Risk Assessment, Hazard Analysis, and Use of Personal Protective Equipment among Small Scale Welders in Industry and City

Pravin Tathod[1] Nisha Kushwaha[2]
[1]PG Scholar [2]Department Head
[1,2]Shiv Kumar Singh Institute of Technology and Science, Indore, India

Abstract— Manufacturing activity because of the very nature of the operation, complexity of the systems, procedures and methods always involves some amount of risk and hazards. Hazard identification and risk analysis is carried for identification of undesirable events that can leads to a hazard, the analysis of hazard mechanism by which this undesirable event could occur and usually the estimation of extent, magnitude and likelihood of harmful effects. It is widely accepted within industry in general that the various techniques of risk assessment contribute greatly toward improvements in the safety of complex operations and equipment. For instance, there is limited information on use of personal protective equipment or work related health problems within this occupational group. Little information is published concerning welders in India, although the number of welders is increasing, especially in small scale enterprises. Thus, the study aimed to gather information about occupational hazards and use of personal protective equipment (PPE) among small scale welders. Acute health effects experienced by the welders were also explored as well as the welders' awareness regarding occupational hazards and use of PPE. This was a cross sectional study of 100 small scale welders conducted after taking the knowledge from base of CASE Construction. A pretested structured interview guide and checklist was used to collect data on demographic characteristics, work experience and occupational hazards, awareness of PPE and hazards, use of PPE and acute health effects experienced. Descriptive statistics were used in the analyses of data, and tests were used for comparing study variables and a generalized linear model with a log link function was used to derive relative risks.

Keywords: CASE Construction, Welding Procedures, Welding Equipments, Safety Measured, Theory, Mathematics. Personal Protective Equipment (PPE) and Test Methods

I. INTRODUCTION

This section provides background information surrounding the research topic as well as the rationale of the study. Inclusive in this section is an overview on the workforce in Madhya Pradesh, India and the position of the small scale welders in this workforce; welding and welding methods; welding related occupational hazards as well as health effects; preventive measures against welding occupational hazards as well as a synopsis of relevant health and safety laws in Case New Holland Construction Equipment (India) Private Limited, Pithampur.

A. Work Force Overview

Workers represent half of the world's population and 70% of this global workforce lives in developing countries [1, 2]. As per 2011 census, the city of Indore has an average literacy rate of 87.38%, higher than the national average of 74%. Male literacy was 91.84%, and female literacy was 82.55% In Indore, 12.72% of the population is under 6 years of age (as per census 2011) [3]. The informal sector comprises mainly of small and medium enterprises (SMEs) which have become central to the poverty reduction strategy and form the fabric on which social and economic stability relies upon [4]. The SMEs are classified based mainly on characteristics such as capital investment, amount of annual revenue or the number of employees. These SMEs are involved in a wide range of manufacturing (i.e. metal fabrication and food processing) trading (i.e. sale of consumer and agricultural goods) or service activities (i.e. education/training and secretarial services). Inclusive in the SMEs category are welders who among many other activities, are involved in maintenance, repair and manufacturing of construction materials (i.e. fences, window frames, door frames, gates etc.), auto-mechanic repairs as well as manufacturing of various artisanal articles. Globally, the welding industry continues to be a critical component of manufacturing [5].

B. Key point for effective management of safety system

Followings are the key points for effective management safety system they are as:

1) Company commitment and policy
2) Organization (the management system and involvement of the line)
3) Planning and application.
4) Measurement of performance and indicators.
5) Auditing and review of performance.
6) Safety improvement tools.[7]

C. Welding

Welding is a process for joining two dissimilar or similar metals by means of heat. In this process heat may be produced either from electric arc, burning of gases, electric resistance or by chemical reaction. Welding activity is a part of fabrication process in manufacturing of any structure.

1) Types of welding

Welding is classified generally into two types they are as follows:

a) Pressure Welding

Welding in which adequate outer force is applied to cause extra or less plastic deformation of both the fronting surfaces, generally without adding of filler metal. Generally, but not essentially, the fronting surfaces are heated in order to permit or to ease bonding.

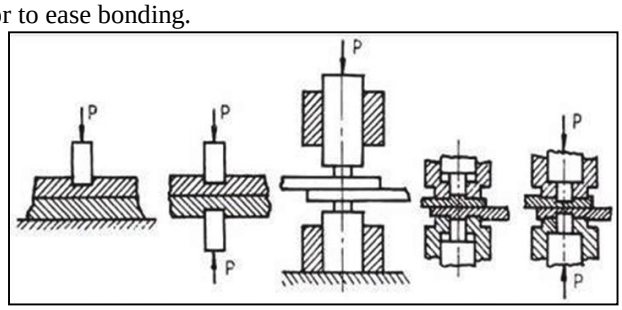

Fig. 1: Pressure Welding [12]

b) Fusion Welding

Welding without submission of outer force in which the facing surface(s) must be melted. Generally, but not essentially, molten filler metal is added.

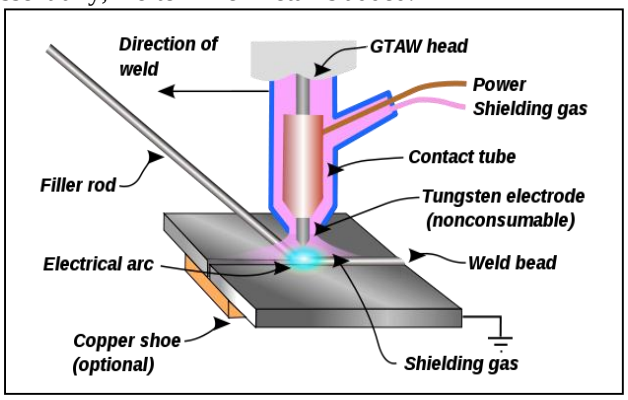

Fig. 2: Fusion Welding [13]

c) Arc Welding

Generally arc is an electric discharge between two electrodes. In this method welding current is lead from the electrode to the work piece through a heated and ionized gas, called plasma. The potential drop and current in the arc give the quantity of electric power that is released out, heat of which melts the electrode and the joint surfaces.

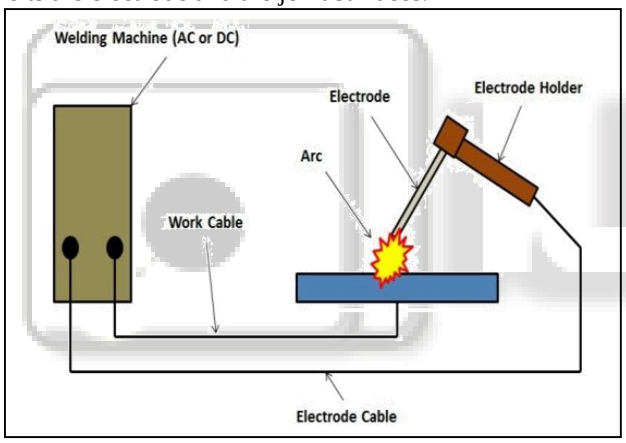

Fig. 3: Arc Welding [14]

d) MIG Welding Process

Metal Inert Gas process was also developed by means of a continuously fed metal wire as the electrode. Primarily, the shielding gases are the inert such as helium and argon, when using a relatively reactive gas such as Carbon dioxide (CO_2) or mixed gases such as argon/CO_2.

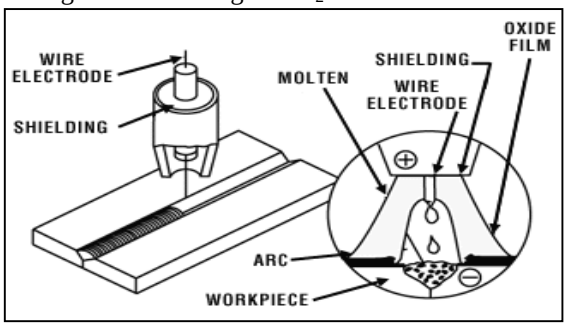

Fig. 4: MIG Welding [15]

e) Tack Welding

Tack welding is a process of joining metal pieces by arranges it in their desired dimensions or position and make a temporary or initial welding operation is performed to make one unit.

Fig. 5: Tack Welding [16]

f) Full Welding

Full welding is the operation of welding in which the component or pieces weld permanently through robot and manually, after the end of tack welding activity.

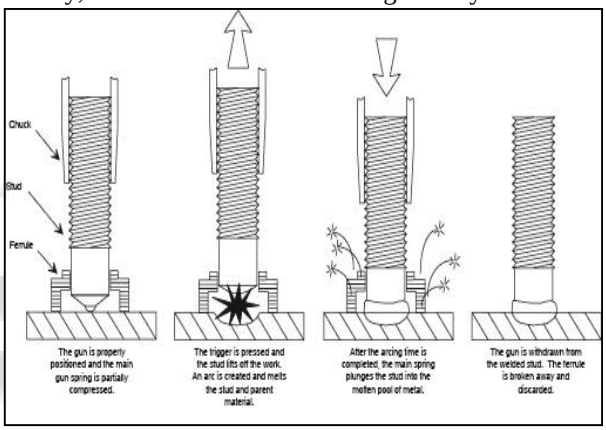

Fig. 6: Full Welding Processes [17]

g) Spot Welding

Spot welding is one of the oldest welding processes. It is used in a wide range of industries but notably for the assembly of sheet steel vehicle bodies. This is a type of resistance welding where the spot welds are made at regular intervals on overlapping sheets of metal. Spot welding is primarily used for joining parts that are normally up to 3 mm in thickness. Thickness of the parts to be welded should be equal or the ratio of thickness should be less than 3:1.

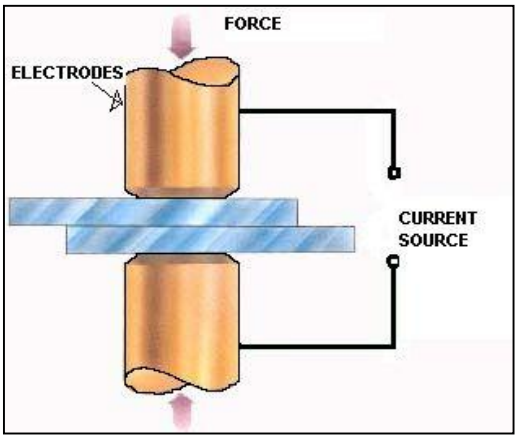

Fig. 7: Spot Welding [18]

h) Butt Welding

Butt welding is a technique used to join two components together (also known as 'jointing'). The idea is to connect parts but not to overlap the ends. Butt welding can be achieved through an automated process, or by hand.

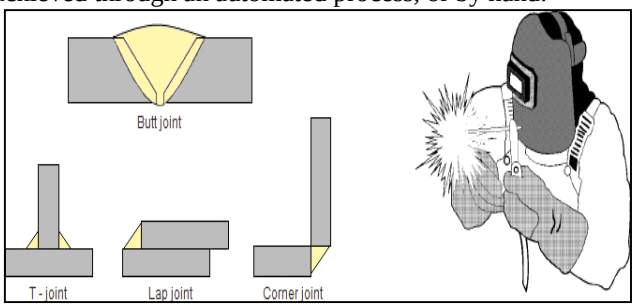

Fig. 8: Butt Welding [19]

i) Projection Welding

Projection welding is a modification of spot welding. In this process, the weld is localized by means of raised sections, or projections, on one or both of the work pieces to be joined. Heat is concentrated at the projections, which permits the welding of heavier sections or the closer spacing of welds.

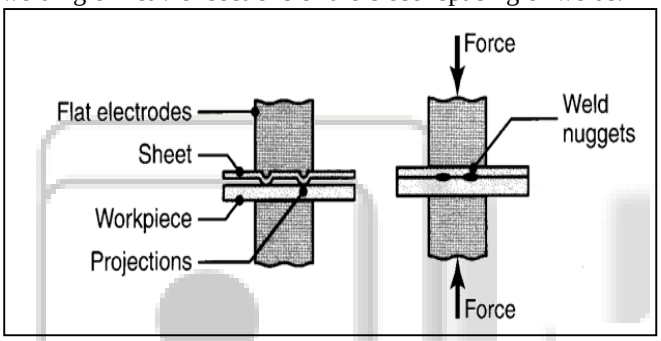

Fig. 9: Projection Welding [20]

j) Flash Welding

Flash welding is a type of resistance welding that does not use any filler metals. The pieces of metal to be welded are set apart at a predetermined distance based on material thickness, material composition, and desired properties of the finished weld.

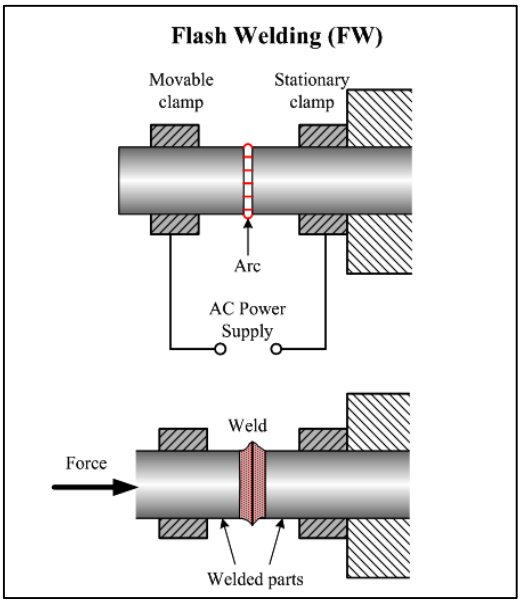

Fig. 10: Flash Welding [21]

k) Ultrasonic Welding

Ultrasonic welding is an industrial technique where by high frequency ultrasonic acoustic vibrations are locally applied to work pieces being held together under pressure to create a solid-state weld. It is commonly used for plastics and metals, and especially for joining dissimilar materials.

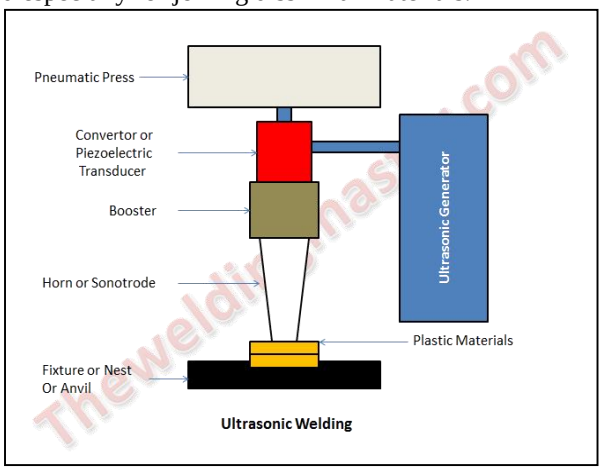

Fig. 11: Ultra Sonic Welding [22]

l) Induction Welding

Induction welding is a form of welding that uses electromagnetic induction to heat the work piece. The welding apparatus contains an induction coil that is energized with a radio-frequency electric current.

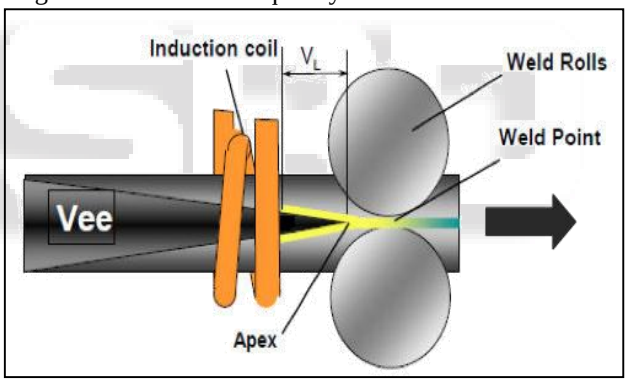

Fig. 12: Induction Welding [23]

m) Gas Welding

Gas welding is a most important type of welding process. It is done by burning of fuel gases with the help of oxygen which forms a concentrated flame of high temperature. This flame directly strikes the weld area and melts the weld surface and filler material.

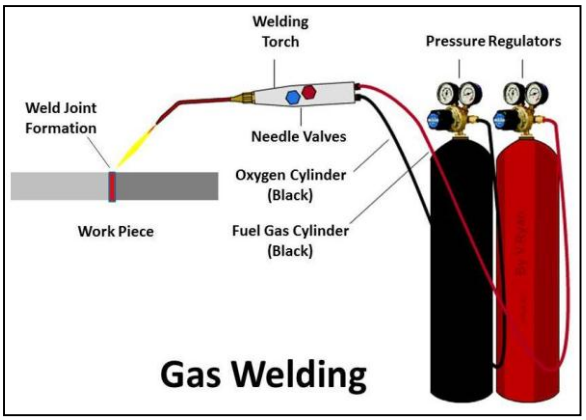

Fig. 13: Gas Welding [24]

n) Laser Welding

The laser beam welding is mainly used for joining components that need to be joined with high welding speeds, thin and small weld seams and low thermal distortion.

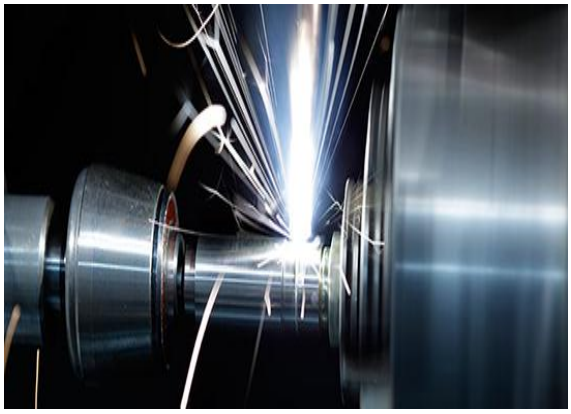

Fig. 14: Laser Welding [25]

The high welding speeds, an excellent automatic operation and the possibility to control the quality online during the process make the laser welding a common joining method in the modern industrial production.

o) Electron Beam Welding

During the electron beam welding process the high velocity of electron beam is impinging on the work piece surface and produce coalescence of metal by heat and part to be weld together.

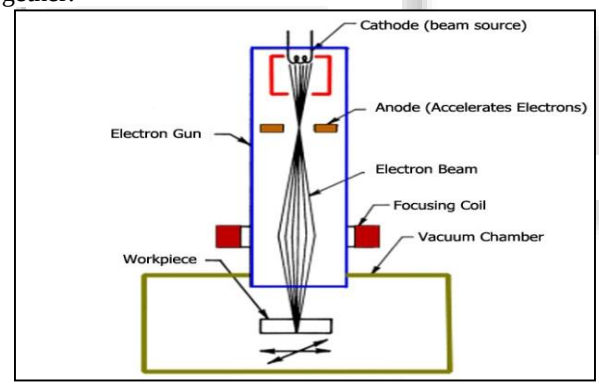

Fig. 15: Electron Beam Welding [26]

D. Hazards in Welding Operation

Following hazards associated with welding on the workplace with operators are as follows-

1) The operations of welding and cutting are carried out at high temperatures which are source of "Fire" or Explosion.
2) Flying metallic sparks and molten metal.
3) Hot surfaces of the work pieces after welding or cutting may cause harms to unsuspicious persons.
4) Glare which comes when the arc is struck.
5) Thermal heat radiation from welding can cause headache, fatigue and eye damage.
6) Infra-red radiation. Some of the IR is stopped by the upper layer of the skin but part of the radiation penetrates the exposed skin and may cause serious skin burns or pigmentation. Since eye has no absorbing layer, it can be severely damaged by this and may cause the problem of cataract.
7) Workers on the shop floors may be exposed to noise due to welding, cutting or chipping operations.
8) Fall of materials and equipment during operation.

E. Safety Requirements during Welding

Followings points are there for the purpose of safe work practice in during welding process, they are as:

1) Use non-flammable curtain to separate walkway from other station in fabrication shop.
2) Use correct safety goggles, face shield or welding helmet.
3) Select correct grade filter glass.
4) Wear adequate protective clothing.
5) Protect your eyes with goggles or helmet with visor when lagging.
6) Make sure that ear thing connection and insulation of welding equipment is satisfactory.
7) Always keep welding torch on a non-conducting or insulated material/ hanger.
8) Do not weld near degreasing operation.
9) Do not weld coated metals or galvanized without taking proper precautions.
10) When it is necessary to weld in a damp or wet area, wear rubber boots or stand on insulation platform.
11) Do not use cables with cracked or bare spots, frayed in the insulation.
12) Provide earth connections as close to welding point as possible and always on the job.
13) Ensure all electrical connections are secure and tight and loose causing arcing.
14) Do not weld in enclosed space without taking adequate precaution.
15) Wear leg guards, apron and ear plugs to protect yourself from spatter.
16) Switch off power while replacing wire spool.
17) Point torch down while feeding wire through it.
18) Hold down wire firmly before cutting bonding wire on the wire spool.
19) Do not use thinner near welding station as well as handling and use of other inflammable materials is strictly prohibited in the vicinity of welding shop.
20) When working above ground level, make sure that the platform, ladder or work surface is rigid and stable.
21) When welding at height, use safety belt or life line.
22) Avoid breathing the air in the fume directly above the arc.
23) Handle all type of compressed gas cylinder with extreme care as when using, open the valve slowly and turn off when not in use and also put the caps when not in use.
24) Always keep the cylinder in upright position.
25) Do not interchange regulators. Use recommended regulator only.
26) Cleaning and removal of combustible materials in the risk zone.
27) Any holes or gaps in the burnable materials used in the building or area must be covered properly or sealed so that weld spatters or flickers, e.g. from gas cutting process, cannot find their way in.
28) Ensuring that adequate extinguishing equipment is available.

II. LITERATURE REVIEW

Yetunde O. Tagurum et.al [27] Welding poses a range of both well-known and subtle hazards to health and safety. These hazards can act quickly or may show up only in the long term. They can be rapidly fatal (electric shock or exposure to cadmium fumes) or have delayed effects (lung changes over time). This study aimed to assess the awareness of occupational hazards and utilization of PPE amongst welders in Jos metropolis.

Mansour A. Balkhyour et.al [28] Small-scale industries account for a large proportion of jobs and play a vital role in most countries' economic growth and prosperity. Due to the very low use of personal protective equipment (PPEs), employees are exposed to numerous physical, chemical, and accidental hazards in small-scale industries. PPEs are very effective in minimizing occupational injuries, accidents, and other hazards which otherwise result in substantial manpower and financial losses.

Vijay Alexander et.al [29] Welders in the unorganized occupational sector in the economically developing world are exposed to respiratory, skin, eye, ear, and neurological problems exacerbated by non-usage of personal protective equipment (PPE).To study the frequency of health problems and the usage of PPE among welders in unorganized welding units in Vellore, India.

Kayode R. Adewoye et.al [30] Welding is associated with workplace hazards that can affect the health of those who engaged in it as they are exposed to harmful dust. This was a health education intervention study carried out among self-employed electric arc welder. Data were collected using an interviewer administered questionnaire and health education intervention was carried out between the pre-intervention and post-intervention stages.

L. M. B.Rongo et.al [31] Workers in informal small-scale industries (SSI) in developing countries involved in welding, spray painting, woodwork and metalwork are exposed to various hazards with consequent risk to health. Researcher focused in group discussions (FGD) were conducted among SSI workers. Participants were assessed for exposure to occupational and environmental hazards, the use of protective equipment and health complaints by interview. The findings were discussed with participants and potential interventions identified. Three hundred and ten workers were interviewed (response rate 98%).There was a high level (>90%) of self-reported exposure to dust, fumes, noise or sunlight in certain occupational groups.

Shyam Sundar Budhathoki et.al [32] the proper use of safety measures by welders is an important way of preventing and/or reducing a variety of health hazards that they are exposed to during welding. There is a lack of knowledge about hazards and personal protective equipments (PPEs) and the use of PPE among the welders in Nepal is limited. We designed a study to assess welders' awareness of hazards and PPE, and the use of PPE among the welders of eastern Nepal.

Ijaz Ahmad et.al [33] Small business industries account for a large proportion of our jobs and play a very vital role in most countries' economic growth and prosperity. However, the employees are routinely and regularly exposed to numerous physical, chemical and accidental hazards and the use of personal protective equipment (PPEs) is very low. PPEs are very effective in minimizing occupational injuries, accidents and other hazards which otherwise result in substantial human sufferings and financial losses.

Queen M. Umoren et.al [34] welding work serves as a means of livelihood for many Nigerians and welders are exposed to a variety of occupational hazards. In Nigeria, high rate of welding injuries has been reported to be due to low or non-use of PPE and this has been attributed to poor knowledge. Several studies have recommended education as a means of educating welders. The aim of the study is to determine the effect of health education intervention on PPE use among oxyacetylene welders.

Dhiraj Kumar Barpete et.al [35] Industrial accidents and disease remain the most terrible human tragedy of modern industry and one of its most serious forms of economic waste. Not only direct but also indirect costs of accidents are tremendously increasing and causing the great national loss. This can be prevented by safety only. As productivity of any organization is interrelated with safety, means increasing and maintaining safety gives good productivity.

Marta Regina Cezar-Vaz et.al [37] This study's aim was to assess the perceptions of welding apprentices concerning welding fumes being associated with respiratory and cardiovascular disorders and assess the implementation of risk communication as a primary prevention tool in the welding training process. This quasi-experimental, non-randomized study with before-and-after design was conducted with 84 welding apprentices in Southern Brazil. Poisson Regression analysis was used. Relative Risk was the measure used with a 95% confidence interval and 5% ($p \leq 0.05$) significance level.

III. METHODOLOGY AND MATERIALS

The study was conducted in Indore and it is the most populous and the largest city in the Indian state of Madhya Pradesh. It serves as the headquarters of both Indore District and Indore Division. It is also considered as an education hub of the state and first city to have campuses of both the Indian Institute of Technology and the Indian Institute of Management. Located on the southern edge of Malwa Plateau, at an average altitude of 550 meters (1,800 ft) above sea level, it has the highest elevation among major cities of Central India. The city is 190 km (120 mi) west of the state capital of Bhopal. Indore had a census-estimated 2011 population of 1,994,397 (municipal corporation) and 2,170,295 (urban agglomeration).

The city is distributed over a land area of just 530 square kilometers (200 sq mi), making Indore the most densely populated major city in the central province. It comes under Tier 2 cities in India. In addition to being the capital city, Indore is also one of the largest cities in Madhya Pradesh, India and a major commerce hub of the country. The economic activity in the city is one of the major attracting factors for the small scale welders who are widely distributed geographically and strategically located around the city, operating on road sides and in markets of Indore city, Pithampur, and Rau in the city. Therefore, it was expected

that these areas would provide the required population of welders sought for in the study.

A. Sample Size Calculation

Going by the sample size calculation for surveys with the confidence interval set at 95% and 5% margin of error, the following sample size was derived:

$$n = \frac{Z^2 P (1-P)}{e^2} \quad (1)$$

$$n = \frac{(0.95)^2 \times 0.5 (1-0.5)}{(0.05)^2} = 90 \quad (2)$$

Where,

P = (expected proportion of welders experiencing acute health effects as a result of work related exposures) = 50% (0.5)

e = desired margin of error of 5% (0.05)

Z = Z score at 95% confidence interval = 0.95 including 10% non-response gave a sample size of 100

Note: Researchers in Pithampur (Indore) - a similar setting as the present study - established a proportion of 37.7% for the least common acute health effects among welders due to cuts/injuries by sharp metal edges [9]. Considering that this proportion lies between 10% and 90% extremes, a proportion of 0.5 was used to get the maximum sample [10].

In order to ensure justice in the study, all welders in the selected areas were invited to participate in the study. Participants were guaranteed the autonomy to take part in the study and all data collected was kept confidential. No information concerning individuals would ever be available for anyone but the researchers. However, the participants were informed that summarized and anonymous results of the study would be shared with relevant stakeholders - at group level only - to ensure maximum benefit to the study participants.

IV. CALCULATION AND RESULTS

In total, 18 locations in which welders operated were visited during data collection (Table 1). The largest number of welders was located in the base CASE construction from where the first phase of my work starts my training, which is also one of the oldest known locations for welding work. Areas occupied by welders were situated in markets, roadsides and residential areas. Welders operated mostly on roadsides small shops, the welding stands/shops for those in markets were also commonly located on the roadsides of the markets.

S. No	Location	(n)	(%)
1.	CASE Construction Pithampur	15	15 %
2.	Kwality Machinery	09	9 %
3.	Imperial Auto Industries	08	8 %
4.	National Welding Workshop	06	6 %
5.	Ador Welding	06	6 %
6.	D&H India Limited	06	6 %
7.	Kach Motors	05	5 %
8.	Belmark Metal India	05	5 %
9.	SK Fabrication	05	5 %
10.	Indian Steel	05	5 %
11.	Jain Engineering Works	05	5 %
12.	RG Steel Craft	05	5 %
13.	Star Electricals	05	5 %
14.	Suraj Welding	05	5 %
15.	Vishal Steel	05	5 %
16.	Raja Bhoj Private limited	02	2 %
17.	Bharat Machinery and Services	02	2 %
18.	Saturn Pre-tab India	01	1 %
TOTAL		100	100 %

Table 1: Welding Locations and the Respective Number of Welders

Welders characteristics	(n)	(%)
SEX		
Male	100	100 %
AGE		
< 28 years	31	31 %
28 to 36 years	36	36 %
>36 years	33	33 %
Mean (SD)	33(10)	
MARITAL STATUS		
Single	28	28 %
Married	69	69 %
Divorced	2	02 %
LEVEL OF EDUCATION		
None	4	04 %
Primary and basic	52	52 %
Secondary and higher	43	43 %
SMOKING		
Currently smoking	16	16 %
Quit Smoking	26	26 %

Table 2: Demographic Characteristics of Welders (n = 100)

A total of 100 male welders were interviewed shown the distribution in Table 6.2. The age of welders ranged from 16 to 74 years with an average age of 33 years (Standard Deviation = 10 years). The majority of the welders were married (n = 69, 69%, Table 6.2) and had received at least primary school education (n = 52, 52%, Table 6.2). Overall, 16% reported that they presently smoked at the time of data collection (Table 2).

Welders' characteristics	(n)	(%)
TYPES OF TRAINING		
Apprenticeship	86	86 %
Technical	14	14 %
WORK EXPERIENCE		
< 4 years	34	34 %
4 to 10 years	34	34 %
> 10 years	32	32 %
Mean (SD)	9(8)	
LENGTH OF WORK DAY		
8 hours	10	10 %
> 8 hours	90	90 %
Time spent welding		
≤ 7 hours	50	50 %
> 7 hours	50	50 %
Welding method used		
Manual Metal Arc Welding	88	88 %
Gas Welding	6	6 %
Both	6	6 %

Table 3: Work Related Descriptive Characteristics of Welders (n = 100)

Acute health symptoms/effects	PPE Use at Work [n (%)]				
		No	Yes	RR	95% CI
Eye symptoms	Eye PPE				
	Yes	61 (88 %)	27 (87 %)	0.99	0.92 – 1.07
	Total	69	31		
Cuts and burns on hands	Hand PPE				
	Yes	54 (92 %)	36 (89 %)	0.97	0.91 – 1.04
	Total	59	41		
Cuts and burns on body	Body PPE				
	Yes	5.2 (16 %)	21 (32 %)	1.99	1.32 – 3.00
	Total	33	67		
Cuts and burns on feet	Feet PPE				
	Yes	15 (35 %)	13 (23 %)	0.65	0.48 – 0.88
	Total	42	57		
Respiratory symptoms	Respiratory PPE				
	Yes	47 (62 %)	12 (74 %)	1.18	1.00 – 1.38
	Total	76	16		
Nasal symptoms	Yes	47 (77 %)	12 (85 %)	1.12	1.00 – 1.26
	Total	76	16		

Table 4: Relationship between Acute Health Effects and Use of Personal Protective Equipment (PPE)

V. CONCLUSION

Welders in this study worked under poor and dangerous conditions that exposed them to several safety and health hazards. Although most welders were aware of occupational hazards and related PPE for their work, this awareness did not translate into use of PPE as the majority reported to have never used the recommended PPE while none of the welders reported to use all the required PPE at any given time.

Welders reported to have experienced various acute health effects, the most frequent being eye, nasal, respiratory and metal fume fever related symptoms in addition to cuts and burns on the hands/arms. Their use of protective measures did not seem to offer the level of protection required against the hazards they are exposed to. Education was positively associated with awareness of both welding hazards and PPE as well as with the use of PPE. Also, the proportion of welders using PPE increased with an increase in age and welding experience.

1) To the welders who already have the correct type of PPE, we recommend that they use this PPE at all times when they are exposed to welding hazards in order to avoid experiencing acute health effects.
2) We recommend that welders create a welders' association or workers union for welders in Indore in general that would provide a platform for communication of information between the welders and relevant stake holders such as the Labor Office, local authorities and funding agencies.
3) Better organization of the small scale welders through the associations can enable welders increase their chances of accessing health education information regarding welding hazards and PPE as well as information on safe work practices.

REFERENCES

[1] World Health Organization. International consultation on workers' health coverage. 2014 [cited 2015 20 Feb]; Available from: http://www.who.int/mediacentre/events/meetings/2014/workers-health/en/.
[2] World Health Organization, Declaration on occupational health for all. 1994.
[3] Workers and Participation rates 2011 Labor Force Survey. 2012: Madhya Pradesh, India.
[4] National Center for Welding Education and Training (Welded), State of the Welding Industry: Executive Summary, Visdos R.J., Editor. 2010.
[5] TEVETA. Training institutions: Metal fabrication. 2015 [cited 2015 25 Feb]; Available from: http://www.teveta.org.zm/index.php/institutions/lusaka-provi.
[6] Welding Safety Manuals: CASE
[7] Safety Management system manual-Case: 2018
[8] Occupational Health and Safety Management System 18001:2007
[9] Hazards Analysis & Evaluation in Steel Processing Plant, Jatin Singh, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-018, Vol. 3 Issue 5, May – 2014
[10] Research on the Application of Artificial Neural Network to the Flood Risk Assessment, Qiong Li and Donghan Liu, International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 3 Issue 1, January – 2014.
[11] Fundamentals of Industrial Safety & Health- K.U. Mistry: 2018
[12] Shirjit G, Technique of cold pressure welding (with diagram), SCRIB: 2018
[13] Technoman, Hub pages, manufacturing processes - different fusion welding processes: 2011
[14] The Welding master, Learn Everything about Welding, What is arc Welding: 2011
[15] MIG Welding, Advantage Fabricated Metals a division of Corrugated Metals, Inc: 2018
[16] Elia Levi, How to perform Tack welding successfully, The Fabricator. Com: 2019
[17] Drawn Arc Stud Welding, Image Industry inc. in: 2018
[18] Spot Welding, Vista Industrial Products: 2012
[19] Butt Welding, Welding Guide, Explore the world of pining: 2018
[20] Welding technology, welding projection welding projection welding machine resistance projection welding (RPW), Encyclopedia of Engineering: 2017

[21] Dr. Dmitri Kopeliovich, Resistance Welding, Metal joining technologies (welding, brazing, soldering): 2015
[22] Ultrasonic Welding Process – Working Principle, Parts, Advantages and Disadvantages with Application, the Welding Master: 2017
[23] O. E. GUngor, P. Yan, P. Thibaux, M. Liebeherr, H. K. D. H. Bhadeshia and D. Quidort, Investigations into the microstructure-toughness relation in high-frequency induction-welded pipes, Proceedings of the 8th International Pipeline Conference, IPC 2010
[24] Admin, Gas welding: Principle, Working, Equipment, application, advantages and disadvantages, Mechanical for Study: 2017
[25] Laser Welding, Deutsch, Coherent, Roefin: 2015
[26] Electron beam welding process, Manufacturing Technology, Mechanical. Techminy. Com: 2014
[27] Yetunde O. Tagurum1, Martin D. Gwomson, Pankyes M. Yakubu, James A. Igbita, Moses P. Chingle, Oluwabunmi O. Chirdan, Awareness of occupational hazards and utilization of PPE amongst welders in Jos metropolis, Nigeria, International Journal of Research in Medical Sciences, Issue 07: 2018
[28] Mansour A. Balkhyour , Ijaz Ahmad, Mohammad Rehan, Assessment of personal protective equipment use and occupational exposures in small industries in Jeddah: Health implications for workers, Saudi Journal of Biological Sciences: 2018
[29] Vijay Alexander,Kulandaipalayam Natarajan C Sindhu,Pradeep Zechariah,Abigail Veravolu Resu,Suryanarayan Rajendran Nair,Deepthi Kattula,Venkata Raghava Mohan &Reginald George Alex T, Occupational safety measures and morbidity among welders in Vellore, Southern India, International Journal of Occupational and Environmental Health, Volume 02, Issue 04: 2016
[30] Kayode R. Adewoye, Oladele A. Atoyebi, Ademola O. Awoyemi, Oluwole A. Babatunde, Funsho Y. Issa, Sarafadeen K. Salami, Effect of health education intervention on the awareness and use of personal protective equipments among small scale electric arc welders in Ilorin, Nigeria, Indian Journal of Occupational and Environmental Medicine, Volume 18, Issue 01: 2014
[31] L. M. B.Rongo, F.Barten, G.I. Msamanga, D.Heederik, W.M.V.Dolmans, Occupational exposure and health problems in small-scale industry workers in Dares Salaam, Tanzania: a situation analysis, Occupational Medicine: 2004
[32] Shyam Sundar Budhathoki, Suman Bahadur Singh, Reshu Agrawal Sagtani, Surya Raj Niraula, Paras Kumar Pokharel, Awareness of occupational hazards and use of safety measures among welders: A cross-sectional study from eastern Nepal, BMJ Open: 2014
[33] Ijaz Ahmad1, Mansour A. Balkhyour, Tarek M. Abokhashabah, Iqbal M. Ismail, Mohammad Rehan, Assessment of Personal Protective Equipment use and Occupational Exposures in Small Industry in Jeddah: Health Implications for Workers, Saudi Journal of Biological Sciences: 2018
[34] Queen M. Umoren, Uwemedimbuk S. Ekanem, Ofonime E. Johnson, Motilewa O. Olugbemi, An assessment of the effect of health education on the use of personal protective equipment among small scale welders (panel beaters) in Akwa Ibom state, Nigeria, International Journal of Community Medicine and Public Health, Volume 11: 2016
[35] Dhiraj Kumar Barpete, Vivek Shukla, Dr. G.D Gidwani, Job Safety Analysis (JSA) with Risk Assessment in Welding of TLB Dipper by Tack Welding, International Journal of Science Technology & Engineering, Volume 03, Issue 08: 2017

