a higher chance of receiving respiratory and hearing protection equipment, and their monthly income and weekly holidays were found to be significantly higher. The findings support the literature. Because the main functions of labor unions are to defend the class struggle and interests in workplace health and safety, working hours, wages, working conditions, and social security issues (25). Therefore, the organization of labor is important. The unionization rate in the study was found to be higher than the rates in the metal sector in our country (33% and 17.7%, respectively) (26). This can be explained by the fact that most of the welders (67%) referred to our hospital had worked with large enterprises with a higher prevalence of unionization. In fact, it is important to note that none of the welders who had worked with SMEs were union members. In the study, a positive correlation was also found between being a union member and education level, SED level of the regional origin and working in the public sector. In the study by Le et al., in which they evaluated the safety culture in the workplace, it was reported that the employees who are union members mostly work in the public sector and have higher education levels (27).

Similarly, in a study conducted in Australia, the number of unionized employees in the public sector and in large enterprises was found to be higher (28). Another factor that has been shown to be determinative in joining a union in previous studies is political and cultural values (left-leaning political view) (29) which can be said to be largely influenced by the environment one belongs to.

In this study, 68% of welders reported that they had at least one work accident during their professional life. The lifetime prevalence of welding accidents reported in same cross-sectional studies in the literature for Uganda, Kenya and Nigeria, respectively; 87.8%, 92%, 99.3% (6, 10, 11). The fact that the prevalence is lower than in other studies may be due to the recall bias that the participants in this study, whose average age is higher, neglected or did not remember the injuries they experienced at the beginning of their professional careers. Another possible reason may be that the number of work accidents was low because the welders included were largely insured and worked in relatively better conditions. The frequency of work accidents may be higher in more heterogeneous welder samples in our country. According to our country data, it is seen that 13,560 accidents occurred in welders between 2015 and 2018, and 0.35% of them were fatal accidents (30). According to the Bureau of Labor Statistic reports, the incidence of work accidents in welders in the USA was 2.3% in 2020 (31). In the welding sector, where the risk of work accidents is clearly high, the most frequently reported injuries are limb cuts and eye injuries (11, 32, 33). Particularly, there are welders among the occupational groups in which eye injuries are seen most commonly (34). Similarly, in this study, eye injuries were one of the most common causes of accidents.

Chronic exposures in the welding sector (welding fumes, noise, radiation and ergonomic hazards) are associated with a wide spectrum of health problems (35). In this study, although the most common self-reports of welders were photokeratitis (arc eye), many welding-related health problems such as asthma, COPD, metal

toxicity, hearing loss, cataract, etc. were described. UV radiation is a known risk factor for skin cancer. The welding procedure is one of the nonsolar UV sources. However, while there is sufficient evidence in the literature for welder's ocular melanoma, it is limited for skin cancer (36). Both of these cancer types were not reported in the study, possibly because of the small sample size. In this study, hearing loss, pneumoconiosis and musculoskeletal system diseases are the most common occupational diseases diagnosed by welders. Today, welding fumes are known as IARC group 1 lung carcinogens (17). Three welders in this study were diagnosed with lung cancer, although this could not be attributed to occupational exposure due to concurrent smoking exposures.

In terms of OHS controls, it has been observed that only a quarter of welders were provided LEV in the working environment and there are significant deficiencies in personal protective equipment. It is known that investments made in OHS improve confidence, motivation and feelings of security in the business. It decreases injuries, increases productivity, provides income security to workers' families, and even creates an international competitive and certification advantage for businesses (37). For all these reasons, prevention is more humane and cheaper than compensation (38, 39). However, improving occupational health as a whole requires the

development of labor and employment policies, strengthening labor union organizations, ensuring equality in other social rights such as medical care, education and transportation (3, 40). The "Health in all politics" approach, which is emphasized in community-based health services today, should also be important in the field of OHS. Additionally, legal support is needed for the continuity and sustainability of this approach (41).

Strengths and limitations of the study

This study emphasized "causes behind causes" rather than traditionally focusing on hazards and outcomes. In this respect, it will contribute to future occupational health studies. Since welders who applied to the occupational disease outpatient clinic were included in the study, the frequency of occupational diseases may be high due to selection bias. In the study, no significant difference was found between current working conditions and occupational diseases. This is the common problem of all occupational health studies with a cross-sectional design because occupational diseases are a cumulative result of lifetime exposures. Despite the limited number of participants, it is important that a significant difference was shown in the leading indicators, even though not in lagging indicators. This bias towards the null shows that testing the hypothesis in a larger study setting may be beneficial.

Conclusion

Workers' health in the workplace is related to the conditions of the environment in which they live, grow, and work. There is a

need for more comprehensive studies that deal with the concept of OHS from this framework.

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