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## Abstract

In this study, occupational health and safety analysis of workers performing welded manufacturing in an organized industrial zone was conducted. The aim of the study is to determine the relationship between the characteristics of the workers and occupational health and safety within the framework of the risks that may occur in welded manufacturing works. According to the results to be determined here, necessary improvements can be made and a healthier and safer working environment can be provided in welded manufacturing works. In this context, a survey including general demographic characteristics, occupational accidents-occupational diseases and occupational health and safety was applied to workers in welded manufacturing works. According to the survey results, it was seen that approximately half of the welding workers had an occupational accident and approximately one third had an occupational disease. It was determined that the rate of occupational accidents and occupational diseases was lower in workers who received welding and occupational health and safety training. The full use of personal protective equipment is not at the desired levels. The rate of occupational accidents and occupational diseases was low in welding workers who used this equipment fully. The most prominent occupational diseases are lumbar-cervical disc herniations, hearing and eye diseases. Long-term welding works and non-ergonomic working conditions were determined as the causes of back and neck disorders.

**Keywords:** Welding, Welded Manufacturing, Occupational Health and Safety.

## INTRODUCTION

Methods such as welding, casting, plastic deformation, machining, powder metallurgy are used to shape metallic materials. Welding is the most preferred method in the shaping of metallic materials by joining, cutting, repair and filling processes. Welding methods are divided into two groups as fusion welding methods and non-fusion (solid state) welding methods. Covered electrode, gas metal arc, submerged arc, plasma arc, laser, electroslag, electron beam, oxy-gas welding are examples of fusion welding methods. Resistance, friction, friction stir, diffusion, explosion, ultrasonic welding methods are examples of solid state welding methods. In these methods, metallic materials are joined by using heat or pressure or both [1- 5]. Welding process is used especially in manufacturing from metallic materials. Main welding manufacturing applications include; steel and aluminum constructions, pressure vessels and equipment, pipelines and systems, boilers, ships and marine vehicles, road vehicles, railways and railway vehicles, space and aviation, power plants, petrochemical facilities, machinery manufacturing industry, fuel storage facilities [2].



**Figure 1.** Welded manufacturing [2]

There are risks of various occupational accidents and occupational diseases when necessary precautions are not taken in welded manufacturing works. Welding workers can be exposed to various occupational accidents as a result of electric shock, fire-explosion, falling from height, splashes, and can catch various occupational diseases due to electromagnetic fields, rays, welding gas-fume, noise, vibration, ergonomic difficulties [1-2, 5-8]. Therefore, for a healthy and safe work, collective protection measures and

personal protection measures are necessary to eliminate and reduce the risk at its source.

There are some studies on occupational safety in welded manufacturing. Okumuş et al. examined the effects of fatigue on the occupational health and safety and performance of shipyard welding workers in their study. For this purpose, data were collected through observations and surveys in the shipyard. The results showed that the most disturbed body parts in the examined welding positions are the eyes, knees, neck and waist. The age of the welders is an important parameter of the most affected body part [9]. Sriram et al. investigated the effect of voltage, one of the welding parameters, on the neurotoxic potential of welding fumes. As a result of the study, they reported that modulating the voltage parameter could potentially help reduce manganese-induced neurotoxicity during welding [10]. Antonini et al. studied the development of an experimental animal model to study the potential neurotoxic effects associated with welding fume inhalation. It was reported that with the development of this system, possible mechanisms by which welding fume may affect the central nervous system could be studied [6]. Özalp et al. examined the risks caused by electricity in welding work in terms of occupational health and safety. It was stated that in welding work, electrical work accidents occur due to reasons such as uncontrolled and careless work, unsafe production methods, irregular work environment, conscious use of machinery and equipment, disregard for risks, inadequate training, lack of experience, excessive self-confidence, fatigue and inadequate use of personal protective equipment [11]. Akçakale, in his study on occupational health and safety in oxy-gas welding, reported that due to the use of flammable and explosive gases in this welding method, work accidents in the form of fire and explosion, and various occupational diseases due to gas, steam and dust in the welding environment, may occur and necessary safety measures should be taken against these [4]. Teker and Gençdoğan, in their study on occupational accidents and safety measures in the welding profession in our country, examined occupational accidents in welding and oxy-gas metal cutting works between 2015-2018 and reported

that there was a 66.4% increase in occupational accidents during this period, therefore, the importance of implementing the necessary occupational safety measures [12]. Bayar and Arabacı determined the causes and levels of thermal comfort exposure in fifteen different workplaces in the welding sector and reported measures to reduce and prevent this exposure [13]. Aydın et al. conducted an occupational health and safety risk assessment in the welding workshop of a company that produces tractor cabins and agricultural machinery, measures were determined to reduce the risks, and all high risks identified in the welding workshop were reduced to acceptable levels with the work carried out [14].

In this study, a survey was conducted on workers in welded manufacturing in a medium-sized organized industrial zone to determine their general demographic characteristics, occupational accidents and diseases they have experienced, and their possession and application of occupational safety information to prevent occupational accidents and diseases, and the results were evaluated.

## MATERIAL AND METHODS

In this study, a survey was applied to welding workers in a medium-sized organized industrial zone (Hitit University Ethics Committee, Date and Number: 28.06.2021/2021-73). This organized industrial zone is a mixed organized industrial zone. In this organized industrial zone, businesses such as machinery, agricultural equipment, food, plastic products, medical products, forest products, chemical industry, ceramics, marble, heat insulation, prefabricated building elements, casting, automotive sub-industry, textile, furniture and metal industry are producing. The survey applied consists of questions that evaluate the general demographic characteristics of the workers such as age, education, experience, work intensity, their background in the welding profession and their perspectives on occupational health and safety. The purpose of the survey is to determine the factors affecting occupational accidents and diseases in welded manufacturing and to minimize occupational accidents and diseases. Then, it was examined whether there was a relationship between the variables considered in the survey and occupational accidents and diseases.

## RESULTS AND DISCUSSION

Some information about the welding workers to whom the survey study was applied is given in Table 3.1.

**Table 3.1.** Some information about the characteristics of welding workers [2]

Age	18-25	26-40	41-55	56-
Percentage (%)	22	40	28	10
Education	Primary school	Secondary school	High school	Vocational high school
Percentage (%)	12.5	32.5	27.5	27.5
Work experience	0-1	1-5	6-15	15-
Percentage (%)	10	42.50	30	17.50
Daily welding duration	1-2	3-4	5-6	7-8

Percentage (%)	10	40	42.5	7.5
Welding Method	Gas metal arc welding (MIG, MAG, TIG)	Covered Electrode	Oxy-Gas	
Percentage (%)	68	18	30	
Status of receiving occupational safety training	Yes	No		
Percentage (%)	88	12		
Risk assessment information	Yes	No	Partially	
Percentage (%)	25	15	60	
Use of personal protective equipment	Yes	No	Partially	
Percentage (%)	63	35	2	
Work accident situation	Yes	No		
Percentage (%)	48	52		
Number of work accidents	1-5	6-10	11-20	
Percentage (%)	74	21	5	
Occupational disease situation	Yes	No		
Percentage (%)	28	72		

The majority of the welding personnel participating in the survey are in the 26-40 age group. When the education levels of the participants are examined, it is seen that the rate of secondary school graduates is slightly higher than that of high school and vocational high school graduates. It has been determined that the rate of high school and vocational high school graduates is equal. Vocational high school graduates are mostly metal department graduates. As it is known, metal department students are given theoretical and practical training on welded manufacturing and occupational safety in their schools. It is seen that the majority of the participants have been working in welding for 1-5 years, and almost half of the employees have 6 years and more welding experience. A significant rate of 90% of the participants weld for more than 3 hours per day. The welding type most commonly performed by the participants in the survey is the gas metal arc welding method (MIG, MAG, TIG). Because gas metal welding is mostly used in the industry due to its advantageous features. The metal that is most commonly welded is steel materials. Because steel materials are the most preferred metal type in manufacturing due to their superior mechanical properties such as strength and shaping and their lower costs compared to other metals. A significant majority of the participants in the survey, 88%, have received training in the field of occupational health and safety in welding and welded manufacturing operations. This training was mostly received at the workplace and the vast majority of employees find this occupational safety training sufficient. Vocational high school graduates received this training at their schools. The rate of welding employees who have full knowledge of risk assessment, which forms the basis of occupational health and safety, is very low. Two-thirds of employees have partial

knowledge of risk assessment. It was determined that 53% of welding employees apply their occupational health and safety knowledge, while 45% apply it partially. The rate of use of personal protective equipment such as masks, helmets, gloves, and high-temperature-resistant work aprons is well below the required rate. Among the reasons for not using this equipment, the most frequently stated answer was “slowing down work”. Approximately half of the welding workers who participated in the survey had at least one work accident, and these accidents were mostly non-injury or minor injury accidents that did not cause time off work. The hands, arms and eyes were the most damaged in these accidents. High-temperature metal spatter and welding rays spread around during welding are effective in these accidents. It is seen that approximately one-third of welding workers have an occupational disease. The most common occupational disease is musculoskeletal disorders. The reason for this is thought to be long working hours, non-ergonomic working positions and carrying heavy metallic materials by hand, as seen in the table.

Some demographic characteristics of welding employees and the relationship between occupational safety variables and occupational accident cases are given in Tables 3.2 and 3.3.

**Table 3.2.** Relationship between some demographic variables and occupational accidents [2]

		Has the participant had an occupational accident while welding?	
		Yes (%)	No(%)
Age range of the participant	18-25	33	67
	26-40	44	56
	41-55	45	55
	56-	100	00
Level education of participant	Primary school	40	60
	Secondary school	62	38
	High school	45	55
	Vocational high school	36	64
Welding experience of participant (years)	0-1	50	50
	1-5	41	59
	6-15	42	58
	Over 15	71	29
Daily welding duration of participant (hour)	1-2	75	25
	3-4	38	62
	5-6	53	47
	7-8	33	67
Vocational education status of participant	Yes	39	61
	No	78	22

**Table 3.3.** Relationship between some occupational safety variables and occupational accidents [2]

		Has the participant had an occupational accident while welding?	
		Yes (%)	No (%)
Participant's occupational health and safety training status on welded manufacturing	Yes	46	54
	No	60	40
According to the participant, are occupational safety trainings sufficient?	Yes	61	39
	No	00	100
	Partially	20	80
According to the participant, are occupational safety trainings necessary and important?	Yes	52	48
	No	50	50
	Partially	33	67
Does the participant apply occupational safety knowledge?	Yes	62	38
	No	100	00
	Partially	28	72
Does the participant use personal protective equipment?	Yes	37	63
	No	100	00
	Partially	67	33
According to the participant, is personal protective equipment alone sufficient to prevent work accidents and occupational diseases?	Sufficient	57	43
	Not sufficient	44	56
	Partially sufficient	47	53
Does the participant know risk assessment?	Yes	40	60
	No	50	50
	Partially	50	50

When we look at the relationship between the age of the participants and having an occupational accident, it is seen that there is a lower accident rate in the 18-25 age group compared to other age groups. The reason for this low occupational accident rate is thought to be that younger people apply the education they receive more meticulously, work more carefully, and employees aged 26 and over are more confident and pay less attention to occupational health and safety principles. When the relationship between the education level of welding workers and work accidents is examined, the lowest accident rate is seen in vocational high school graduates. Since a significant majority of vocational high school graduates are metal department graduates, they have received a lot of theoretical and practical training in this

department, welding manufacturing and occupational health and safety in welding manufacturing. The rate of occupational accidents in those with the most experience in welding work is higher than others. As in the age of the worker, it is seen that more experience also produces negative results due to overconfidence and disregard for work safety. A high rate of 78% of those who did not receive vocational training in welding had an occupational accident. There are various risks that cause occupational accidents in welding manufacturing works. Fire and explosions, electric shock, high temperature splashes burning the body, burrs in the eyes, welding rays damaging the eyes are some of these occupational accident risks. Therefore, it is not possible for people who do not receive vocational training in welding to fully know these risks and take the necessary precautions. In the study of Özalp and his colleagues on electrical hazards in welding works [11], it was emphasized that insufficient training and overconfidence of employees increase electrical accidents in welding works.

Occupational health and safety trainings related to welding works are also very important. Especially welding workers who do not receive vocational training should generally attend these trainings given at their workplaces. As mentioned above, vocational high school graduates receive this training at their schools. It is seen in Table 3.3 that the rate of occupational accidents in those who do not receive occupational safety training in welding works is higher. The rate of occupational accidents was higher in those who considered the occupational safety training they received sufficient. It is seen that welding workers who care about occupational safety very much and consider even the occupational safety training they receive insufficient do not have occupational accidents. The priority in occupational health and safety measures is collective protection methods and eliminating or reducing the risk at the source. In cases where the risk cannot be completely eliminated, personal protective equipment should be used. There is also personal protective equipment that should be used in welding works. As seen in Table 3.3, while the risk of occupational accidents is the lowest in those who use personal protective equipment, the rate of occupational accidents increases in those who use this equipment partially, and occupational accidents are inevitable in those who do not use it at all. Because some risks such as spatter and harmful rays in welding works cannot be prevented without this protective equipment.

A comparison of various variables and the occupational disease status of welding workers is given in Tables 3.4 and 3.5. When welding workers are examined in terms of occupational diseases, some findings in Tables 3.4 and 3.5 stand out. First of all, when the relationship between welder age and occupational diseases is examined, it is seen that the occupational disease rate is highest in workers over 56 years of age. Since occupational diseases occur due to the work carried out and repeated reasons at work, the duration of exposure to the risk of occupational disease increases as the welder's age increases. For example, the duration of exposure to mechanical effects, ergonomic difficulties, harmful welding rays such as visible, infrared, ultraviolet, and noise increases. Similarly, the occupational disease rate is highest in those with 15 and more years of work in the Table. In the study of

Okumuş et al., it was stated that the age of the worker is one of the most important parameters in occupational diseases seen in shipyard welding workers [9]. Another striking finding in the tables is that the rate of occupational diseases is very low in those who receive occupational health and safety training in welded manufacturing. Similarly, it is seen that the rate of occupational diseases is lower in vocational high school graduates who receive this training. Those who do not receive this occupational health and safety training do not have knowledge about the risks that create many occupational diseases in welding works. For example, it is not known that noise above the specified limit will cause hearing loss in the coming years, and that welding rays can cause not only eye diseases but also many types of cancer. The increase in the number of welding hours per day also slightly increases the rate of occupational diseases since it increases the exposure time. Various musculoskeletal system occupational diseases such as back pain and herniated discs will occur as a result of long-term welded production, especially under unsuitable ergonomic conditions. Another striking point in Table 3.5 is that the rate of occupational diseases in welding workers who use personal protective equipment is much lower than in those who do not use this equipment. Masks and other work clothes used against welding rays, and earplugs used against noise, reduce the level of risks that cause many occupational diseases.

**Table 3.4.** Relationship between some demographic variables and occupational diseases [2]

		Has the participant suffered from any occupational disease due to welding work?	
		Yes (%)	No (%)
Age range of the participant	18-25	33	67
	26-40	13	87
	41-55	27	73
	56-	75	25
Level education of participant	Primary school	00	100
	Secondary school	46	54
	High school	30	70
	Vocational high school	18	82
Welding experience of participant (years)	0-1	25	75
	1-5	25	75
	6-15	8	92
	Over 15	71	29
Daily welding duration of participant (hour)	1-2	25	75
	3-4	27	73
	5-6	29	71
	7-8	33	67
Vocational education status of participant	Yes	27	73
	No	33	67



**Table 3.5.** Relationship between some work safety variables and occupational diseases [2]

		Has the participant suffered from any occupational disease due to welding work?	
		Yes (%)	No (%)
Participant's occupational health and safety training status on welded manufacturing	Yes	21	79
	No	80	20
According to the participant, are occupational safety trainings sufficient?	Yes	33	67
	No	50	50
	Partially	10	90
According to the participant, are occupational safety trainings necessary and important	Yes	29	71
	No	50	50
	Partially	22	78
Does the participant apply occupational safety knowledge?	Yes	30	70
	No	100	00
	Partially	22	78
Does the participant use personal protective equipment?	Yes	22	78
	No	100	00
	Partially	36	64
According to the participant, is personal protective equipment alone sufficient to prevent work accidents and occupational diseases?	Sufficient	29	71
	Not sufficient	40	60
	Partially sufficient	18	82
Does the participant know risk assessment?	Yes	11	89
	No	50	50
	Partially	29	71

## CONCLUSIONS

In this study, occupational health and safety analysis was conducted in welded manufacturing works in a medium-sized mixed organized industrial zone and the general results and recommendations obtained are given below.

The rate of occupational accidents and diseases is lower in employees who have received vocational training and occupational safety training related to welding. Therefore, the state, employers and employees should give due importance to vocational training.

Approximately half of the welding workers do not apply the occupational safety training they receive or apply it partially. It is very important for occupational health and safety to create safety awareness and culture in employers and employees. The full use of personal protective equipment by workers in welded manufacturing is not at the desired levels. Necessary training should be given and inspections should be carried out in this regard.

The most common occupational diseases among welding workers are determined to be herniated discs, hearing and eye disorders. To prevent this, working hours should be arranged appropriately and ergonomic improvements should be made. Personal protective equipment should be used to prevent hearing and eye disorders.

It is observed that the knowledge level of welding employees regarding risk assessment is quite low. Necessary training should be provided on this subject and the participation of employees in risk assessment activities should be ensured.

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