Impact Assessment of Educational Level and Training Background of Welders on Safety Awareness and Analysis of Safety Issues in Welding Industries in Ghana

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Abstract– This study investigates the educational and training background of welders in welding industries in Ghana and assesses the impact of educational level, training background, age of welders and number of years of welding after qualification on safety awareness in industry. The study also investigates some safety practices associated with welders and the welding industry. Designed questionnaires were used to collect the data for the study. The study respondents were 200 welding industries across the regions of Ghana comprising of sixty eight (68) from the formal sector and one hundred and thirty two (132) from the informal sector. Some of the results from the study are that, about eighty eight percent (87.50%) of the welders do not go beyond secondary and vocational school education and the majority in this group attains their welding training through apprenticeship. Sixty-seven percent (67.00%) of the welders have high level of knowledge of hazards in industry. About fifty-seven percent (56.50%) of welders are highly prone to hazards in industry. It was also found out that sixty percent (60.00%) of welders suffer from various eye problems and about fifty-one percent (50.50%) suffer from various skin diseases likely stemming from long periods of exposure to radiations from the welding arc/flame daily in their work environment and the unavailability of PPE's. The paper recommends among others that all welding industries in Ghana must institute some form of insurance policies for the industry and the welders due to the hazards and dangers associated with welding activities.

Index Terms – Education, Training, Hazards, Personal Protective Equipment, Safety, Welding Industries, Ghana.

1.0 INTRODUCTION

Welding is a very difficult and dangerous profession so it is important for welders to follow general safety guidelines. In this way, they can insure not only their safety but the safety of others around them [2]. Globally the education and training of welders in all aspects of welding and fabrication especially safety in the welding industry is thought to be very important due to the hazards and risk associated with the welding process. Education and training increase the knowledge base of all people employed in the welding industry, at every level, enabling them to make decisions that will result in utilization of the best welding technology for each application [12]. Providing enough training for all workers is crucial to ensuring worker safety and to make them aware of any possible dangers and ways to avoid them [5] [7]. Although industrial safety and health problems are sometimes inevitable, the education and training background of employees on the job is one of the most effective ways of preventing its prevalence. These trainings should start on the day they are recruited since obtaining the necessary information about how to carry on the job will reduce the risk of accidents [8]. Awareness and implementation of occupational safety and health (OSH) standards by employers and employees will help curb the rate of accidents in industries. The Occupational Safety and Health Administration (OSHA) require, and employers rely on, worker training programs to educate workers to "do the right thing" on

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the shop floor, thereby managing residual risks. Many worker training programs fall under the general category of hazard recognition (i.e., risk perception); the assumption made is that if workers and their management are aware of workplace risks and are trained on how to manage the risks, there will be fewer workplace illnesses and injuries due to these risks [3].
Employers in Ghana including the welding industry are required by among other legislations the Ghana Labour Act 2003 (Act 651) and the Factories, Offices and Shops Act 1970 (Act 328) to ensure their employees are not exposed to conditions that would lead them to work related injuries or illnesses. Employees are also required to exhibit their duty of care in ensuring that they work as per the employers' standard operating procedures which must incorporate safety and health requirements. The Ghanaian welding industry is populated by the informal sector. These industries operate mostly in clusters in suburbs of the big cities in Ghana such as Accra, Kumasi and Takoradi. The Welders and Pipe Fitters Association of Ghana (WAPAG**)** have in their records, about 3000 welders and estimates that the total number is increasing steadily in Ghana across various industries. A visit taken to some industrial estates in Ghana such as "Suame Magazine", in Kumasi, "Kokompe", in Accra and in most villages in Ghana reveal thousands of welders that are engaged in heavy welding without regard to proper safety and health practices. Dartey et al [4], in their work, 'evaluation of airborne lead levels in storage battery workshops and some welding environments in Kumasi Metropolis in Ghana' reported that, the mean values recorded at the workshops were high as compared to WHO standards and exceeded the threshold limit values of 100 to 150 $\mu g/m^3$ recommended in most jurisdictions. Kumah et al [9] in their study stated that the commonest radiation-related ocular eye diseases among welders at the Suame magazine were pterygium (56.6%), photoconjunctivitis (22.6%) and cataract (5.1%) where as in the control group the commonest conditions were pterygium (6.2%), pinguecula (2.2%) and cataract (1.3%). There were a small number of retinopathies associated with radiation (4.0%). Monney et al [10] recommended the need for collaboration between the artisans and relevant stakeholders, such as Department of Factories Inspectorate to train the artisans on occupational health and safety. This should include intensive education on skin care and the usefulness of rudimentary protective equipment in forestalling work-related injuries and illnesses.

The main objective of this study was set to assess most importantly the impact of the educational level and training background of welders on safety awareness and analysis of some of the safety practices in welding industries in Ghana. The study makes conclusions and recommendations for effective policy implementation for government and stakeholders in the welding industry in Ghana.

2.0 PROBLEM STATEMENT AND RESEARCH RELEVANCE

As in the case in most metalworking industries, the potential for bodily harm and hazardous situations exists. High electrical currents and voltages are used to operate machinery and welding equipment. Machinery for shearing, forming, and punching various thicknesses of materials is used. Flammable and other compressed gases are used during flame cutting and welding operations. Welders may work in enclosed, restricted spaces and at times at high elevations and in awkward positions. An undesirable noise level is sometimes generated during the production process [1]. The welder must take safety precautions, and be safety conscious at all times.
Education and training programmes for welders in the welding industry are geared towards changing the attitude, imparting skill and knowledge and reorienting the mindset of the welder that will result in utilization of the best welding technology, improved manufacturing and enhanced safety practices. The need for assessing the educational and training background of welders and industry on safety practices becomes even more imperative for the welder and his immediate environment.

3.0 MATERIALS AND METHODS

The study was carried out in some major welding industries across seven (7) out of the ten (10) regions of Ghana namely: Ashanti region, Greater Accra region, Western region, Eastern region, Brong Ahafo region, Upper East region and Central region using designed questionnaires through industrial and institutional visits. No questionnaires were administered in the Volta, Northern and Upper west regions. These industries were made up of both the

formal and informal sectors. In all two hundred and fifty (250) questionnaires were administered and two hundred (200) responded and retrieved, comprising of sixty eight (68) from the formal sector and one hundred and thirty two (132) from the informal sector.
The welding industries were selected from the Association of Ghana Industries (AGI) database, National Board for Small Scale Industries (NBSSI) records, firms suggested by interviewees, website pages and telephone directory. The 'Simple Random Sampling' technique was used. The questionnaire was organized to capture information pertaining to respondents demographic characteristics of both welders and industry (age, educational level, welding training background, certificates acquired, number of years welding industry have been in operation, etc.), welders awareness of accidents/hazards in industry, availability of Personal Protective Equipment (PPE's), proneness level of hazards in industry, exposure period to arc/flame and insurance policies for welders. The data were analyzed using STATA: Data Analysis and Statistical Computer Software Package. To provide understanding of trends and proportions, descriptive statistics and cross-tabulation were used for data analysis to determine associations between study parameters using the Chi-square test (X^2), degree of freedom and the Pearson's Contingency Coefficient (CC) tested at 5% two-tail test level of significance.

4.0 RESULTS

4.1 Demographic Characteristics of Respondent Welders

This section presents the demographic characteristics of the welders under study. As shown in Table 1, the age group of welders used in this study is between 18 – 70 years among which 18 - 30 years account for 63 (31.50%), 31 - 49 years were 100 (50.00%) while 50-70 years were 37 (18.50%). The research did not capture any welder less than 18 and above 70 years. The research captured 200 (100%) male welders and no female welders. The educational level of the welders revealed that 59 (29.50%) completed primary school, 47 (23.50%) completed secondary school, 25 (12.50%) completed tertiary institution, 59 (29.50%) completed vocational/technical school. Those without formal education were 10 (5.00%). The respondents were of age and had good understanding of the topic of interest. Thus the data gathered from the field are accurate, valid and useful for this research work.

Table 1: Demographic Information

Welders Age Group in Years	Frequency	Percent (%)
18-30	63	31.50
31-49	100	50.00
50-70	37	18.50
Gender		
Male	200	100
Female	Nil	Nil
Educational Level		
Primary completed	59	29.50
Secondary completed	47	23.50
Tertiary completed	25	12.50
Vocational/Technical	59	29.50
No formal education	10	5.00

4.2 Training, Certification and Qualification and Rank of Respondents in Industry

Of interest to this study, was to elicit information on how respondents attained their welding training, whether the welders had any certificate after training, the type of certificate, the number of years of practicing welding after qualification and their rank or grade in industry. As shown in Table 2, the analyses of the training background of the welders under study revealed that 100 (50.0%) went through apprenticeship to a master, 64 (32%) welding craft practice from a technical institute and 36 (18%) through apprenticeship to a master and welding craft practice from a technical institute.
A total of 112 (56%) had certificates after training and 88 (44%) had no any certificate after training.

Table 2: Training, Certification and Qualification and Rank of Respondents in industry

Welding training	Frequency	Per (%)
A. Through apprenticeship to a master	100	50.00
B. Welding craft practice from a technical institute	64	32.00
C. Both A & B	36	18.00
Certificate after Training		
Welders with Certificate	112	56.00
Welders without Certificate	88	44.00
Type of certificate		
Intermediate certificate in welding	45	40.18
Advanced certificate in welding	29	25.89
NVTI cert I	11	9.82
(NVTI) cert II	11	9.82
Others (testimo. & short courses)	14	12.50
Did not respond	2	1.79

Table 2 continued

Years of practicing welding after qualification	**Freq'cy**	**Per (%)**
less than 1yr	1	0.50
1-5	36	18.00
6-10	66	33.00
11-15	27	13.50
16-20	22	11.00
21-25	15	7.50
26-30	20	10.00
above 30	13	6.50
Rank or Grade of welders		
Welding technician grade I	28	41.18
Welding technician grade II	13	19.12
Senior welding technician	10	14.71
Welding supervisors	7	10.29
Welding instructor	2	2.94
Did not respond	8	11.76
Employee/Industry		
Formal sector	68	34.00
Informal sector	132	66.00
Number of Years Industry has been Welding		
1-10	66	33.00
11-20	54	27.00
21-30	40	20.00
31-40	18	9.00
41-50	11	5.50
Above 50	11	5.50

The type of certificate analyses shows 45 (40.18%) had intermediate certificate in welding, 29 (25.89%) advanced certificate in welding, 11 (9.82%) NVTI cert I, 11 (9.82%) NVTI cert II, 14 (12.50%) others while 2 (1.79%) did not respond. None of the welders interviewed had diploma or degree certificates.

The number of year groups of welders under this study for practicing welding after their qualification shows less than 1 year were 1 (0.50%), 1-5 years account for 36 (18.00%), 6-10 years were 66 (33.00%), 11-15 years were 27 (13.50%), 16-20 years were 22(11.00%), 21-25 years were 15 (7.50%), 26-30 years were 20 (10.00%) while respondents welding above 30 years were 13 (6.50%).

Out of the 200 industries surveyed, 132 (66.00%) are qualified welders operating as informal industries. The rest 68 (34.00%) are qualified welders operating in the formal sector in industry. The ranked status of those in the formal sector revealed that 28 (41.18%) of the respondents are graded Welding Technician Grade I, 13 (19.12%) are graded as Welding Technician Grade II, 10 (14.71%) are graded Senior Welding Technician, 7 (10.29%) are graded Welding Supervisors, 2 (2.94%) are graded Welding Instructors, 8 (11.76%) did not respond.

Tables 3 - 5 show the classification of respondents' training programmes, type of certificate in welding and rank or grade in industry according to educational level.

Table 3: Classification of Welders Training Programmes According to Educational Level

Educational Level		Welding Training			Total
		Apprentice to master	Technical Institute	Both	
Primary completed	Count Percent %	51 51.00	1 1.56	7 19.44	59 29.50
Secondary completed	Count Percent %	31 31.00	5 7.81	11 30.56	47 23.50
Tertiary completed	Count Percent %	6 6.00	18 28.l3	1 2.78	25 12.50
Vocational/tech.	Count Percent %	4 4.00	40 62.50	15 41.67	59 29.50
No formal educ.	Count Percent %	8 8.00	0 0.00	2 5.56	10 5.00
Total		100 100.00	64 100.00	36 100.00	200 100.00

Table 4: Classification of Respondents Type of Certificate in Welding According to Educational Level

Educational Level		Type of Certificate in Welding						Total
		Intermediate	Advance	NVTI Cert. I	NVTI Cert. II	*Others	No response	
Primary completed	Cnt %	4 8.89	0 0.00	2 18.18	2 18.18	4 28.57	0 0.00	12 10.71
Secondary completed	Cnt %	9 20.00	1 3.45	3 27.27	3 27.27	5 35.71	0 0.00	21 18.75
Tertiary completed	Cnt %	2 4.44	15 51.72	0 0.00	0 0.00	2 14.29	0 0.00	19 16.96
Vocational/technical	Cnt %	30 66.67	12 41.38	6 54.55	5 45.45	1 7.14	2 100.00	56 50.00

Table 4 continued

Educational Level		Type of Certificate in Welding						
		Intermediate	Advance	NVTI Cert. I	NVTI Cert. II	*Others	No response	Total
No formal educ.	Cnt %	0 0.00	1 3.45	0 0.00	1 9.09	2 14.29	0 0.00	4 3.57
Total	Cnt %	45 100.00	29 100.00	11 100.00	11 100.00	14 100.00	2 100.00	112 100.00

*Others (certificates and testimonials issued by private welding companies)

Table 5: Classification of Respondents Rank or Grade in Industry According to Educational Level

Educational Level		Rank or Grade in Industry						Total
		Technician Grade I	Technic. Grade II	Senior Welding Technic.	Welding Supervisor	Welding Instructor	No Response	
Primary completed	Cnt %	2 7.14	0 0.00	0 0.00	1 14.29	0 0.00	2 25.00	5 7.35
Secondary completed	Cnt %	0 0.00	2 15.38	1 10.00	0 0.00	0 0.00	2 25.00	5 7.35
Tertiary completed	Cnt %	9 32.14	2 15.38	7 70.00	2 28.57	0 0.00	1 12.50	21 30.88
Vocational/tech.	Cnt %	17 60.71	8 61.54	1 10.00	4 57.14	2 100.00	3 37.50	35 51.47
No formal educ.	Cnt %	0 0.00	1 7.69	1 10.00	0 0.00	0 0.00	0 0.00	2 2.94
Total		28 100.00	13 100.00	10 100.00	7 100.00	2 100.00	8 100.00	68 100.00

4.3 Safety of Welders in Industry

The responses obtained on safety issues are presented in this section. Of interest to this study was respondents' knowledge of hazards in industry, the welders' proneness to hazards in industry, availability or requirements of safety or protective equipment in industry, exposure time to arc/flame duration and insurance for welders in industry.

4.3.1 Analysis of Safety

The response options of the research items were scaled and given one-point weight for every selected response. This enabled the researcher to generate quantitative data from the various responses by total point score of each respondent. The descriptive analysis of the data set (Table 6) provides the maximum score, the minimum score, the mean score, and standard deviation of the scores. The mean value, served as a cut-off point for dichotomous classification of the respondents into categories of interest to this study (eg. high knowledgeable, less knowledgeable, highly prone and less prone etc.).

Table 6: Descriptive Statistics of Overall Response

Sections of Questionnaire	Research Items	Number of Respondents	Minimum Score	Maximum Score	Mean of Scores	Standard Deviation of Scores
Section A	Knowledge of Welders on Accidents/ Hazards in Industry	200	1.00	6.00	4.77	1.3251
Section B	Accidents/ Hazards Prone Level of Welders in Industry	200	0.00	5.00	2.77	1.3439
Section C	Safety/ Personal Protective Equipment Availability	200	1.00	8.00	5.11	2.0662
	Valid Number	200				

Section A elicits information on the general knowledge of welders on hazards in industry as a result of lack of safety measures. For this part of the analysis, since electrical hazards/shock is associated with arc/resistance welding and cylinder explosions/flashback is associated with gas welding, correct

response of any of the two or all two options were scaled and given one point weight. From Table 6 the responses obtained on knowledge of welders on hazards shows that the maximum score is six (6) and minimum score is one (1) with a mean of 4.77. Score from 5-6 were taken as high knowledge and scores from 4 and below taken as low knowledge.

Section B was used to measure the welders' proneness to hazards in industry and the responses obtained are presented in Table 7. The proportions of the degree of hazards are also shown in Table 7.

Table 7: Distribution of Respondents Proneness to Hazards in Industry

Research Items	Frequency Distribution of Responses		Degree of Hazards	
	Yes	No	Severe	Less Severe
Accidents/hazards often encountered in the welding industry or shop				
a) Fire outbreak	39 (19.50%)	161 (80.50%)	35 (89.74%)	4 (10.25%)
b) Explosion of cylinders/Flashback	40 (20.00%)	160 (80.00%)	40 (100%)	0 (0.00%)
c) Electric shock	155 (77.50%)	45 (22.50%)	146 (94.19%)	9 (5.81%)
d) Burns	172 (86.00%)	28 (14.00%)	123 (71.51%)	49 (28.49%)
e) Inhalation of welding fumes leading to respiratory diseases or headache	121 (60.50%)	79 (39.50%)	118 (97.52%)	3 (2.48%)
f) Skin diseases from ultraviolet light/infra-red when welding	101 (50.50%)	99 (49.50%)	96 (95.05%)	5 (4.95%)
g) Eye damage/problems	120 (60.00%)	80 (40.00%)	119 (99.17%)	1 (0.83%)

From Table 6 the responses obtained on the hazards proneness of welders in industry shows that the maximum score is five (5) and minimum score is zero (0) with a mean of 2.77. Score 3-5 were taken as highly prone and 2 and below were taken as less prone. Since this research cut across arc, gas and resistance welders, this classification of respondents was done without electric shock and explosion of cylinders/flashback. This is because electric shock is associated with arc/resistance welding and cylinder explosions/flashback is associated with gas welding but the rest of the hazards can be said to be common to all the welder groups. This made sure the analysis of their responses was not biased towards one group but unbiased to all the welders.

Section C was used to investigate the availability of safety or personal protective equipment used by welders in industry. The responses obtained are presented in Table 8.

Table 8: Distribution of Availability of Safety/Personal Protective Equipment

Research Items	Frequency Distribution of Responses	
	Yes	No
Safety mechanisms in welding industry or shop		
(a) Fire extinguishers	107 (53.50%)	93 (46.50%)
(b) First aid box	93 (46.50%)	107 (53.50%)
(c) Respirators	88 (44.00%)	112 (56.00%)
(d) Welding goggles	188 (94.00%)	12 (6.00%)
(e) Welding gloves	167 (83.50%)	33 (16.50%)
(f) Welding screens/shield	177 (88.50%)	23 (11.50%)
(g) Welding aprons and welding jackets	114 (57.00%)	86 (43.00%)
(h) Safety boots	91 (45.50%)	109 (54.50%)

From Table 6 the responses obtained on availability of safety or personal protective equipment in industry shows that the maximum score is eight (8) and the minimum score is one (1) with a mean of 5.11. Score from 5-8 were taken as high availability of safety equipment and 4 and below were taken as less availability of safety equipment.

Table 9 compares the responses presented above on the safety issues; on the general knowledge of welders on hazards in industry, the welders proneness to hazards in industry and the availability of safety or personal protective equipment.

Table 9: Distribution of Respondents Knowledge of Hazards, Proneness to Hazards and the Availability of Safety or Personal Protective Equipment

Safety Analysis Response	Knowledge of Welders on Hazards in Industry		Welders Proneness to Hazards in Industry		Availability of Safety or Personal Protective Equipment	
	Frequency	Percent (%)	Frequency	Percent (%)	Frequency	Percent (%)
Less	66	33.00	87	43.50	80	40.00
High	134	67.00	113	56.50	120	60.00
Total	200	100	200	100	200	100

The analysis revealed that 134 (67.00%) of the welders under this study have high knowledge of hazards in industry while 66 (33.00%) have low knowledge of hazards in industry. A total of 113 (56.50%) are highly prone to hazards in industry while 87 (43.50%) are less prone to hazards in industry. On the availability of safety or personal protective equipment in industry or for use by welders, 120 (60.00%) have high availability of safety or personal protective equipment and 80 (40.00%) have less availability of safety or personal protective equipment.

Tables 10 - 13 show the classification of the respondents' knowledge of hazards in industry according to age, education, welding training and number of years of welding after qualification as welder.

Table 10: Classification of Respondents' Knowledge of Hazards in Industry According to Age

Age in Years		Classification of Respondents' Knowledge of Hazards in Industry		Total
		Not Knowledgeable	Knowledgeable	
18-30	Count Percentage %	24 38.10	39 61.90	63 100.00
31-49	Count Percentage %	33 33.00	67 67.00	100 100.00
50-70	Count Percentage %	9 24.32	28 75.68	37 100.00
Total		66 33.00	134 67.00	200 100.00

Table 11: Classification of Respondents' Knowledge of Hazards in Industry According to Educational Level

Educational Level		Classification of Respondents' Knowledge of Hazards in Industry		Total
		Not Knowledgeable	Knowledgeable	
Primary completed	Count Percentage %	28 47.46	31 52.54	59 100.00
Secondary completed	Count Percentage %	9 19.15	38 80.85	47 100.00
Tertiary completed	Count Percentage %	7 28.00	18 72.00	25 100.00
Vocational/tech.	Count Percentage %	19 32.20	40 67.80	59 100.00
No formal educ.	Count Percentage %	3 30.00	7 70.00	10 100.00
Total		66 33.00	134 67.00	200 100.00

Table 12: Classification of Respondents' Knowledge of Hazards in Industry According to Welding Training

Welding Training		Classification of Respondents' Knowledge of Hazards in Industry		Total
		Not Knowledgeable	Knowledgeable	
A. Apprenticeship to master	Count Percentage %	32 32.00	68 68.00	100 100.00
B. Technical institute	Count Percentage %	23 35.94	41 64.06	64 100.00
C. Both A & B	Count Percentage %	11 30.56	25 69.44	36 100.00
Total		66 33.00	134 67.00	200 100.00

Table 13: Classification of Respondents' Knowledge of Hazards in Industry According to Number of Years of Welding after Qualification

Number of Years of Welding after Qualification		Classification of Respondents' Knowledge of Hazards in Industry		Total
		Not Knowledgeable	Knowledgeable	
Less than 1 Year	Count Percent %	1 100.00	0 0.00	1 100.00
1-5	Count Percent %	13 36.11	23 63.89	36 100.00
6-10	Count Percent %	25 37.88	41 62.12	66 100.00
11-15	Count Percent %	8 29.63	19 70.37	27 100.00
16-20	Count Percent %	5 22.73	17 77.27	22 100.00
21-25	Count Percent %	5 33.33	10 66.67	15 100.00
26-30	Count Percent %	8 40.00	12 60.00	20 100.00
Above 30	Count Percent %	1 7.69	12 92.31	13 100.00
Total		66 33.00	134 67.00	200 100.00

Tables 14 - 17 show the classification of the respondents' proneness to hazards in industry according to age, education, welding training and number of years of welding after qualification as welder.

Table 14: Classification of Respondents' Proneness to Hazards in Industry According to Age

Age in Years		Classification of Respondents' Proneness to Hazards in Industry		Total
		Less Prone	Highly Prone	
18-30	Count Percent %	29 46.03	34 53.97	63 100.00
31-49	Count Percent %	43 43.00	57 57.00	100 100.00
50-70	Count Percent %	15 40.54	22 59.46	37 100.00
Total		87 43.50	113 56.50	200 100.00

Table 15: Classification of Respondents' Proneness to Hazards in Industry According to Educational Level

Educational Level		Classification of Respondents' Proneness to Hazards in Industry		Total
		Less Prone	Highly Prone	
Primary completed	Count Percentage %	21 35.59	38 64.41	59 100.00
Secondary completed	Count Percentage %	18 38.30	29 61.70	47 100.00
Tertiary completed	Count Percentage %	15 60.00	10 40.00	25 100.00
Vocational/tech.	Count Percentage %	29 49.15	30 50.85	59 100.00
No formal educ.	Count Percentage %	4 40.00	6 60.00	10 100.00
Total		87 43.50	113 56.50	200 100.00

Table 16: Classification of Respondents' Proneness to Hazards in Industry According to Welding Training

Welding Training		Classification of Respondents' Proneness to Hazards in Industry		Total
		Less Prone	Highly Prone	
A. Apprenticeship to master	Count Percentage %	36 36.00	64 64.00	100 100.00
B. Technical institute	Count Percentage %	30 46.88	34 53.13	64 100.00
C. Both A & B	Count Percentage %	21 58.33	15 41.67	36 100.00
Total		87 43.50	113 56.50	200 100.00

Table 17: Classification of Respondents' Proneness to Hazards in Industry According to Number of Years of Welding after Qualification

Number of Years of Welding after Qualification		Classification of Respondents' Proneness to Hazards in Industry		Total
		Less Prone	Highly Prone	
Less than 1 Year	Count Percent %	1 100.00	0 0.00	1 100.00
1-5	Count Percent %	14 38.89	22 61.11	36 100.00
6-10	Count Percent %	29 43.94	37 56.06	66 100.00
11-15	Count Percent %	15 55.56	12 44.44	27 100.00
16-20	Count Percent %	8 36.36	14 63.64	22 100.00
21-25	Count Percent %	7 46.67	8 53.33	15 100.00
26-30	Count Percent %	9 45.00	11 55.00	20 100.00
Above 30	Count Percent %	4 30.77	9 69.23	13 100.00
Total		87 43.50	113 56.50	200 100.00

Table 18 show the classification of the availability of safety or personal protective equipment in industry according to number of years firm has been practicing welding.

Table 18: Classification of the Availability of Safety or Personal Protective Equipment in Industry According to Number of Years Firm has been Practicing Welding

Number of Years Industry has been Welding		Classification of the Availability of Safety or Personal Protective Equipment		Total
		Less Availability	High Availability	
1-10	Count Percent%	39 59.09	27 40.91	66 100.00
11-20	Count Percent%	19 35.19	35 64.81	54 100.00
21-30	Count Percent%	14 35.00	26 65.00	40 100.00
31-40	Count Percent%	5 27.78	13 72.22	18 100.00
41-50	Count Percent%	2 18.18	9 81.82	11 100.00
Above 50	Count Percent%	1 9.09	10 90.91	11 100.00
Total		80 40.00	120 60.00	200 100.00

4.3.2 Exposure Time to Arc/Flame

The response to the exposure period to arc/flame daily, revealed that 29 (14.50%) of the welders are exposed for less than an hour to arc or flame, 27 (13.50%) for between an hour and two hours and a great proportion of the welders 144 (72.00%) are exposed in the work to arc or flame for above two hours. Figure 1 shows the exposure time to arc/flame daily against percentage count of welders.

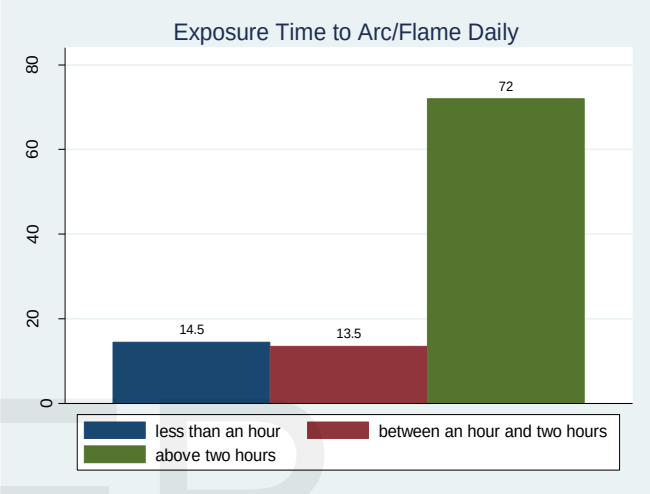

Figure 1: Exposure time to arc/flame daily

4.3.3 Insurance for Welders

Out of the 200 industries surveyed, 63 (31.50%) of the firms responded that they have insurance for their welders. The remaining 137 (68.50%) responded they do not have insurance for the welders. Figure 2 shows the distribution of the responses received.

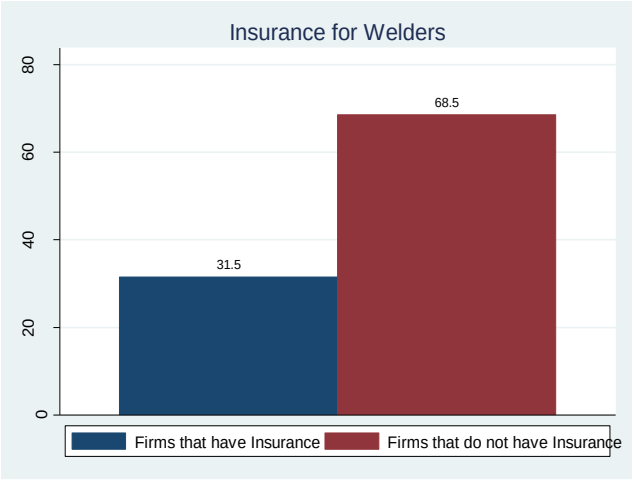

Figure 2: Distribution of Insurance for Welders in Industry

4.4 Hypotheses Testing

The hypotheses raised in this study were tested using chi-square X^2 test statistic because the tables built in this study are an *r* x *c* contingency tables and satisfies the requirements for use of the chi-square X^2 distribution for contingency table tests of hypothesis. This section presents the stated hypotheses, the chi-square results, degree of freedom and the Pearson's Contingency Coefficient (CC) tested at 5% two-tail test level of significance. The X^2 is calculated using

$$X^2 = \sum_{i=1}^{r}\sum_{j=1}^{c}\frac{(O_{ij}-E_{ij})^2}{E_{ij}} \quad \text{where}$$

O_{ij} = observed frequency for the cell at row i and column j

E_{ij} = expected frequency for the cell at row i and column j

The number of degrees of freedom (df) in a two-variable contingency table equals the number of rows *r* minus one (i.e., *r* - 1) times the number of columns *c* minus one (i.e., *c* - 1).

df = (*r* - 1) (*c* - 1).

The Pearson's Contingency Coefficient; a measure of the association for X^2, is calculated as

$$CC = \frac{\sqrt{\frac{X^2}{(N+X^2)}}}{\sqrt{\frac{(L-1)}{L}}} \quad \text{Where,}$$

X^2= value obtained from analysis

N= total number of observations in the *r* x *c* table

L= the smaller of the value of *r* x *c* (Runyon P. et al. [11])

According to Montgomery and Runger [6], the hypothesis is rejected if the observed value (calculated value) of the test statistic exceeds the critical values from the chi-square distribution table. The results of the tests are shown in Table 19.

Table 19: Hypotheses Test Results

Stated Hypotheses	**df**	**X^2 Calculated Value**	**X^2 Critical Value**	**CC-Value**	***Hypothesis* Accepted or Rejected**
1) There is no significant relationship between the age of welders and their level of knowledge of hazards in industry.	2	1.9993	5.9915	0.1407	Accepted
2) There is no significant relationship between the education of welders and their level of knowledge of hazards in industry.	4	9.9963	9.4877	0.3086	Rejected
3) There is no significant relationship between the training the welders go through and their level of knowledge of hazards in industry.	2	0.3922	5.9915	0.0625	Accepted
4) There is no significant relationship between the number of years the welder has been welding after qualification as a welder and their level of knowledge of hazards in industry.	6	6.2398	12.5916	0.2459	Accepted
5) There is no significant relationship between the age of welders and their proneness to hazards in industry.	2	0.3063	5.9915	0.0553	Accepted

Table 19: Hypotheses Test Results continued

Stated Hypotheses	df	X^2 Calculated Value	X^2 Critical Value	CC-Value	*Hypothesis* Accepted or Rejected
6) There is no significant relationship between the education of welders and their proneness to hazards in industry.	4	5.6024	9.4877	0.2335	Accepted
7) There is no significant relationship between the training the welders go through and their proneness to hazards in industry.	2	5.8082	5.9915	0.2376	Accepted
8) There is no significant relationship between the number of years the welder has been welding after qualification as a welder and their proneness to hazards in industry.	6	3.3045	12.5916	0.1803	Accepted
9) There is no significant relationship between the number of years the industry has been welding and the level of availability of safety or personal protective equipment in industry.	5	18.642	11.0705	0.4130	Rejected

5.0 DISCUSSIONS

The results of the study are discussed under two main headings:

- Educational background and welding training programmes of welders in Ghana
- Safety issues in welding.

5.1 Education Background and Welding Training Programmes of Welders in Ghana

5.1.1 Education and Training

The research has revealed that 59 (29.50%) of the welders completed primary school, 47 (23.50%) secondary with most of them dropping at the junior high school or middle school level and 10 (5.00%) with no formal education. Fifty nine 59 (29.50%) completed vocational or technical and 25 (12.50%) completed tertiary with most of them coming from the polytechnics. This indicates that majority of the welders do not go beyond the secondary or high school level.

From Table 2, 100 (50.00%) of the welders acquired their welding trade through apprenticeship, 64 (32.00%) from a technical institute and 36 (18.00) went through apprenticeship and have gone through a few weeks of trade test from the National Vocational Training Institute (NVTI). This is an indication that most of the welders acquire the welding trade through apprenticeship training from experienced welders without attending any formal welding schools.

5.1.2 Certification and Qualification and Rank of Welders in Industry

Welder qualification means "the demonstration of a welder's ability to produce welds meeting prescribed standards (i.e. welding codes and specifications written to provide a minimum set of rules for the construction of weldments that will protect public life and property)". *Welder certification* means "certification in writing that a welder has produced welds meeting prescribed standards (welding codes and specifications)." The research revealed that, although all the welders interviewed from the 200 industries had qualified from one training programme or another i.e. through apprenticeship to a master, formal training from a technical institute or both training programmes, only 112 (56.00%) had certification. The highest among the certificates welders held is advanced certificate in welding with 29 (25.89%) out of the 112 having this advanced certificate. The study also discovered that none

of the welders interviewed had diploma or degree certificates. This confirms the lack of welding programmes leading to award of diploma or degree certificates in the universities and polytechnics in Ghana. Again the very fact that 88 (44%) of the welders had no any kind of certification, significantly indicates that welding standards are not regulated among the welders. Establishing standards (welding codes and specifications) will ensure product uniformity and improve quality.

A total of 68 (34.00%) of the welders were employees in the formal sector industries. Their rank status revealed that 7 (10.29%) are graded welding supervisors, 2 (2.94%) are graded welding instructors, and 51 (75.00%) of the welders being welding technicians (28 (41.18%) are graded welding technician grade one, 13 (19.12%) are graded as welding technician grade two whilst 10 (14.71%) are graded senior welding technician). A total of 8 (11.76%) of the respondents did not respond.

From the classification of welders training programmes according to educational level (Table 3), for welders who went through the apprenticeship trade, out of 100, 51 (51.00%) had primary education, 31 (31.00%) had secondary education, 6 (6.00%) had tertiary (most polytechnic graduates) education, 4 (4.00%) completed vocational/technical institute, and 8 (8.00%) had no formal education. For welders who went through a technical institute training out of 64, 1 (1.56%) had primary education, 5 (7.81%) had secondary education, 18 (28.l3%) had tertiary education, 40 (62.50%) completed vocational/technical institute, and 0 (0.00%) had no formal education. This indicates that, majority of the welders with low educational background who did not go past the secondary school level goes through the apprenticeship training while majority who completed vocational/technical institute acquire their welding training from a technical institute.

The classification of respondents' type of certificate in welding according to educational level (Table 4) shows that for the different levels of education of the welders, majority of those with vocational/technical education hold certificates. For those with intermediate certificate in welding, out of 45, greater percentage 30 (66.67%) have vocational/technical education. For those who hold advance certificate, out of 29, majority i.e. 15 (51.72%) and 12 (41.38%) have tertiary education and vocational/technical education respectively. For those who hold the national vocational training institute (NVTI) Cert. I, out of 11, majority of 6 (54.55%) have vocational/technical education. For those who hold national vocational training institute (NVTI) Cert. II, out of 11, 5 (45.55%) have vocational/technical education. This indicates that welders who have vocational/technical education hold majority of the certificates. Also, welders with tertiary and vocational/technical education have the highest certificates of the advance certificates.

Table 5 of this research shows that for the different levels of education of the welders in Ghana, majority of those with tertiary and vocational/technical education hold majority of the welding positions in industry. For those graded technician grade I, out of 28, majority 17 (60.71%) have vocational/technical education. For those graded technician grade II, out of 13, majority, 8 (61.54%) have vocational/technical education. For those graded as senior welding technicians, out of 10, majority, 7 (70.00%) have tertiary education. For those graded as welding supervisors, out of 7, majority, 4 (57.14) have vocational/technical education. For those graded as welding instructors, out of 2, all 2 (100%) have vocational/technical education. This is an indication that welders with tertiary and vocational/technical education hold majority of the welding positions in industries in the country.

5.2 General Safety of Welders in Industry

The distribution of respondents' knowledge of hazards in industry, proneness to hazards in industry and the availability of safety or personal protective equipment as summarized in Table 9 indicates that, on the knowledge of welders on hazards in industry, 67.00% had high knowledge and 33.00% had low knowledge. On the welders' proneness to hazards in industry, 56.50% are highly prone and 43.50% are less prone. On the availability of safety or personal protective equipment in industry, only 60.00% had high availability and 40.00% had less availability. The figures give a course for concern because most welding processes involve the use of high energy and are inherently dangerous. Having a total knowledge of the hazards in industry and availability of safety or protective equipment will help to a large extend reduce the proneness to hazards in industry to a very low level and hence lowest frequency of accidents.

5.2.1 Knowledge of Welders on Hazards in Industry

Tables 10 - 13, show the classification of the respondents' knowledge of hazards in industry according to age, education, welding training and number of years of welding after qualification as welder.

In the age group (Table 10) 18-30, 39 (61.90%) out of 63 have high knowledge of hazards in industry, in the age group 31-49, 67 (67.00%) out of 100 have high level of knowledge of hazards in industry and in the age group 50-70, 28 (75.68%) out of 37 have high level of knowledge of hazards in industry. Because the data are the frequency of specific categories, the chi-square is used. A chi-square test was used to find out if age had any influence on the level of knowledge of welders on hazards in industry.

In terms of education (Table 11), 31 (52.54%) out of 59 with primary education have high knowledge of hazards in industry, 38 (80.85%) out of 47 with secondary education have high knowledge of hazards in industry, 40 (67.80%) out of 59 with vocational/technical education have high knowledge of hazards in industry, 18 (72.00%) out of 25 with tertiary education have high knowledge of hazards in industry and 7 (70.00%) out of 10 with no formal education have high knowledge of hazards in industry. A chi-square test was used to find out whether education had any influence on level of knowledge of welders on hazards in industry.

In terms of welding training (Table 12), 68 (68.00%) out of 100 who went through the apprenticeship to master training programme have high knowledge of hazards in industry, 41 (64.06%) out of 64 who went through the technical institute training programme have high knowledge of hazards in industry and 25 (69.44%) out of 36 who went through both training programmes have high knowledge of hazards in industry. A chi-square test was used to find out whether the welding training programmes they go through had any influence on the level of knowledge of welders on hazards in industry.

In terms of the number of years of welding after qualification (Table 13), for the year group less than one year, no welder 0 (0.00%) out of 1 has knowledge of hazards in industry. For the year group 1-5, 23 (63.89%) out of 36 have high knowledge of hazards in industry. For the year group 6-10, 41 (62.12%) out of 66 have high knowledge of hazards in industry. For the year group 11-15, 19 (70.37%) out of 27 have high knowledge of hazards in industry. For the year group 16-20, 17 (77.27%) out of 22 have high knowledge of hazards in industry. For the year group 21-25, 10 (66.67%) out of 15 have high knowledge of hazards in industry. For the year group 26-30, 12 (60.00%) out of 20 have high knowledge of hazards in industry and for those who have been welding after qualification for above 30 years, 12 (92.31%) out of 13 have high knowledge of hazards in industry. It appears those who have been welding after qualification for above 30 years are more knowledgeable. However the numbers sampled are not comparable. A chi-square test is used to find out whether the length of period of welding after qualification really has any influence on the level of knowledge of hazards in industry. Those welding for less than 1 year were not included.

The study (Table 9) has revealed that only 67.00% have high level of knowledge of hazards in industry. The percentage of 33.00% having low level of knowledge at 95% confidence interval translates to 26%-40% of the welders surveyed in the various industries having low level of knowledge of the hazards that can arise as a result of the lack of education and observing proper safety measures**.**

5.2.2 Proneness of Welders to Hazards in Industry

Tables 14 - 17, show the classification of the respondents' proneness to hazards in industry according to age, education, welding training and number of years of welding after qualification as welder.

In the age group (Table 14) 18-30, 34 (53.97%) out of 63 are highly prone to hazards in industry, in the age group 31-49, 57 (57.00%) out of 100 are highly prone to hazards in industry and in the age group 50-70, 22 (59.46%) out of 37 are highly prone to hazards in industry. It appears the age group 50-70, are more highly prone to hazards in industry than the other age groups. However such a conclusion cannot be drawn because the sample space is not the same. A chi-square test was used to find out if age had any influence on the prone levels to hazards in industry.

In terms of education (Table 15), 38 (64.41%) out of 59 with primary education are highly prone to hazards in industry, 29 (61.70%) out of 47 with secondary education are highly prone to hazards in industry, 30 (50.85%) out of 59 with vocational/technical education are highly prone to hazards in industry, 10

(40.00%) out of 25 with tertiary education are highly prone to hazards in industry and 6 (60.00%) out of 10 with no formal education are highly prone to hazards in industry. A chi-square test was used to find out whether education of the welders had any influence on their prone levels to hazards in industry.

In terms of welding training gone through (Table 16), 64 (64.00%) out of 100 who went through the apprenticeship to master training programme are highly prone to hazards in industry, 34 (53.13%) out of 64 who went through the technical institute training programme are highly prone to hazards in industry and 15 (41.67%) out of 36 who went through both training programmes; that is, apprenticeship and technical institute training programs are highly prone to hazards in industry. It appears the welders who went through the apprenticeship to master training programme are more highly prone to hazards in industry than the other groups. A chi-square test was used to find out whether the welding training programmes the welders go through had any influence on their prone levels to hazards in industry.

In terms of the number of years of welding after qualification (Table 17), for the year group less than one year, no welder 0 (0.00%) out of 1 are highly prone to hazards in industry. For the year group 1-5, 22 (61.11%) out of 36 are highly prone to hazards in industry. For the year group 6-10, 37 (56.06%) out of 66 are highly prone to hazards in industry. For the year group 11-15, 12 (44.44%) out of 27 are highly prone to hazards in industry. For the year group 16-20, 14 (63.64%) out of 22 are highly prone to hazards in industry. For the year group 21-25, 8 (53.33%) out of 15 are highly prone to hazards in industry. For the year group 26-30, 11 (55.00%) out of 20 are highly prone to hazards in industry and for those who have been welding after qualification for above 30 years, 9 (69.23%) out of 13 are highly prone to hazards in industry. These percentages are obtained under different sample spaces of the year groups and so a clear conclusion cannot be drawn. A chi-square test is used to find out whether the length of period of welding after qualification really has any influence on the welders prone levels to hazards in industry. Those welding for less than 1 year were few (1), hence were not included in the chi-square test.

These demographic classifications can help in planning effective interventions when and where necessary.

The study (Table 9) has revealed that only 43.50% of the total welders surveyed are less prone to hazards in industry. A look at Table 7 shows that, the only areas of the hazards that the welders are very less prone are explosions/flashback 160 (80.00%) and fire outbreak 161 (80.50%). From Table 7, the percentage of highly prone levels of the various hazards studied ranges from 19.50% to 86.00%. At 95% confidence interval these figures translate to ranges of 13.50%-25.50% and 81.00%-91.00%. That is among the welders surveyed, between 13.50% and 91.00% are highly prone in many areas of hazards in industry.

5.2.3 Availability of Safety or Personal Protective Equipment in Industry

Table 18 shows the classification of the availability of safety or personal protective equipment in industry according to number of years industry has been practicing welding.

For industries practicing welding between 1-10 years, 27 (40.91%) out of 66 have high availability of safety or personal protective equipment. For industries practicing welding between 11-20 years, 35 (64.81%) out of 54 have high availability of safety or personal protective equipment. For industries practicing welding between 21-30 years, 26 (65.00%) out of 40 have high availability of safety or personal protective equipment. For industries practicing welding between 31-40 years, 13 (72.22%) out of 18 have high availability of safety or personal protective equipment. For industries practicing welding between 41-50 years, 9 (81.82%) out of 11 have high availability of safety or personal protective equipment. For industries practicing welding above 50 years, 10 (90.91%) out of 11 have high availability of safety or personal protective equipment. Comparing the year groups it appears that as the industries are practicing welding for longer periods, they tend to have high availability of safety or personal protective equipment in terms of percentages. However, such a conclusion cannot be drawn because the numbers sampled are not comparable. A chi-square test is used to find out whether the length of period industry has been practicing welding really has any influence on the availability of safety or personal protective equipment in industry.

The study (Table 9) has revealed that only 60.00% of the industries surveyed have high availability of safety

or personal protective equipment. From the answers to the individual questions in the test of the availability of safety or personal protective equipment (Table 8), the only safety or personal protective equipment that are of very high availability in the industries are welding goggles 188 (94.00%), welding gloves 167 (83.50%) and welding shields 177 (88.50%). For the items that are mostly lacking; about 46.50% of the industries have no fire extinguishers, 53.50% of the industries have no first aid box, 56.00% of the industries have no respirators, only 6.00% of the industries have no welding goggles, 16.50% of the industries have no welding gloves, only 11.50% of the industries have no welding shield, 43.00% of the industries have no welding aprons and jackets, and about 54.50% of the industries and for that matter the welders have no or do not use safety boots.

The above percentages of lack of availability of safety or personal protective equipment are quite high and give course for concern. The percentage lack ranges from 6.00% to 56.00%. At 95% confidence interval these figures translate to ranges of 3.00%-9.00% and 49.00%-63.00%. That is among the industries surveyed between 3.00% and 63.00% lack in many areas of safety protective equipment.

5.2.4 Exposure to Arc/Flame Duration

From section 4.3.2, about 72.00% of the welders surveyed are exposed to arc/flame radiation for at least two hours daily. Although exposure of the body to radiations from the arc/flame as a welder is inevitable, very long periods of exposure without proper precautionary measures could be dangerous to parts of the body. The arc/flame emits ultra-violet and infra-red radiation. Ultra-violet radiation is damaging to both eyes and skin. Exposure of the tissue of the eyeball to ultra-violet radiation will produce a condition known as 'arc-eye'. At the same time, attention must be paid to the effect of ultra-violet radiation on the skin. Small amounts of radiation simply result in a suntan effect, but prolonged exposure causes severe burning, and the welder should wear suitable protective clothing to cover any areas of skin which might be exposed to the arc. Also specific forms of cataract of the eye have been attributed to the effect of regular exposure to infra-red radiation. From this research it has been established that among the industries surveyed between 3.00% and 63.00% lack in many areas of safety protective equipment. This indicates that the welders long periods of exposure to arc/flame has to some extend a causative influence on the percentages of eye problems (60.00%) and skin diseases (50.50%) realized in this study.

5.2.5 Insurance for Welders

From section 4.3.3, 68.50% of the welders do not have any life insurance policy. Since welders are exposed to a lot of risks such as the dangerous high temperatures of molten metals, fire hazards, hazards of electrical shock, hazards of explosions or flashback, etc one would have expected that most of these welders will be insured in case of accidents. Without any insurance policy for these welders, they will be responsible for their own care in case of an accident. A life insurance will give the welders some claim for their care in the event of an accident in the course of their work.

5.3 Test of Hypothesis

From Table 19, the following conclusions regarding the hypotheses tested are:

Hypothesis 1: We accept the null hypothesis that there is no significant relationship between the age of welders and their level of knowledge of hazards in industry.

Hypothesis 2: We reject the null hypothesis and conclude that there is significant relationship between the education of welders and their level of knowledge of hazards in industry.

Hypothesis 3: We accept the null hypothesis that there is no significant relationship between the training the welders go through and their level of knowledge of hazards in industry.

Hypothesis 4: We accept the null hypothesis that there is no significant relationship between the number of years the welders have been welding after qualification as welders and their level of knowledge of hazards in industry.

Hypothesis 5: We accept the null hypothesis that there is no significant relationship between the age of welders and their proneness to hazards in industry.

Hypothesis 6: We accept the null hypothesis that there is no significant relationship between the education of welders and their proneness to hazards in industry.

Hypothesis 7: We accept the null hypothesis that there is no significant relationship between the training the welders go through and their proneness to hazards in industry.

Hypothesis 8: We accept the null hypothesis that there is no significant relationship between the number of

years the welders have been welding after qualification as welders and their proneness to hazards in industry.

Hypothesis 9: We reject the null hypothesis and conclude that there is significant relationship between the number of years the industry has been welding and the level of availability of safety or personal protective equipment in industry.

6.0 CONCLUSIONS

This study has investigated the educational and training background, certification and ranking or grading systems among welders in welding industries in Ghana and has done an impact assessment of educational level, training background, age of welders and number of years of welding after qualification on safety awareness in industry. The study has also investigated the availability of PPE's in industry, exposure to arc/flame duration of the welders and existence of insurance policies in industry. This paper therefore makes the following conclusions:

1. About eighty eight percent (87.50%) of the welders do not go beyond secondary and vocational school education and the majority in this group attains their welding training through apprenticeship.
2. Fifty percent 100 (50.00%) of the welders acquired their welding trade through apprenticeship, 64 (32.00%) from a technical institute and 36 (18.00) went through apprenticeship and have gone through a few weeks of trade test from the National Vocational Training Institute (NVTI).
3. Only 56.00% of the welders have certification and the highest certification is the advanced certificate in welding; most issued by some of the polytechnics. The National Vocational Training Institute (NVTI) also issues NVTI I and NVTI II certificates. None of the welders interviewed had diploma or degree certificates.
4. Welders with tertiary and vocational/technical education hold majority of the welding positions in industries, such as technicians, senior welding technicians, welding supervisors and welding instructors.
5. Sixty-seven percent (67.00%) of the welders have high level of knowledge of hazards in industry and 33.00% have low level of knowledge of hazards in industry.
6. The education of the welders has an influence on their level of knowledge of hazards in industry but the age, training the welders go through and the numbers of years the welders have been welding after qualification as welders does not influence their level of knowledge of hazards in industry.
7. About fifty-seven percent (56.50%) of the welders are highly prone to hazards in industry and 43.50% of the welders are less prone to hazards in industry.
8. The age, education of the welders, training the welders go through and the numbers of years the welders have been welding after qualification as welders, all, does not influence their proneness to hazards in industry.
9. Sixty percent (60.00%) of the industries have high availability of safety or personal protective equipment and 40.00% have less availability of safety or personal protective equipment.
10. The number of years the industry has been welding has an influence on the level of availability of safety or personal protective equipment in industry.
11. Sixty percent (60.00%) of the welders suffer from various eye problems and about fifty-one percent (50.50%) suffer from various skin diseases and these diseases are most likely due to the long period of time they are exposed to radiations daily in their work environment and the unavailability of PPE's.
12. About thirty-two percent (31.50%) of the firms have insurance policies for their welders and 68.50% of the firms do not have any insurance policies for their welders.

7.0 RECOMMENDATIONS

It is recommended that:

1. Stakeholders in the welding industry such as the Government of Ghana Ministry of Trade and Industry, metal manufacturing industries, the universities, polytechnics and technical institutions in Ghana should institute regular training programmes and/or refresher courses for the welders in all aspects of welding and fabrication to improve general industrial welding safety practices such as hazards in welding, importance of having and using safety and per-

sonal protective equipment during welding, etc.

2. The universities, polytechnics, and other technical institutions in Ghana should mount higher and professional courses in welding and fabrication leading to awards higher than the advanced certificate in welding as this study has revealed, such as the award of diploma and degrees in welding.
3. Ghana should establish welding standards for the welding industry.
4. All welding industries in Ghana must institute some form of insurance policies for the industry and the welders due to the hazards and dangers associated with welding activities.

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