

Conference Paper

Ergonomics Analysis and Social Demographic Factors Associated with Welder in Small-scale Workshops in Makassar, Indonesia

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Abstract

Welding is an important process of steel fabrication. Even though welder is associated with various occupational hazards, there is limited information of work-related health problems within this occupational group. This study aimed to gather information about occupational hazards, use of personal protective equipment, and demographics among small-scale welding workshops. A work site-based cross-sectional study was conducted at 34 small-scale welding workshops in Makassar, Indonesia. Interviews, questionnaire, and direct observation used to collect data on demographic characteristics, occupational hazards, and musculoskeletal disorder experience. The demographic factors that were collected were age, work duration, educational status, work experience, technical training, safety tools, also smoking and drinking habit. Working posture assessed using OWAS and level of musculoskeletal disorder using Nordic body map. Descriptive statistics and bivariate logistic regression was used for correlations analysis. In general, result indicated that workers were 34 ± 11 years old, 66 percent married, 78 percent smoking, 22 percent had drinking habit, 56 percent had grade school education or less, 66 percent were employed for more than 4 years, 73 percent worked less than 8 hours a day, 95 and 84 percent, respectively, did not take safety training and safety awareness. Work condition assessed concludes that 36 percent of participants perceived the temperature was hot, 47 percent noisy, 66 percent illuminations were good enough, and 44 percent did not use chair to support them. Nordic body map and OWAS posture analysis indicated that 51 percent welders were experiencing moderate level of musculoskeletal complaint and 55 percent welders were category 3. Nevertheless, the only factor having a significant value associated with musculoskeletal symptoms was working posture (p -value = 0.030). Welders in this study were experiencing musculoskeletal complaint of back pain, hip, forearm, buttock, and shoulder; which OWAS suggest need improvement immediately. Further research needed within this occupational group to improve working posture, safety, and protective equipment awareness, also avoiding musculoskeletal disorder.

Keywords: welder, small-scale workshop, posture, musculoskeletal disorder, OWAS, occupational safety

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1. Introduction

Small and Medium Enterprises (SMEs) plays important role to improve Indonesia's economic growth and contribute considerably to employment of the local communities [1, 2]. Employment absorption in SMEs or informal sector increase to 97.22 percent in the last five years periods of more than 110 million people of total workers [3, 4]. National data from Center Biro of Statistics (BPS) in 2016 reflect that Indonesian SMEs sector were reaching 56.5 million enterprises [4]. Unfortunately, the increasing of this sector also parallels with high occupational accident and injury cases.

The number of occupational accidents and injuries in Indonesia are quite high. Based on the BPJS Ketenagakerjaan data, number of accidents in 2016 reached 101,367 cases. More than 50 percent cases occur within the company when they work, and the others were outside the work areas and road accidents [4, 5]. SMEs face serious occupational health and safety challenges [6]. Another survey noted about 80 percent of informal workers does not have social security or insurance [7]. This situation is very alarming given that the economic activities of the informal sectors are exposed to work and health risk. This is implying that total accident and injury cases could be higher, if include non-reported data.

According to the World Bank, SMEs can be grouped as a small-scale with less than 30 workers and medium scale with maximum 300 workers [2]. One of small-scale business which is currently developing in Makassar, Indonesia, is welding workshop. Welding is an important process of steel fabrication and the most common way to connect metal parts permanently [9]. Even though welder is associated with various occupational hazards, ergonomics considerations in developing country are not taken seriously [10]. Welding workshop in Makassar, serves welding products/constructions such as iron fence/doors, security/window trellis, stairs, canopy, roof truss and others.

Interview result by Suprianto & Evendi [8] found that most welder of SMEs (66.7%) experienced about 6–10 injuries types at workplace, such as blistered skin, electrocuted burns, bump, discomfort, and eye pain. Finding by Tadesseet al. [9] include breathlessness, cough and fever, also hearing impairment. Most studies conclude that welder is exposed to several hazards, namely: intense bright light, intense heat, electricity, excessive noise, vibrations, high temperature, welding fume and gases, and awkward work postures [9, 10]. Welding also often requires awkward work postures [6] and combines with some organizational problems such as exceed working hours and unsafe working condition scan lead to musculoskeletal disorder [11]. However, there is limited information on use or work related health problems within this occupational

group. This study aimed to gather information about occupational hazards, use of personal protective equipment and demographics characteristics among small-scale welders in Makassar, Indonesia.

2. Methods

Seventy three welders participated from 34 of 50 welding workshop spread across 14 districts in Makassar City (Figure 1). They have been involved in a work site-based cross sectional study of welding workshops SMEs.

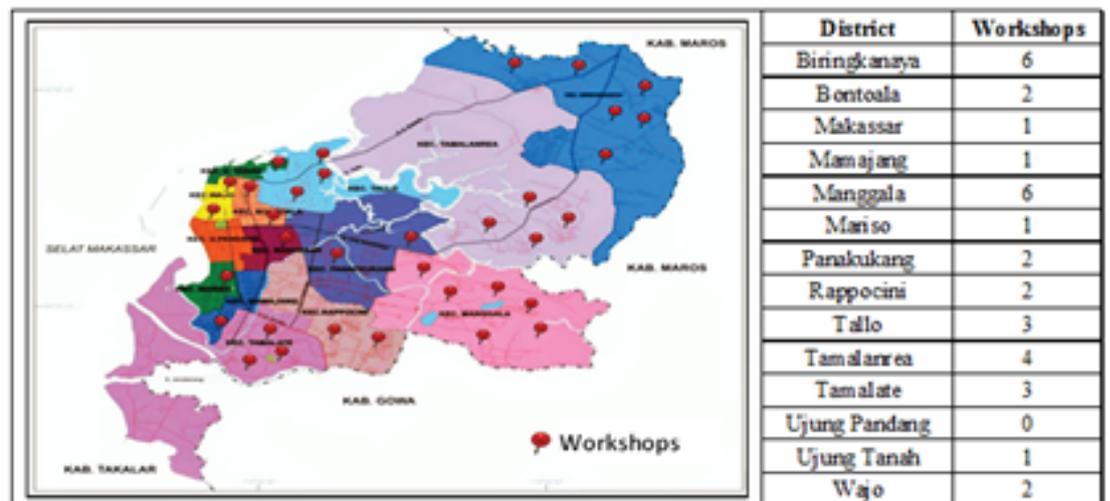


Figure 1: Distribution of welding in Makassar City.

Interviews, direct observation, and questionnaire, respectively, were used to collect data on demographic characteristics, occupational hazards, and musculoskeletal disorder experience. Demographic factors that collected were age, work hour, educational status, work experience, safety training, use of safety tools, also smoking and drinking habit. Working posture assessed using OVAKO Working Analysis System (OWAS) method [12] and level of musculoskeletal disorder (MSDs) complaints using Nordic Body Map [13]. Descriptive statistics were used in data analysis, and bivariate logistic regression was used for correlate between variables.

3. Results and Discussions

3.1. Demographics characteristics

The mean age of workers was 33.47 (range 18–58) years, all male, 66 percent are married, 78 percent smoke cigarette, 22 percent has drinking habit, and 56 percent

had grade school education or lower. Details of demographics characteristics can be seen in Table 1.

TABLE 1: Socio-demographics characteristics.

Variables	Number	Percent
Age (in years)		
18-29	31	42%
30-41	23	31%
42-53	15	20%
> 54	4	5%
Marital Status		
Single	24	33%
Married	48	66%
Divorced	1	1%
Educational Status		
No Education	2	3%
Grade School	20	27%
Junior High	19	26%
Senior High	17	23%
Collage	12	17%
Others	3	4%
Smoke Cigarette		
Yes	57	78%
No	16	22%
Drink Alcohol		
Yes	16	22%
No	57	78%

Some of the findings were similar with other researches which more than 50 percent of Indonesian SMEs welders were ranged 18-41 years old [3, 14] and have low educational status whom less than 21 percent have education above senior high school [3].

3.2. Behavior and the use of personal protective equipment (PPE)

Working experience of 66 percent welders was over 4 years, corresponded with Dzulfiqar & Handayani [5] which 59 percent employment was over 5 years. Most of them

(73%) worked less than 8 hours a day, but it was different with Ramadhana & Amir [3] which 74.6 percent of SMEs welders worked in range 7–12 hours/day.



Figure 2: Welder posture.

Most of the workers were 95 and 84 percent did not take safety training/course and safety awareness, respectively. This also found in other studies [5, 9, 14], where almost 70 percent of SMEs workers have less knowledge about safety and personal protective equipment (PPE). PPE are treated as luxuries rather than necessities [10]. There were 96 percent of SMEs did not sufficiently provide PPE (Table 2). In average, only 44 percent of workers use the proper equipment, and this similar with Dzulfiqar & Handayani [5] that 66.7 percent of PPE available, however only 64.9 percent of them used while welders working.

3.3. Workplace conditions

Work condition assessed by interview concludes that 63 percent of welders perceived the temperature of their workplace were comfortable, 53 percent falls quite environment, and 66 percent illuminations were good enough to do their job. These imply that workplace of small-scale welding workshops in Makassar were in rather appropriate condition.

3.4. Worker complaints and posture analysis

As seen in Figure 2, most of welders do their work in sitting position, bending their knee and back for a long time. This corresponded to Ismaila et al. [15] found that majority of the welders (58.3%) claimed that they worked with their arms above the shoulder

TABLE 2: Worker and behaviors characteristics.

Variables	Number	Percent
Work Experience (in years)		
< 1	7	9%
1-4	18	25%
> 4	48	66%
Hour work per day		
< 8	53	73%
> 8	17	23%
Attended Safety Training		
Yes	4	5%
No	69	95%
Safety Awareness		
Yes	12	16%
No	61	84%
PPE Available		
Yes	3	4%
No	70	96%
PPE Used		
Welding Mask	25	34%
Safety Helmet	10	14%
Safety Glove	23	32%
Safety Shoes	34	47%
Safety Goggle	57	78%
Supporting Chair	41	56%
APAR availability	32	44%

and/or away from the body, 50 percent of the welders often squat for more than two hours while doing their work and 77.1 percent had to bend or twist the spine.

Nordic body map analysis indicated that 51 percent welder experiencing moderate level prevalence of musculoskeletal complaints (Figure 3) on back (57%), hip (41%), forearm (14%), buttock (11%), and shoulder (8%). Those complaints separated as discomforts (47% of worker) and pain (4%) at their parts of body. This finding is in line with Kurnianto & Mulyono [16] that workers discomfort site was on hip (92.37%), shoulder (76.92%) and leg (76.92%), and with Malikraj et al. [17] which highest prevalence were back (81.3%) and shoulders (32%).

TABLE 3: Work conditions.

Variables	Number	Percent
Temperature		
Comfortable	46	63%
Warm	21	29%
Hot	5	7%
Very Hot	1	1%
Noise		
Quite	39	53%
Rather Noisy	15	21%
Noisy	11	15%
Very Noisy	8	11%
Illumination		
Dark	0	0%
Rather Dark	13	18%
Sufficient	48	66%
Bright	13	18%
Dazzling	0	0%
Blinding	0	0%

Posture analyses by OWAS concluded that 55 percent of welders were fall under category 3 (Table 4), similar finding with Mahendra et al. [6] in small-scale workshop, imply that their work postures in high risk which suggests need improvement immediatly. Welding in medium enterprises also has risks which 57 and 95 percent of their workers scored 2 OWAS, respectively, study by Nikpeyet al. [11] and Kurnianto & Mulyono[16].

TABLE 4: OWAS identification.

OWAS Category	Total
Category 1	13
Category 2	19
Category 3	40
Category 4	1

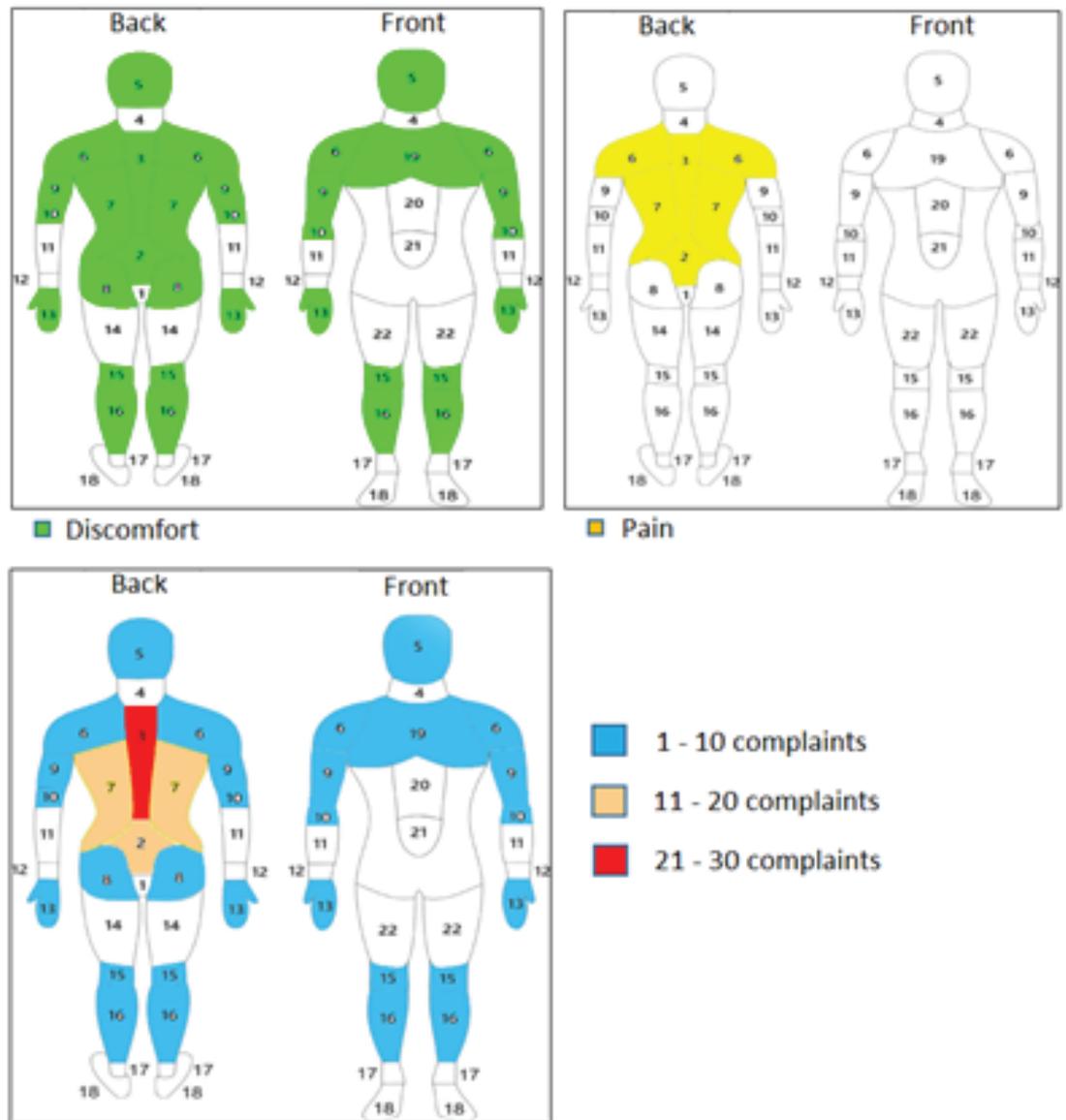


Figure 3: Complaints of discomfort and local pain.

3.5. Factor associated with occupational hazards

The data obtained was processed by using software STATA. The result of bivariate analysis between demographics variables and musculoskeletal complaints provided in Table 5.

The relationship between ages and the prevalence of complaints is not significant ($p = 0.971$). This result agreed to Dofina & Nawawinetu [18] that there is no correlation between ages with the prevalence of subjective complaints MSDs in welding workshop workers. The relationship between educational status and the prevalence of complaints is also not significant ($p = 0.489$). However, Tadesse et al. [9] found that

TABLE 5: The relationship of social demographic and musculoskeletal disorders.

Variables	z	p> z	Relations
Age	0.04	0.971	Not Significant
Educational Status	-0.69	0.489	Not Significant
Employment	1.04	0.301	Not Significant
Hour Work	-1.00	0.316	Not Significant
Safety Training	0.65	0.517	Not Significant
Safety Awareness	0.59	0.556	Not Significant
PPE Available	0.22	0.824	Not Significant
Smoking Habit	-0.98	0.327	Not Significant
Drink Alcohol	0.47	0.637	Not Significant
Work Posture	-2.17	0.030	Significant

workers who attained a higher level of education could have the tendency to change available information into mature stage which increased their awareness of hazards.

Similar tendency also spotted in the relationship between the prevalence of complaints and employment ($p = 0.301$), and with also hours of work ($p = 0.316$). Dofina & Nawawinetu [18] also found that there was no significant correlation between working period and prevalence of subjective complaints MSDs. Research by Dzulfiqar & Handayani [5] imply that there was no significant correlation between the employment variable with workers safety behavior. But Das et al. [10] revealed that number of years of welding have good correlation with percentages of welders with eye diseases, regular headache, cardiovascular diseases & respiratory diseases; and more severely affected than the persons not working in welding shop.

No significant relationship also found between the prevalence of complaints and safety training ($p = 0.517$), and safety awareness ($p = 0.556$). These results contradict with study by Singh & Singhal [19] that found untrained welders are serious concern in high musculoskeletal disorders risk in welding. Dzulfiqar & Handayani [5] also highlight that there was a significant relationship between knowledge of safety and safety behavior. Other studies found that hazards awareness significantly associated with the presence of workplace safety regulations [9].

The relationship between availability of PPE and the prevalence of complaints is not significant ($p = 0.824$). These results indicate that the availability of PPE indirectly related to workers complaints, but correlate to behavior of worker safety [5] and safety knowledge [14] in the welding workshop. Study by Salawati [14] shows that well-knowledgeable welders (76.9%) tend to use eye protective equipment than the less

informed workers (36.4%). Results by Suprianto & Evendi [8] conclude that there is moderate relationship between compliance of PPE and workplace accident. Workers who have poor conformity to PPE have 2.750 times higher accident risk than workers who obedient to use of PPE.

The prevalence of complaints and smoking habit also has no significant relationship ($p = 0.327$) as well as to the drink alcohol habit ($p = 0.637$). This result agreed to Dofina & Nawawinetu [18] that there was no correlation between the smoking habit with the prevalence of subjective complaints MSDs in welding workshop workers.

The only factor that have a significant value associated with musculoskeletal symptoms was the working posture ($p = 0.030$). This result support to Dofina & Nawawinetu [18] that awkward posture have a significant correlation with subjective MSDs complaints ($p = 0.003$) and the study by Jalajuwita & Paskarini [20] which found working positions have high correlation with prevalence of musculoskeletal complaint.

4. Recommendation

Results conclude that small-scale welders in Makassar have high self-reported complaint, which are back and hip discomfort. Bend or squat position while working is the most common factor induced musculoskeletal disorder between welders. Data collected by Dofina & Nawawinetu [18] obtained that body posture that tends to bend or tilt has a risk of lower back pain 2.58 times greater than the upright posture, while the attitude of combination between bending, tilting, and twisting rising risk to 2.68 times higher. Ergonomics interventions can improve working condition and decrease exposure level [17], focused on eliminating awkward posture of shoulder, back and neck and eliminate static working posture because correlate with subjective MSDs complaints [15, 18].

The most successful approaches with outcome to reduce workplace injuries are safety behavior (59.6%), followed by an ergonomic approach (51.6%), the last was engineering control approaches (29%) [21]. As concludes by Dzulfiqar & Handayani [5] and Salawati [14] there was a significant correlation between attitudes in working with safety behavior and PPE use in welding workshop workers. Proper awareness of welding hazards is important to design safety education program, using different protective tools, and improve efficiency [9].

The existence of PPE is often underestimated by workers [8]. About 72 percent of welders were not clear about hazards of welding and reluctant to accept that prolonged exposure to welding fumes could be fatal [10]. Only a small proportion of welders had

all the mandatory personal protection equipment. This can be seen in the study that only 4 percent of workers have PPE available, and 44 percent of workers use the PPE even though not the required ones. Another interesting finding of Tadesse et al. [9] was that the odds of hazards awareness between employees that satisfied of their job and who were not. The satisfied employees were aware of hazards more than nine times higher.

Engineering control approaches suggested by Das et al. [10] that welding should be performed in well-ventilated areas and use local-exhaust ventilation to remove fumes and gases at their source in still air. Smoke inhalation risk assessment study [22], for example, by calculating volatility score of each danger chemical agent of a process must be done regularly. Other recommendation by Nikpey et al. [11] in welding workstation, which classified as the heavy works, using electric or pneumatic fixed welding instead of manual welding.

5. Conclusions

Welders in this study experiencing numbers of musculoskeletal disorder. OWAS analysis indicated that 55 percent welders fall in the Category 3, which need improvement immediately. The only factor have a significant value associated with musculoskeletal complaints is the working posture. Further research needed within this occupational group to avoid musculoskeletal disorder and increase welder well-being. Some recommendations are suggested to improve working posture and safety behavior, increase protective equipment awareness, also engineering control approaches.

Conflict of interest

The authors declare that they have no competing interest.

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