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A STUDY ON INFLUENCE OF INDIVIDUAL FACTORS, PRECARIOUS EMPLOYMENT IN WORK INJURY EXPOSURES AMONG WELDERS EMPLOYED IN ORGANIZED SECTOR FABRICATION UNITS

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ABSTRACT

The present study analyses relations between high frequency low severity work injuries Individual factors : age, experience, physical work load Precarious employment: working hours, physical work load, mode of employment, mode of acquired trade knowledge.. High frequency low severity work injury exposures is measured through self reported responses, by means of questionnaire survey. The sample contains 1075 welders employed in engineering fabrication cluster. The data was subjected to (i) ANOVA to find significant variance between high frequency low severity work injury exposure, and individual factors (ii) Independent't' test is performed to compare significance between high frequency low severity work injury exposures, precarious employment for significant safety interventions. The results shows significant results for individual factors – age, physical work load, precarious employment – working hours, mode of employment and recruitment

I. INTRODUCTION

Global statistics reveals, each year 268 million non fatal workplace accidents with 160 million new cases of work related morbidity causes severe socioeconomic consequences for workers and society (Abugad, 2009; Kunar et al., 2008). Developing countries employs 60% of the global workforce with 80% employed in heavy and dangerous work places, with only 5–15% of them have access to occupational health service (Ergor et al., 2003). High uncontrolled chemical exposures, physical hazards, child employment, poverty, hunger, poor interventional health and safety mechanisms caters to high incidences of occupational injuries. Aggravating this situation, neglected occupational health with low profile public health policies on occupational health have remained low in commitment at national priorities list of developing countries (Mohammadfam and Moghimbeigi, 2009; Mazaheri et al., 2009). Post liberalization in Indian economy has seen burgeoning of industries. Out of total employed population in the country during 2001, 17.8% (17 million) was in the organized sector. Among the 83 million engaged in the unorganized sector 82 % related to agriculture, as it was the major activity, trailed by manufacturing, retail trade and other activities (Registrar General of India, 2001). Industrial injuries among employed workers in India was 9 per 1000, with a frequency of 2.6 per 100, 000 man days work (CSO, 2004). National Crime Records Bureau of India, reports 667 death incidents related to

factory/machine related incidents, 446 deaths in mine/quarry, 220 due to inhaling poisonous gases and 2346 death due to collapse of structures (NCRB, 2001. b). A study conducted on 2682 workers in Digboi oil refinery in Assam, India, reports 35 % of work injuries occurred at work place, (Sharma et al., 2001). In Indian manufacturing sector, the fatal accident rate is near to 100 fatalities per million employees as against 10 to 30 million in advanced countries and puts the figure of 200 non fatal injuries per million (DGFASLI, 2009).

A study among workers working in a Indian glass manufacturing industry showed injury incidence of 1105.1 per thousand workers with working environment , machinery and lack of protective clothing being a major cause (Bazroy et al., 2003).

There is no centralized agency in India to investigate the occupational injuries (NCMH, 2005). Workers are exposed to hazardous work environment that results in work injuries of varied nature, like musculoskeletal disorders, physical work injuries depending on the specificity of the work environment in which he is employed. Moreover, death resulting from occupation are listed in general medical condition and underlying causes are not documented and reported, hence precise extent of occupational injuries are difficult to establish (NCMH, 2005). It is of great importance to improve safety and reduce the accident and injuries specific to industrial settings. The terms 'accident' and 'injury' have sometimes been used interchangeably, particularly when considering prevention (Hale and Hale, 1972 and Langley, 1988). As the terms accident and injury are used interchangeably, inconsistencies and overlapping is seen in accident/work injury literature, and research studies set to analyze accidents, in fact, end up as injury analysis (Langley, 1988). But in fact the terms are distinct. An accident can occur without injury, and not all injuries are 'accidental', that is unintentional. Injury is defined as the energy exchange between human above the physiological threshold, which results in harm or injury. There is no such condition for an accident, injuries are remotely governed by chance, while an event occurring accidentally connotes to a chance phenomenon (Wehmeier et al., 2005).

Injury is defined as tissue damage due to transfer of one or combined forms of five types of energies e.g. kinetic, mechanical, thermal, chemical, electrical or radiation or it can happen due to absence of energy e.g. lack of oxygen in drowning incidents, (Feyer. and Williamson 1991). In any productive work system, different kind of forces and energies interact with each other and is controlled within the work system. At some instances, this control weakens and a uncontrolled energy exchange takes place, resulting in a accident/injury incident. Work injuries can also be classified into two types, based on energy exposures on the human body in its vicinity: acute and chronic. Work injuries of short impulsive (acute) exposures are termed as traumatic injuries and of long and repetitive (chronic) exposures are called Cumulative Trauma Disorders (CTD) or Repetitive Strain Injuries (RSI), (Putz-Anderson, 1988; Tayyari and Smith, 1997). During last three decades, the researchers are of the view to treat injury research as distinct from accident research (Mckenna, 1983) and (Robertson, 1998). Casual models postulated for accident analysis, does not appreciate injury incidents elaborately, but accident theories explaining accident causation are accepted in literature, but no theories are termed as injury theories.

System level accident causation models analyzes event chains that initiates from components level to system level failures and eventually leads to accidents, of low frequency and high severity injuries, but not to high frequency and low severity injuries. In view of injury research, high frequency and low severity injury incidents are of prime importance. Approaches that analyzes low frequency and high severity injury incidents are not helpful in identifying injury patterns. These anomalies are reflected in compiled reports published for work injuries, and reveals new approaches to be developed to address specificity in injury incidents, (Khanzode et al., 2012).

In appreciating the injury phenomenon these variable should possess content validity specific to injury episode viz., injury rate, man days lost, and accident rates, which are some of the direct indicators of injury risk. Studies by Rundmo and Hale. (2003) and Seo. (2005), have used safe behavior as indirect indicators of injury risk, while Hopkins, (2006) used safety attitude as indirect indicators of injury risk. In another study by Vinodkumar and Bhasi, (2009) safety climate had been used as indirect indicator of injury risk.

The aim of this paper is of relevance to Indian fabrication industry (i) to evaluate the association between individual related factors and high frequency low severity work injury exposures (ii) to evaluate organization related factors and high frequency low severity work injury exposures (iii) to evaluate precarious employment and high frequency low severity work injury exposures. A case study was conducted for welders performing manual metal arc welding at heavy engineering fabrication cluster supplying fabricated components to public sector units in Tamilnadu, India

II MATERIAL AND METHODS

2.1 Description of the subject population – Welders Work

Welders permanently join pieces of metal by applying heat, using filler metal or by fusion process. They join parts being manufactured, build structures and repair damaged or worn parts. They use various welding and cutting processes to join structural steel and cut metal in vessels, piping and other components. They also fabricate parts, tools, machines and equipment used in the construction and manufacturing industries.

Welders may specialize in certain types of welding such as custom fabrication, pressure vessel, pipeline, structural welding, and machinery and equipment repair. They are employed in fabrication shops, steel and platform manufacturers, mechanical contractors, transportation contractors and specialized welding shops. The work may be performed outdoors or indoors, and demand travelling to remote locations.

Fundamental welding process have not changed, improved consumables e.g., welding wire, gases etc, have enhanced the productivity and quality of end product. Present day technology have made more energy efficient and lighter welding equipments based on ergonomic principles, have made safer, lighter and efficient tools.

Further more, some of the layout skills like parallel line and radial line development have moved into design office. Welders work with greater variety and volume of alloys and knowledge of metallurgy is becoming must for welders. Moreover environment issues and awareness have increased. These advances are not available, to average welder employed in Industrially Developing Country.

In general the skill of a welder involves (i) setting trade machinery e.g. presses, shears, plasma cutters, oxy fuel cutting torches, grinders, drills to bend, cut and form metal components (ii) analyzes and interpret blue print, drawing (iii) perform calculations with trade shop formulas, uses mathematical methods to develop patterns and lays out structural steel (iv) plans task sequence and decides to cut steel effectively (iv) makes the assembly process by fitting metal sections (v) fasten tack welding, bolting and riveting (vi) utilizes material handling, rigging, hoisting and lifting equipment to relocate completed assembly safely (vi) performs duties with care and precision.

2.1.1 Sampling and Data Collection

Random sampling was followed to collect the response form welder's employed in engineering fabrication cluster. As the all firms in engineering fabrication cluster are of private nature, initially negative apprehension about the survey was felt. With help of SSIA and persuading that the information will be used for only academic purpose. The survey was administered only to subjects who performed manual metal arc welding in their firms. The researchers were present in engineering fabrication cluster attending to the respondents when ever the situations warranted clarification. The time span to collect spanned over one year. Out of 2225 administered in the engineering fabrication cluster, 1513 filled in response was personally collected from the welders with response rate of 68%, out of which only 1075 were in usable form for analysis purpose.

2.2 Variables

In tune with aims of the study, the variables considered are of two types (i) criterion variable (ii) explanatory variable. Criterion variable is used to measure the effect, whereas the explanatory variables are used to describe the path to effect. In safety and accident analysis literature, the criterion variables studied are injury rates, accident rates, and man-days lost which are direct and good measures of injury risk (Khanzode et al., 2012).

In this study, self reported, non reportable work injury exposure frequency is considered as the criterion variable. The explanatory variable, for this study are demographic factors: age, total welder experience, organization related factors: physical work load, working hours, precarious employment: contract or on job apprenticeship, mode of trade knowledge acquired: institutional certification or on job apprenticeship and work factor dimensions and its characteristic. In following section, brief description of findings for each variable is stated.

2.3 Work Injury Exposure

In welding environment, physical hazards are hazards that causes physical damage or injury, includes exposure to vibration, radiation (ionizing nature) or excesses of heat, cold and physical trauma (Erdal and Berman, 2008). Work injuries exposures are due to multiple causal factors. Arc welding environment is highly hazardous due to heat of electric arc, danger of electric shock etc. Injury exposures in welding environment can be of two types (i) energy exchange below the physiological threshold which leads to presenteeism i.e. visible in workers as reduced effective worker effort, a state of morbidity and (ii) energy exchange above the physiological threshold, leads to absenteeism i.e. away from work, caused by imbalance between work factors. In welders work, hazards always lurk in environment as extreme temperatures are involved. High frequency low severity work injury exposures i.e. frequent short time exposures, are the most experienced hazards by the welders. Work injury exposure rates can be recommended as a best measure of safety performance (Shannon et al., 1997). Work injuries exposures is used as a performance measure in mine safety studies by Paul and Maiti, (2008). McGonagle and Kath (2010) used work injuries exposures as safety performance measure to analyze the relation with 'work-safety tension.

In this study work injury exposures means, self reported non reportable high frequency low severity work injuries exposures – more than 6 and less than 6 work injury exposures is considered as criterion variable.

2.3.1 Individual Factor – Age, Experience, Physical work load

Age is the one of the most investigated factors on work injury studies. General belief that aged persons are likely to have more experience, are familiar with the jobs they do and have a lesser probability of getting a work injury. Salminen, (2004) in his comprehensive review have stated that young workers - below 25 years are more prone of non fatal injury incidents, while older workers are more prone for fatal injury incidents. While, Maiti and Bhattacharjee.

(1999), reported no relationship between age and work injuries, higher injury rate has been reported in young workers by Schoemaker et al., (2000) in a steel manufacturing plant in Brazil. Thus contradictory findings exist in age and work injury relation.

Experience means, the familiarity/proficiency of particular trade attained by the welder. The concept postulates, effective work practice implies lesser work injuries than a young or inexperienced worker. Industrial worker having experience lesser than a year are prone to higher injury risk (Keyserling, 1983; Buttani, 1988). Absence of correlation had been reported between experience and work injury (Gun and Ryan, 1994). Absence of relationship between work injuries and experience have also been reported by Maiti and Bhattacharjee. (1999) and Breslin et al.(2007). More the experience, more familiar about hazard and work place hence more control over the safe work.

Higher Physical Work Load (PWL), mean higher injury risk. A study on hotel room cleaners by Niklas Krause et al.,(2005) reports a strong association between physical work load and work injuries. Workers in the highest exposure quartiles for physical workload were between 3.24 times more likely to report severe pain than workers in the lowest quartile. Comparative study between office clerks and welders by Torner et al.,(1991) indicates heavy dynamic physical work load and prolonged static physical work load causes shoulder injuries but are of different nature. (Roland Khadefors. 2005 and Roland Khadefors et al., 1997) hypothesizes that welders have higher risk of acquiring work injury due to high static physical work load which is not ergonomically sound, and the load is characterized as dynamic load. This dynamic load is due to, high physical effort, where manual welding provides a good example. A study on nursing profession by Josephine et al., (1996) for work related risk factor inducing musculoskeletal work injuries, concludes suggesting that research on health risk to be focused on physical work load. Based on the above review the following hypothesis is set;

2.3.1.1 Analysis

ANOVA results in Table 1 show, that age is statistically significant $F(3, 1071) = 4.80$, $p < .05$, in causing high frequency low severity work injury exposures. Physical work load is statistical significant in causing high frequency low severity work injury exposures $F(2,1072) = 325.70$, $p < .01$, While experience is not associated with high frequency low severity work injury exposures.

TABLE 1
One way ANOVA comparing high frequency low severity work injury exposures individual factors

Age	$F_{(3,1071)} = 4.80$	$p < .05$
Experience	$F_{(2,1072)} = 1.67$	n.s
Physical work load	$F_{(2,1072)} = 325.70$	$p < .05$

2.3.2 Precarious Employment – Working hours, Mode of recruitment, Mode of training

Term “precarious” explains work experiences, related to instability, lack of protection, insecurity across various dimension of work as stated by Leah H Vosko, (2006). While Rodgers state a general frame work based on work experiences in line with notion of insecurity. Postulates a construct ‘a typical work’ synonymous with non standard work. He classifies work forms and arrangements, to form key dimensions of work experiences which may give rise to instability, insecurity and vulnerability. A review on global precarious employment by Michael Quinlan et al., (2001) reveal these job to be associated with unregulated working hours, higher rates of injury, increased exposure to hazards, increased risk of contacting a risk and poor knowledge of occupational health, safety and regulatory responsibilities.

Table 2
Comparison of high frequency low severity work injury (less than 6 and more than 6 workinjury exposures) among welder - mode of recruitment, mode of training, working hours

Variable	M	SD	t	df	p
Working hours			-15.292	1013.26*	.000
8 hrs	3.99	1.315			
< 8 hrs	5.62	2.14			
Mode of recruitment			-10.817	767.6*	.000
Regular	4.03	1.259			
Contract	5.19	2.103			
Mode of training			-13.528	1006.7*	.000
On job	3.94	1.274			
Institutional	5.35	2.107			

* The t and df were adjusted because variances were not equal

2.3.2.1 Analysis

Independent sample 't' in test Table 2 shows, welders working in regular working hours (8 hours) ($M = 3.99$, $SD = 1.315$) are less exposed to high frequency low severity work injury exposures, than welders working in extended working hours (more than 8 hours) ($t(1013.26) = 15.292$, $p = .000$, the magnitude of difference $d = .19$ small effect. Contract welders have higher high frequency low severity work injury exposures ($M = 5.19$, $SD = 2.103$), than regular welders ($M = 4.03$, $SD = 1.259$), $t(767.6) = -10.817$, the magnitude of difference $d = .77$ a large effect. Institutional certified welders are more prone to high frequency low severity work injury exposures ($M = 5.35$, $SD = 2.107$) than on job trained welders ($M = 3.94$, $SD = 1.274$), $t(1006.7) = -13.528$, $p = .000$ the magnitude of difference $d = 0.86$, a large effect.

III. DISCUSSIONS AND CONCLUSIONS

The study reveals Table 3 age (H1) is significant with work injury exposures which is in line prior studies by Salminen, (2004), considering the average age of the study population 'contradicts the findings that workers below 25 years age are more prone for fatal injury exposures also contradicts the findings of Maiti and Bhattacharjee. (1999), of null age and work injury exposures relation. Contradicts the finding that less experienced (H2) worker are prone to work injury exposures by Keyserling, (1983) and Buttani, (1988) this study reports, null relationship between experience and work injury exposures.

Table 3

Summary of results with respect to hypothesis			
Sl No	Null Hypothesis	Result	Remarks
H1	Age has no influence on high frequency low severity work injury exposures	Supported for work injury exposures	Surprising fact to be considered for safety intervention efforts considering the mean age
H2	Experience has no influence on high frequency low severity work injury exposures	Not supported	Not a surprising fact considering the average experience
H3	Physical work load has no influence on high frequency low severity work injury exposures	Supported for work injury exposures	To be considered for safety intervention efforts
H4	Welders working hours have no influence on high frequency low severity work injury exposures	Supported for work injury exposures	Realistic result welders working extended hours to be considered for safety intervention efforts
H5	Mode of employment has no influence on high frequency low severity work injury exposures	Supported for work injury exposures	A likely result welders on contract are more prone work injury exposure reasons to be considered for safety intervention efforts
H6	Mode of trade apprenticeship hours has no influence on high frequency low severity work injury exposures	Supported for work injury exposures	Surprising result as institutional trained welders are more to work injury exposures reasons to be explored

This study shows physical work load (H3) associated is positive with work injury exposures in tune with the prior studies by Khadefors 2005 & 1997 and Josephine et al., 1996. Precarious (H3 – H6) Table 3 employment spells extended working hours, lack of normalized recruitment process and safety training the results in this study show welders working extended working hours (more than 8 hours) and contract welders are more prone to work injury exposures in tune with prior studies of precarious employment by Michael Quinlan et al., (2001). The general perception is that institution certified welder will be less prone to the work injury exposures compared to on the job trained welders, the finding in the study contradicts the fact that on the job trained welders are less prone to the work injury exposures perhaps to due the nature of the welders trade which heavily relies on the on the job welding skills acquired by practice. These facts discussed above can be considered for safety intervention efforts.

IV. RECOMMENDATIONS

1. Ageing work force 'welders' tend to have changes in physical and cognitive capacities – the declines in musculoskeletal, respiratory, circulatory, nervous, and mental functions decrease people's capabilities to perform physical work, in terms of both short-term efforts (strength) and lasting efforts (endurance). These declines are often accompanied by difficulties in maintaining postural stability and greater vulnerability to acute or cumulative injuries work is composed of so many components, both physical and attitudinal, that a wide range from strong to weak prevails among aging individuals a little attention has been paid to the perception of the older work force, though studies have contradicting literature experience of aging in contemporary work force. This study uses quantitative methods to gain new insights in work injury exposures and welders performing manual metal arc welding.

2. Physical work load (metal deposit in manual arc welding) performed repeatedly over longer period leads to fatigue, discomfort and injury mainly work related musculoskeletal injury due to awkward postures, heavy lifting due to static and dynamic loads during weldment and static position during weldment in turn can induce first degree physical injuries. Applying proper ergonomic principles can reduce the potential risk these injuries.
3. Precarious employment can be tuned in terms of regulatory interventions in which dimensions of precariousness can be offset by Rodgers (1989) (i) degree of certainty of continuing work (ii) control over work process (iii) legal and institutional protection (iv) income and benefits adequacy (v) work role status (vi) socio cultural dimension in work place (vii) risk of exposure to physical hazards (viii) training and career advancement opportunities.

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