

Eye protection practices and symptoms among welders in the Limpopo Province of South Africa⁺

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Abstract

Welding is associated with several ocular and systemic hazards especially where adequate protective measures are not taken. The purpose of this project was to study the eye protection practices and symptoms among welders in the Capricorn District of Limpopo Province, South Africa. Questionnaires designed to investigate eye protection practices and symptoms experienced were completed by one hundred and fifty (150) welders. The types of welding done were shielded metal arc (84%), oxyacetylene gas (4%) and silver brazing (12%). The number of years spent in the welding industry ranged from one to 10 years with a mean of 5 ± 3.1 years and the number of hours of welding per day ranged from one to 10 hours with a mean of 6 ± 2.1 hours. A large percentage of the welders (89%) reported wearing protective devices when welding and the most common protective devices used by the welders were: helmets (57%), goggles

(22%), and face shields (15%). Six percent used inefficient protective devices such as sunglasses. Sixty one percent reported occasional exposure to welding flashes when not wearing any eye protection. Welding-related eye symptoms reported included foreign body sensation (18%), persistent after-images (31%), and watery eyes (50%). Although the majority of the welders wore protective devices while welding, a few did not always use such devices while others used sunglasses for protection. Moreover, many of the welders were occasionally, and only a few were always, exposed to welding flashes when protective devices were not used. Therefore, we concluded that eye protection practices amongst the welders appeared to be inadequate to avoid hazards associated with welding. It is recommended that an eye protection educational campaign for welders should form part of the South African Government's workplace safety program.

Key words: Welders, welding, eye protection, eye symptoms, radiation, protective devices.

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Introduction

Welding is an important tool for maintenance and construction in industry but, it is also a source of artificial ultraviolet radiation (UVR)¹. There are several types of welding which include forge, arc, gas, aluminothermic, ultrasonic and electron beam welding². However, there are two major types namely, Shielded Metal Arc (SMA) and gas (oxyacetylene) welding³. SMA is the most common type of welding used in industry¹. Welding emits high levels of UVR, metal fumes and gases⁴ and exposure to these adverse effects could potentially cause injury to workers¹. The spectral emission of welding arcs peaks in the ultraviolet and blue light region of the spectrum and for this reason, the amount of energy in this region is potentially more hazardous to the eyes⁵, therefore welders must protect themselves against these radiations.

The main actinic component of welding is UVB which is produced mainly by arc welding and to a lesser extent by gas welding⁵. Exposure to UVB has been considered to be associated with many ocular conditions such as cataract^{6, 7} which is the major cause of blindness in most parts of the world⁸ including South Africa⁹. Acute exposure to UVB results in acute kerato-conjunctivitis, a condition also known by various names such as welding flash, flash eye, photophthalmia, arc eye or actinic ray photokeratitis¹⁰. Exposure to UVR has also been considered to increase the risk of age-related macular degeneration^{11, 12}. Repeated exposure to natural UVR sources such as sunlight has been associated with pterygium, pingueculae⁸, and corneal endothelial changes¹³ which have also been observed in some welders¹⁴. Conditions involving the eyelids such as squamous cell carcinoma, basal cell carcinoma, and malignant melanoma also affect welders exposed to intense UVR¹⁵.

There are other ocular and systemic problems associated with welding, and these include foreign objects entering the eye, fume inhalation, electric shock and injuries resulting from explosion³. Hazardous gases such as carbon dioxide, carbon monoxide, nitrogen oxide and ozone are associated with the welding process and when welding takes place in a poorly ventilated or confined space, these gases are more likely to cause eye irritation¹⁵.

Even when not welding, welders may be inadvertently exposed to arcs of nearby welders¹⁵. It has been

estimated that about half of welder's flash injuries occur in co-workers who are usually in the immediate surrounding of where welding takes place but not being involved in welding¹⁶. Unprotected exposure to welding often occurs when the electrical current is first turned on (termed 'striking the arc'). This may occur if the density of the welding filter being used is very dark and makes it impractical for the welder to accurately position the welding electrode without lifting the welding filter. As welders strike the arc, they flip their head down to reposition the welding filter. Any mistiming of this procedure may cause the welder to be exposed briefly to the intense radiation produced by the arc, resulting in a welding flash¹⁶. In view of these exposures, adequate precaution and protection should be maintained in the welding environment.

The hazards associated with the welding process depend on the type of welding, the materials (base metals, surface coatings, electrodes) to be welded, and the environmental conditions (outside or in a confined space, for instance)¹⁵. It is vital that appropriate eye protection be used for all welding operations to protect the eyes from bright light, heat, ultraviolet light, and flying sparks. Welders generally shield themselves from harmful radiation and mechanical injuries by using protective devices such as safety goggles, helmets and face shields¹⁷. However, some radiation may enter the welding helmet from behind and be reflected into the welder's eyes by the filter glass and other parts of the inside of the helmet¹⁶.

Various optical densities (shade numbers) of filters for different types of welding have been published and the shade numbers such as 4 to 8 have been recommended for gas welding¹⁷. The shade numbers may be as high as 15 for plasma arc cutting¹⁷. The appropriate shade numbers for different welding operations are shown in Table 1.

Table 1: Showing different welding operations and appropriate shade numbers (Adapted from AFSCME¹⁸)

Welding operations	Shade numbers
Plasma arc cutting and spraying	15
Atomic hydrogen welding	10-14
Shielded metal arc welding	10
Gas shielded arc welding	12
Oxyacetylene gas welding	4-8
Silver brazing	3 or 4
Soldering	2

In order to avoid eye injuries due to welding, personal protective equipment (PPE) should always be used along with welding helmets, goggles and safety spectacles¹⁹.

Welding is a common occupation in South Africa and no record of any previous study on eye protection practices and symptoms among welders could be found in the literature. Therefore, this project was carried out to study eye protection practices and symptoms among welders in the Capricorn District of the Limpopo Province.

Methods

A map of the Capricorn District of the Limpopo Province was obtained from the Geography Department of the University of Limpopo, and all the five municipalities were chosen for the study. The capital of each municipality was included in the study. All the towns and villages shown on the map of each municipality were numbered, and a person who did not know what the numbers represented was asked to pick four of the numbers. Therefore, a total of 25 towns and villages were the study sites for this project. The proposal for this study was approved by the University of Limpopo Research and Ethics Committee. Welders' workshops were sought in each of the 25 study sites and permission was obtained from the managers as well as the individual welders before the commencement of the study. All welders in each workshop or industry were included in the study. The participants were informed that the findings of the study would enable the researchers to recommend eye care awareness campaigns for welders to the government, so as to reduce the risk of injuries in the industry. Those who agreed to participate were given the University of Limpopo consent form for completion before the commencement of the study. All those requested to participate in the study completed the consent form, therefore, nobody was excluded from the study as a result of refusal to complete the form.

A questionnaire (Appendix A) was used as an instrument to establish the eye protection practices and symptoms experienced. It was administered individually to each welder confidentially and those who needed assistance with the completion of the form were assisted by the researcher or a research assistant. All those who participated were motivated by the prospects of future eye care awareness campaign

that may reduce the risk of eye and systemic injuries in the industry. Descriptive statistics using the SPSS and Microsoft Excel statistical packages were used to analyze the data.

Results

One hundred and fifty welders responded to the questionnaire. All were black male South Africans and their ages ranged from 18 to 65 years with a mean of 39 ± 14.9 years. The age distribution is shown in Figure 1.

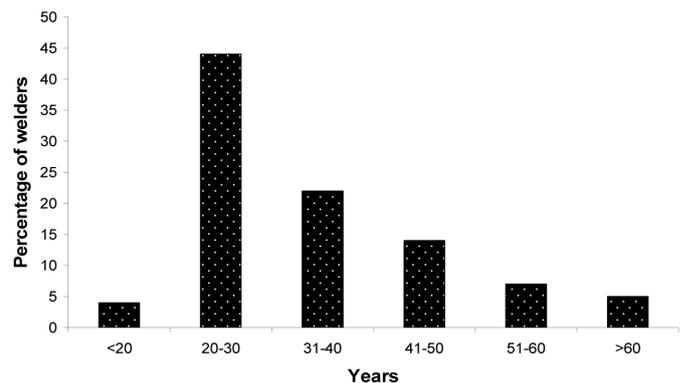


Figure 1: The age distribution of subjects included in the study. A large proportion of the participants were between the ages of 20 and 50 years.

The majority of the welders, 64% ($n = 96$) were found in the towns and cities, while other 36% ($n = 54$), were found in the villages. Three types of welding were performed by the participants, namely: shielded metal arc welding, 84% (126), oxyacetylene gas welding, 4% (6) and silver brazing, 12% (18). Years spent in welding ranged from one to over 10 years with a mean of 5 ± 3.1 years. The distribution of years of welding is shown in Figure 2.

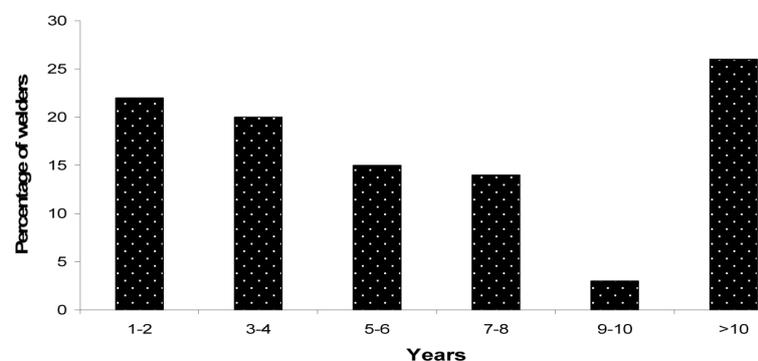


Figure 2: Distribution of years of welding among the subjects. Many subjects have worked for more than 10 years.

Hours spent in welding per day ranged from one to over 10 hours with a mean of 6 ± 2.1 hours. The distribution of hours spent welding per day is shown in Figure 3.

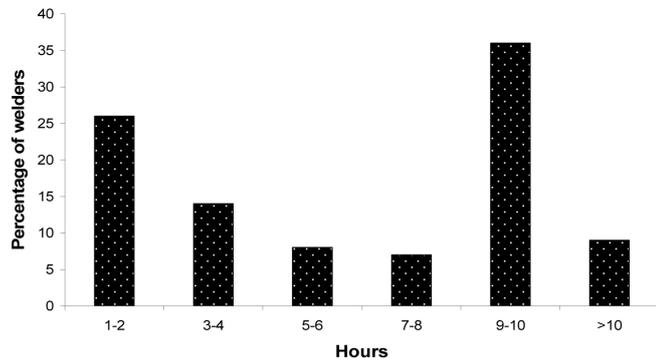


Figure 3: The maximum number of hours spent welding per day.

The time spent welding in the previous week ranged from one to 20 hours. The distribution of hours spent welding in the previous week is shown in Figure 4. The reported frequencies of exposure to nearby welding without eye protection are shown in Table 2

The responses on the knowledge of shade numbers and the importance of wearing protective devices when welding are shown in Table 3.

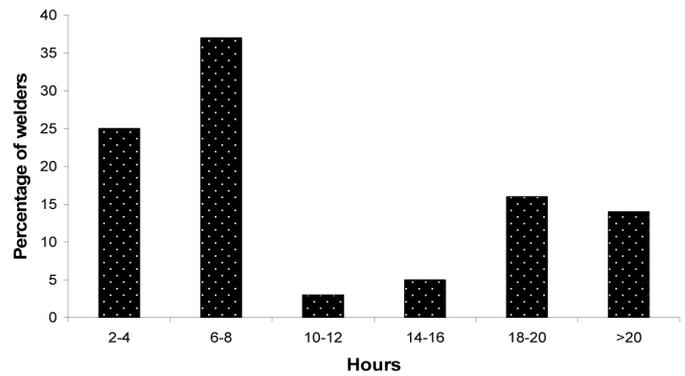


Figure 4: The maximum number of hours spent welding in the previous week.

The majority, 89% (133), of the welders wore eye protective devices when welding. The types and proportion of protective devices used during welding are shown in Figure 5.

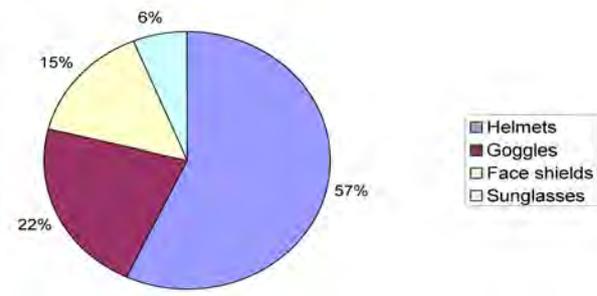


Figure 5: Different protective devices used by subjects.

Table 2: Showing the percentages of subjects whose responses were frequently, sometimes and never to the questions indicated on the table (The figures in brackets represent the number of subjects).

Questions	Frequently	Sometimes	Never
How often are you exposed to nearby welding when not wearing eye protection?	17% (26)	61% (92)	21% (32)
Do fumes from welding irritate your eyes?	18% (27)	65% (98)	17% (25)
Does dust in the work place irritate your eyes?	63% (94)	32% (48)	5% (8)
Do you experience foreign body sensation during welding operation?	7% (11)	11% (17)	81% (122)

Table 3: The percentages of subjects who responded to the questions indicated on the table (The figures in brackets represent the number of subjects).

Questions	Yes	No
Do you always wear eye protective devices when welding?	89% (133)	11% (17)
Do you know what welding shade number means?	1% (1)	99% (149)
Do you know the importance of protective devices when welding?	91% (137)	9% (13)
Do you ever notice after-images (like after a camera flash) after welding?	31% (47)	69% (103)
Did you experience any other eye symptom in the previous working days as a result of welding?	20% (30)	80% (120)



Eighteen per cent (27) and 63% (94) of the welders reported frequent irritation by fumes and dust respectively. Another 7% (11) experienced frequent foreign body sensation. The frequency of fume and dust irritation as well as foreign body sensation is shown in Table 2.

Thirty one per cent (47) reported to have noticed after-images after welding as shown in Table 3. At least 20% (30) of the respondents reported other eye symptoms illustrated in Figure 6.

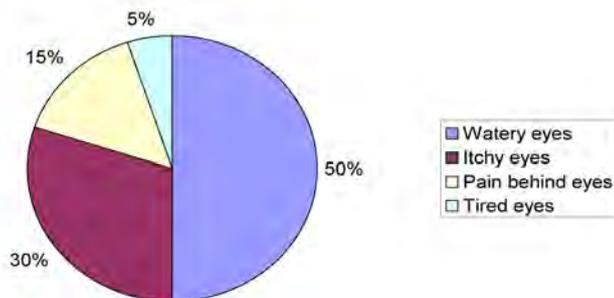


Figure 6: Percentage of subjects experiencing ocular symptoms.

Seventy two per cent (108) commented that welding could damage eyes if precautionary measures were not taken. Twenty one per cent (32) gave no comment and 7% (10) indicated that one could experience eye problems when welding without the use of specially prescribed eye protective devices.

Discussion

The Capricorn District was chosen for the study because of its proximity to the University of Limpopo where the main researcher was based. Most of the younger welders (20-30 years) worked in the towns and cities, presumably because they were still in their prime working ages; hence it was easy to find employment in the welding industries. Contrarily, those in the villages were 50 years and older, suggesting that they may have retired from previous employments and started their own businesses in the villages where it would be cheaper to operate.

Shielded metal arc welding has been considered to be the most commonly preferred method of welding due to the non-complexity of the method^{5, 15}. This agrees with the findings in this study as most welders (84%) performed this type of welding. Unfortunately, this type of welding produces full spectrum of UVR

(UVC, UVB and UVA)¹, therefore one would expect the welders to take adequate precautions.

The number of years spent in welding may influence the injury inflicted on the eye if adequate precautions are not taken. Although 26% of the welders had spent over 10 years in the industry, however, statistical analysis revealed no correlation between years spent in welding and ocular disorders reported by the welders. Although 36% of the welders reported welding for a maximum of nine to 10 hours per day, this may not be an everyday occurrence. It is assumed that when they had a task to be completed urgently, they would spend many hours working. There may be days, however, when they do not weld at all, as some (14%) of these welders also reported welding for just 20 hours in the previous week.

Although 89% of the welders reported wearing protective devices always when welding but a few (11%) reported not always using them. The latter therefore exposed themselves to welding hazards that could cause eye injuries which may lead to low vision and/ or blindness. This risky practice may be due to poor knowledge of adverse effects of welding process. There is therefore, a need for preventive health education for welders on the systemic and ocular adverse consequences of welding.

The South African Occupational Health and Safety Act¹⁹ stipulates that; no employer or user shall permit welding operations to be undertaken, unless: i) the person operating the equipment has been fully instructed in the safe operation and use of such equipment and in the hazards which may arise from its use; ii) effective protection is provided and used for the eyes and where necessary, for the face and body of persons performing such operations, as well as against heat, incandescent or flying particles and dangerous radiations; iii) the workplace is effectively partitioned off where practicable and where not practicable, all the other persons exposed to the hazards are warned and provided with suitable protective equipment. The act, however, does not include details of the specific types of devices for different types of welding operations. Although many welders in this study used effective devices such as helmets, goggles and face shields; a minority (6%) used ordinary sunglasses. Agreeably, most sunglasses with less than 1% UV-B and UV-A transmittance can provide adequate protection against ultraviolet radiation, they are usually limited when

used during welding²⁰. Also, their lack of side shields for protection against flying particles, dust and fumes is a major limitation which may cause serious injuries to the eye. It is necessary to educate the welders that wearing an inappropriate protective device is as detrimental as not wearing one at all.

Many (61%) of the welders in this study were sometimes exposed to welding flashes when not welding, long term of which may increase the risk of serious eye diseases^{6, 7, 11, 12}. To minimize the risk of exposure to welding arcs, plastic welding curtains which are flexible, transparent, tinted to absorb ultraviolet radiation and formulated with a flame retardant²¹ should be used to enclose welding operations. Also, surfaces surrounding the welder should be painted with a matt finish to minimize reflections of ultraviolet radiation²¹. It may be necessary to include this type of detail in the occupational health and safety regulations relating to welding.

As 99% of the welders did not have knowledge of shade numbers, this implies that they simply bought whatever shade that was available, which may be dangerous. Therefore, the use of appropriate shade numbers should be emphasized in the awareness campaigns in South Africa. Lack of knowledge of the importance of eye protective devices when welding among 9% of the welders highlights the need for eye protection awareness campaigns for the welders in the Province. Occasional fume irritation (65%) and frequent dust irritation (63%) reported by the welders may be due to poor ventilation increasing the concentration of dust and fumes. The welders therefore need to be educated on the need for good ventilation in the welding areas.

Foreign body sensation reported by 19% of the welders suggests a deficiency in safety precautions. Foreign body injuries may lead to loss of production and increased workers compensation premiums²². The use of helmets, goggles or face shields when performing hazardous procedures (aside from welding) may reduce the incidence of foreign bodies.

After-images reported by the welders, (some persisting for over a minute following welding), may among other reasons, suggest that some of the welders were exposed to high levels of visible radiation when ineffective or no protective devices were worn when welding. Again, this suggests the need for education regarding the use of appropriate devices and shade numbers for welding.

The reported watery and itchy eyes may be due to dry eye and dusty environment. Pain behind the eyes and tired eyes could be associated with prolonged near work. Therefore, welders need to be educated about occupational hygiene and effects of long hours of welding.

It is commendable that many, 72%, of the welders knew that welding can damage eyes if one does not take precautionary measures; however, this knowledge will only be of advantage if adequate protective measures are taken to prevent damage to the eye, which is presently not the case. No awareness campaign on the various adverse effects of welding has been carried out in the Limpopo Province and other parts of South Africa. Such campaigns are recommended in order to reduce the risk of eye injuries and long term adverse ocular effects among the welders.

As 17% of the welders reported regular exposure, 61% reported occasional exposure to nearby flashes without eye protection; a few used sunglasses when welding and 99% did not know what shade numbers meant, it was concluded that there was inadequate eye protection knowledge and practices among the welders in the Province. Also, welding-associated symptoms were common among the welders. These situations were similar to what was reported in Nigeria by Oduntan²² and Australia by Ten-Kate and Collins¹⁶. Poor protective practices and long period of welding may result in high levels of discomfort symptoms and eye injury among welders²³. It is therefore necessary for welders to take adequate precaution and avoid lengthy welding periods.

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Appendix A (Questionnaire)		
1	Age (years):	<input type="checkbox"/> <input type="checkbox"/>
2	Gender: Male [1] Female [2]	<input type="checkbox"/>
3	Race: African [1] Indian [2] White [3] Coloured [4]	<input type="checkbox"/>
4	Location: Town [1] Village [2]	<input type="checkbox"/>
5	What type of welding did you perform? Shielded metal arc welding [1] Oxyacetylene gas welding [2] Other [3]	<input type="checkbox"/>
6	For how many years have you been welding? 1-2 [1] 3-4 [2] 5-6 [3] 7-8 [4] 9-10 [5] >10 [6]	<input type="checkbox"/> <input type="checkbox"/>
7	On average, how many hours do you weld in a day (specific of hours)? 1-2 [1] 3-4 [2] 5-6 [3] 7-8 [4] 9-10 [5] >10 [6]	<input type="checkbox"/> <input type="checkbox"/>
8	How many hours of welding did you perform in the previous week? 1-2 [1] 3-4 [2] 5-6 [3] 7-8 [4] 9-10 [5] >10 [6]	<input type="checkbox"/> <input type="checkbox"/>
9	Do you always wear eye protective devices when welding? Yes [1] No [2]	<input type="checkbox"/>
10	What do you use for protection against radiation? Helmet [1] Goggles [2] Face shield [3] Other, please specify:.....	<input type="checkbox"/>
11	How often are you exposed to nearby welding when you are not wearing eye protection? Frequently [1] Sometimes [2] Never [3]	<input type="checkbox"/>
12	Do you know what welding shade number means? Yes [1] No [2]	<input type="checkbox"/>
13	If yes, what does it mean?	<input type="checkbox"/>
14	Do you know the importance of protective devices when welding? Yes [1] No [2]	<input type="checkbox"/>
15	Do fumes from welding irritate your eyes? Frequently [1] Sometimes [2] Never [3]	<input type="checkbox"/>
16	Does dust in the work place irritate your eyes? Frequently [1] Sometimes [2] Never [3]	<input type="checkbox"/>
17	Do you experience foreign sensation during welding operation? Frequently [1] Sometimes [2] Never [3]	<input type="checkbox"/>
18	Do you ever notice after-images (like after a camera flash) after welding? Yes [1] No [2]	<input type="checkbox"/>
19	If yes, how long do they normally last (seconds)? 1-5 [1] 5-10 [2] 10-15 [3] 15-20 [4] 20-25 [5] 25-30 [6] 30-35 [7] 35-40 [8] 40-45 [9] 45-50 [10] 50-55 [11] 55-60 [12] ≥1min [13]	<input type="checkbox"/> <input type="checkbox"/>
20	Did you experience other conditions of the eye after welding? Yes [1] No [2]	<input type="checkbox"/>
21	If yes, what was/were the condition(s)?	
22	Do you have any other comments about the effects of welding on your eyes?	

