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Occupational Exposure and Health Problems of Workers in Unauthorised Small-Scale Welding Industries in Delhi: A Situational Analysis

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***Abstract*—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. These occupational hazards faced by workers can result in temporary or permanent physical injury, short- or long-term adverse health effects, discomfort and even death. The objectives of our study were to assess occupational exposures and perceived health risks of workers in unauthorized small-scale industries (SSI) in the informal sector and to identify possible interventions. The study was carried out at different locations in Delhi. Focused group discussions 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. The results were compared with that of a control group of the same age group, same locality, and the same socioeconomic class. Also, analysis and monitoring of suspended particulate matter (SPM) using personal air sampler in the workplace was done. We observed that the workers had high levels of exposure to multiple health hazards.**

Keywords*— *Welding, small scale industry, occupational hazard, health assessment, particulate matter, fume concentration.

I. INTRODUCTION

The population of Delhi has increased from 13.8 million in 2001 to 16.9 million in 2008 and 22 million in 2011[1]. Due to such rapid urbanisation, many people seek work in the informal sector, defined by The International Labour Conference of 1995 as: 'small-scale units producing and distributing goods and services, and consisting largely of independent, self-employed producers' [2]. As per the 1998 economic census, there are 129,363 small unauthorised industrial units in Delhi employing 1,440,000 workers [3]. Such small-scale industries play a vital role to improve economy and also cater the needs of people of local area and industrial activities [4]. They contribute considerably to employment as well as to the gross national product [5].

Many informal sector workers are urban poor, include women and children, lack access to medical care and are not covered by employment legislation [6, 7]. India is a population intensive country; labour available is cheap and illiterate, proper occupational hygiene practices are generally ignored at workplaces. Personal protective equipment (PPE) for workers are treated as luxuries rather than necessities and not sufficiently provided. Hence workers of these units are very much exposed to excessive amount of physical and chemical pollutants [8]. Such countries are far behind in implementing occupational hygiene and pollution control measures at work sites. Occupational health and safety have not been at the top of small and medium scale manufacturing industry agenda.

The technology of welding is extremely labour-intensive, labour accounting for 80-90% of production costs for all but the most modern automatic processes [9]. It is a hazardous activity that poses a unique combination of both safety and health risks to workers in a wide variety of industries [10]. The first impression of welding processes with exposure to blinding white flame and high temperatures is suggestive of risk [11]. According to the Occupational Safety and Health Administration (OSHA), the risk from fatal injuries alone is more than four deaths per thousand workers over a working lifetime [10]. One hazard of welding, which is less readily noticeable, but has both acute and more long-term chronic effects is welding fume [12]. Despite advances in control technology, welders continue to be exposed to high temperatures, welding fume and gases [13]. Other hazards from welding operations include burns, eye damage, electrical shock, cuts, and crushed toes and fingers. Many of these can be controlled with proper work practices and personal protective equipment (PPE) [14].

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II. MATERIALS AND METHOD

The locations that have been carried under this project are parts of South Delhi, Faridabad, Shahbad Dairy ,Badli, Sheik Sarai, Gautam Nagar, Yusuf Sarai, Naraina, Karol Bagh, Okhla Phase-I,II and III. There were 10 welding shops that were surveyed, and all of them come under small scale and medium scale industries. On an average the working hours of the welders were 8 to 9 hours and the number of workers working in the welding shop was 5 to 8. The methodology was divided into two phases: Surveying and Sampling.

A. Surveying:

Working conditions of the welders who were working in the welding shops were studied. This study was done with the help of a questionnaire prepared for the workers keeping in mind the factors which will affect the health of the workers. This questionnaire was based on daily habits of the welders which plays a very important role in the health of the workers. Also similar questionnaire was used for control group (persons in similar economic condition with similar type of work environment). After this, the control study was used to calculate Relative Risk, Population Attributable Risk (PAR) and Odds Ratio (OR) among workers.

B. Sampling:

The sampling was done with the help of the PERSONAL AIR SAMPLER (Envirotech Model of APM 800). The sampling was done in between the time period of 09.00 am to 06.00 pm and the sampler was kept on for 4 hours. The sampler was placed in Breathing Zone, that is the height at which worker breathes. Glass microfiber filters Whattman GF/A type (2.5cm) were used and Gravimetric method of sampling was done. The total suspended particulate matter (TSP) is calculated using the equation:

$TSP\ (mg/m^3) = 1000\ M/\ R\ A$

Where M = difference in weight of filter paper in mg,

R = measured sampling rate in litres/min,

A = time in min for which the sample were collected at rate R. The rate was maintained at 1.6 lit/min.

C. Estimating Population Attributable Risk:

Attributable burdens are assessed on the basis of population. Attributable risk (PAR) is defined as the proportion of disease thought to be attributable to the exposure of interest. This has been calculated as follows:

$$PAR\ (\%) = \frac{[Risk\ (total) - Risk\ (unexpected)] \times 100}{Risk\ (total)}$$

	Cases	Controls	Total	Risk
Exposed	a	b	a+b	r1=a/(a+c)
Unexposed	c	d	c+d	r2=b/(b+d)
	a+c	b+d	a+b+c+d	r3=a+b/(a+b+c+d)

So, PAR = $r_3 - r_2$: PAR% = $(r_3-r_2)/r_3 *100$

D. Estimating Odds Ratio:

Odds ratio (OR) is the estimate of the relative risk (i.e. the underlying incidence rate ratio) that resulted in the increased number of cases among the exposed.

OR = Odds cases exposed / Odds Controls exposed

	Cases	Controls
Exposed	a	b
Unexposed	c	d

So, OR = ad/bc

III. RESULT

One hundred and sixty three workers participated out of 170 available (response rate 96%). 122 were welders, 41 were non-welder workers. The mean age was 27.9 years (range 13–66). Among the 163 workers, 65 were non-smokers. Fifteen per cent had <7 years of education, while 85% had 7 years or more. Nearly 70% of the workers had worked in the welding shop for <10 years; the maximum was 40 years. Table 1 reveals that 56 out of 122 are suffering from eye problems. Also 112 out of 122 (91.8%) workers had precaution for eyes, namely goggles or hand held shield. Table 2 shows cumulative percentages of different exposures and duration of exposure among 122 male workers in 10 different welding shops of Delhi. Table 5 shows the total fume concentration or TSP in all the 10 workshops. Table 7 and Table 6 calculate the PAR% & Odds Ratio; and Risk among the 65 non-smoker workers, 48 being welders and 17 non-welders. The results from our study were discussed with participants. The focus was on 'healthy workplaces', 'raising awareness among SSI workers and policy makers', 'prevention' and 'further research.'[15] Participants expressed the need of healthy workplaces. They also emphasized the need to raise awareness among other workers and residents. The need for health information on work related exposures, accidents, respiratory symptoms and availability of effective protective devices was expressed. Also, the necessity to provide treatment for affected persons, screening of workers, tetanus vaccination and first aid boxes and to make protective equipment available was emphasized.

Results of workshops:

TABLE 1

Total no. of workers: 122 [Welders]

	Percentage of workers suffering from health hazards		
	Type of hazard	*Disease Frequency*	*Percentage*
1	Eye problem	56	45.9
2	Skin problem	73	59.8
3	Respiratory problem	67	54.9
4	Headache	80	65.5
5	Heart problem	14	11.4

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TABLE 2

Total no. of workers: 41 [Non Welders]

	Percentage of workers suffering from health hazards		
	Type of hazard	*Disease Frequency*	*Percentage*
1	Eye problem	11	26.8
2	Skin problem	05	12.1
3	Respiratory problem	13	31.7
4	Headache	16	39.0
5	Heart problem	02	04.8

TABLE 3

Working Years	Percentages of exposures and duration of exposure among 122 male workers in welding shops				
	Eye problem	*Skin problem*	*Respiratory problem*	*Head-ache*	*Heart problem*
00-05	27.27	50.00	31.81	45.45	00.00
05-10	41.86	55.81	44.18	60.46	02.32
10-15	44.82	51.72	51.72	58.62	10.34
15-20	57.89	73.68	89.47	94.73	26.31
20-25	88.8	100.00	100.00	100.00	55.55

TABLE 4

	Equation Coefficient for different hazards		
	Type of hazard	*Regression Equation (y)*	*Coefficient of correlation*
1	Eye problem	1.3925x-3.556	0.947
2	Skin problem	1.1787x-3.556	0.883
3	Respiratory problem	1.4337x+14.504	0.941
4	Headache	1.8167x-9.232	0.967
5	Heart problem	1.3509x-35.132	0.931

TABLE 5

Shop No.	TSP and incidence of respiratory diseases among welders in welding shops			
	Fume Concentration in mg/m^3 (x)	*Total no. of workers*	*Affected workers*	*Percentage (Y)*
1	7.812	5	2	40.00
2	5.208	4	1	25.00
3	7.812	4	2	50.00
4	10.416	5	4	80.00
5	5.208	5	2	40.00
6	7.812	3	2	66.60
7	10.414	4	3	75.00
8	2.604	3	-	-
9	5.208	5	1	20.00
10	7.812	6	3	50.00

TABLE 6

	Risk among non-smoker male workers in welding shops				
	Eye problem	*Skin problem*	*Respiratory problem*	*Head-ache*	*Heart problem*
Welders (r1)	0.437	0.500	0.583	0.541	0.104
Non-Welders (r2)	0.235	0.294	0.117	0.352	0.058
r3	0.384	0.446	0.461	0.492	0.092

TABLE 7

	PAR% and Odds Ratio among non-smoker male workers in welding shops				
	Eye problem	*Skin problem*	*Respiratory problem*	*Head-ache*	*Heart problem*
Odds Ratio	2.5	2.4	10.5	2.16	1.86
PAR= (r3-r2)	0.149	0.152	0.343	0.139	0.033
PAR%	38.82	34.07	74.5	28.3	36.27

IV. DISCUSSION

The study identified the prevalence and correlates occupational health hazards in unauthorized small-scale units. We found that workers in SSI were exposed to a variety of work-related hazards, though most of them were using protective equipment. Workers and employers were both unaware of occupational and environmental health hazards. Workers in SSI perceive themselves to be exposed to many occupational and environmental health hazards.

In China, Zhi and colleagues reported that 83% of the SSI surveyed in county towns had at least one type of occupational hazard [16]. A follow-up study in small mechanical enterprises in Norway showed that use of personal protection devices reduced accidents at work [17]. Sultan & Thamir stated that welding workers are more prone to impaired pulmonary function, chronic bronchitis, interstitial lung disease, asthma, lung cancer, eye burns, short- and long-term injury to the skin, non-melanocytic skin cancer [18]. A similar case study said that because of frequent inhalation exposures to high concentrations of fumes and gases during welding, interest in potential health problems has centred on respiratory effects, particularly lung cancer, which could be caused by effect of metals in stainless steel welding fumes [19]. The type and amount of welding fumes and respiratory symptoms depend on duration of welding, welding method, welding material, ventilation facilities and respiratory protection [20]. Akbarkhanzadeh reported that fifty-one per cent of the welders had one or more of the respiratory symptoms, while only 26% of the controls had any of the symptoms [21].

The results of our study revealed that the welding workers are more severely affected by eye diseases, respiratory diseases & skin diseases than the persons not working in welding shop. Percentages of welders with eye diseases, regular headache, cardiovascular diseases & respiratory diseases have good correlation with no. of years of welding. No good relation is found between the percentages of

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welders with skin diseases & burns and no. of years welding. Odds ratio for all diseases are greater than 2 for welders which shows that welding shop workers are twice as much susceptible to skin, respiratory and heart diseases as compared to non-welders. The odds ratio is highest for skin diseases & burns (>10) which shows that welding shop welders are at least 10 times susceptible to skin diseases & burns as compared to non-welders. The PAR% is highest in case of skin diseases & burns which indicates that proper preventive measures are not available. Suitable provisions must be provided such as welding jackets & gloves to control this hazard. About 72% (89 welders) were not clear about all the health hazards of welding. They were reluctant to accept that prolonged exposure to welding fumes could be fatal. Only a small proportion of welders (25.4%) had all the required personal protection equipment like welding helmet, safety glasses , apron, welding gloves, high boots, hand held shield ,etc. Also, welding should be performed in well-ventilated areas and use local-exhaust ventilation to remove fumes and gases at their source in still air. Furthermore, the average suspended particulate matter concentration is 7.03 mg/m3, which is more than TLV given by EHIS, U.K (5mg/m3) [22]. Thus safety measures (use of eye shield, gas mask, gloves etc.) should be strictly followed to create safe & hygienic conditions at workplace. In about 90% shops surveyed the suspended particulate matter concentration is more than TLV limit & the percentage of affected workers is directly related to magnitude of SPM concentration [23].

Hence, to identify the susceptible workers in due time and to improve the work efficiency, preventive measures are needed to reduce the risk of welding fumes in industrial workers. However, a study on small group of workers makes it very difficult to conclude the occurrence of diseases due to inhaling of the pollutants coming out of the welding process. Hence a larger group can be taken into consideration to conclude the same.

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