Hand Arm Vibration Syndrome Complaints among Casting Workers at a Construction Project in Indonesia

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ABSTRACT

Casting workers are at risk of experiencing HAVS complaints because in the work process required to use tools that are designed with high acceleration so that it can transmit vibrations in the hands and arms of workers during the work process takes place. This study aimed to determine the relationship of daily vibration exposure, age, duration of works, time of exposure, PPE usage, and socialization about vibration with HAVS complaints. This research uses quantitative analytic research with a cross-sectional design. The data were analyzed in univariate and bivariate ways using Chi Square Test and Independent T- test. The vibration was measured using calibrated vibration meters. The questionnaire was used for the workers. This study sample was 50 workers in the lower casting section who used Concrete Vibrators while working on Project X. The results showed that 58% of respondents had HAVS complaints. The results of the Chi-Square bivariate analysis showed a significant relationship between age (POR = 8.08; 95% CI = 2.13-30.57), daily intensity of vibration exposure (POR = 4.75; 95% CI = 1, 41-16.65), duration of exposure (POR = 5.23; 95% CI = 1.41-19.43), and use of PPE (POR = 7.80; 95% CI = 2.14-28.78) with HAVS Complaints. Independent T-test results showed a difference in the average daily intensity of exposure between groups with HAVS complaints of 77.42 (SD = 18.54) m/s^2 and those without HAVS complaints 64.93 (SD = 15.35) m/s^2. Therefore, it is advisable for workers always to use PPE, especially anti-vibration gloves, and to the management, it is advisable to install a damping device on a concrete vibrator and set the work times of workers and provide information about vibration to workers.

Keywords: *vibration, hand arm vibration syndrome complaints, casting workers*

1. Introduction

Construction becomes a well-known and well-established industry in every country. The recent study found that construction industry development becomes one of the countries' improvement indicators and support various significant businesses, such as trade and tourism [18]. However, the Indonesian Minister of Labour mentioned that construction becomes the aspect that contributes to the highest occupational injuries in the nation [6]. Thus, this industry must be assessed to consider the cause of these injuries.

Casting work, which can be defined as pouring the mix consist of concrete into a mold, is one of the essential works in the construction industry [7]. To ensure that the required quality is met, adequate equipment must be used. The concrete vibrator is one of the equipment used in the casting work, which applied the right amount of vibration to solidify the concrete mix [10]. Rodriguez (2019) mentioned that the equipment eliminates the air bubble in the concrete mix [17]. Furthermore, Mishra (2019) declares that the equipment uses electrical or diesel motor as a power supply with 3000-6000 rpm as minimum frequency [12]. Babu et al. (2017) explained that high vibration is used to be transmission all over the workers' hands and arm [1].

Hand-arm vibration (HAV) can be defined as the vibration exposure received at the workers' hands and arm when they used the vibrated equipment [22]. WHO (2009) also mentioned that the prolonged use of the vibrated equipment would cause Hand Arm Vibration Syndrome (HAVS), which can disrupt the blood vessel, neurology system, and musculoskeletal system which consists of muscle, joint, and tendon. Some effects that can be felt by the workers are uncomfortable feeling and the reduced working performance [22].

Bozenvi (2012) mentioned that roughly 1.7 % to 3.6 % of workers are exposed to HAV in Europe and the United States. The Norwegian Central Bureau of Statistics reported that 5 % of the workers are exposed to the same hazard, and 25 % are exposed daily. Furthermore, several studies show that workers worldwide, including

Americans, Canadians, South Africans, Malaysians, and Vietnamese, are exposed to HAV and experienced HAVS [8], [20], [21]. Buhaug et al. (2014) informed that most HAV exposed workers are welding men, wood makers, and construction workers [3]. Similar to that, Shen (2017) explained that most exposed workers are construction workers, miners, forestry men, and casting men [20]. Indonesian Ministry of Health (2018) stated that upper limb injuries are 32.7 %, and 9.1 % occur in the workplace [11]. However, the current data could not estimate the HAVS prevalence in Indonesia [4]. Several studies in Indonesia show a significant association between HAV exposed workers, the equipment they used, and HAVS complaints [12], [16], [19], [21].

Project X is a large-scale toll road construction project that was built with the aim of reducing the traffic burden on routes passing through Jakarta. This toll road project has a length of 26.47 km which is divided into 2 sections. Project X involved approximately 900 workers. In Project X, there are two casting activities, bottom casting and top casting. In bottom casting, casting is carried out on making the median barrier and stepping plate. In upper casting, casting is done on the pierhead. At the casting stage, the tested concrete from the Mixer Truck into the formwork. For casting on concrete, it is poured using a Concrete Pump. After the concrete is poured into the formwork, the concrete is compacted using a Needle Vibrator. The concrete must be poured evenly. For casting the median barrier on the outside of the formwork, an external vibrator is also provided to help compaction the concrete. The last step is finishing which is done after the median barrier concrete is dry and solid.

The preliminary study at construction project X shows that there are ten complaints from the workers related to the joints and muscle pain. It was also found that the project never conducts vibration measurement before. The research was conducted in Project X which started in 2015 and is still working until now. Thus, the HAVS still becomes an understudied hazard in Indonesia, and very little information is known about it. We assessed the HAV exposure among workers and aimed to understand the association between the equipment used and HAVS complaints.

2. Methods

We used a well-calibrated *Vibration meter* Lutron VB 8200 to measure the acceleration of vibrations at a concrete vibrator. Vibration direct measurement using a well-calibrated Vibration Meter is needed to examine the workers' exposure and can be used to determine whether they're above the threshold limit [23][24][25]. The modified and validated Health and Safety Executive (HSE) questionnaire was distributed among the casting workers at the construction project X to assess complaints of HAVS among workers. The sampling method in this study used total sampling. The population in this study were 50 workers. There are 50 workers, and all of them are asked about their HAV complaints, age, duration of work, daily exposure time, PPE usage, and whether they ever get knowledge socialization about the hazard. The *Vibration Meter* Lutron VB 8200 is a direct measurement that shows the result after one minute put at the equipment. The inclusion criteria for the sample are Respondents as casting workers, using a concrete vibrator, working on Project X and respondents willing to become respondents by signing an agreement sheet. The exclusion criteria for the sample were employees who worked in project management X. The vibration result then compared to the Indonesian Minister of Labour Regulation Number 5 the Year 2018 to know whether the result is above the standard. This research uses quantitative analytic research with a cross-sectional design. In this study, the data were analyzed in univariate and bivariate ways using Chi Square Test and Independent T- test. We analyzed the data using appropriate data processing software named Statistical Package for the Social Science (SPSS) to understand the association between variables.

3. Result and Discussion

Vibration Measurement

We measured the vibration of the equipment used (concrete vibrator) using well-calibrated *Vibration meter* Lutron VB 8200 at some points at the casting section, involving STA 33+ box, STA 34+ box, STA 39+110 barrier median, and STA 37+ barrier median. The five measured concrete vibrators have a size of 60 mm and 40 mm (see Table 1). We also calculate the workers' daily HAV exposure (see Table 2).

Table 1 shows the results of measuring the acceleration of vibration on a concrete vibrator using a vibration meter. In the box STA 34+, measurements were made on a concrete vibrator with a size of 60 mm with a result of 119.3 m/s^2. In the box STA 33+, measurements were made on a concrete vibrator with a size of 60 mm with a result of 124.3 m/s^2. In the median barrier STA 37+ measurements were made on a concrete vibrator with a size of 60 mm with a result of 160.3 m/s^2. In the median barrier STA 37+ measurements were taken on a concrete vibrator with a size of 40 mm with a result of 155.6 m/s^2. In the median barrier STA 39 + 110, measurements were taken on a concrete vibrator with a size of 40 mm with a result of 140.5 m/s^2

Table 1. The result of vibration measurement

No	The Measured Concrete Vibrator	*Acceleration*
1	*Concrete Vibrator* 60 mm di *box STA 34+*	119.3 m/s^2
2	*Concrete Vibrator* 60 mm di *box STA 33+*	124.3 m/s^2
3	*Concrete Vibrator* 60 mm di *barrier median* STA 37+	160.3 m/s^2
4	*Concrete Vibrator* 40 mm di *barrier median* STA 37+	155.6 m/s^2
5	*Concrete Vibrator* 40 mm di *barrier median* STA 39+110	140.5 m/s^2

Table 2. The calculation of daily workers' HAV exposure

No.	α_T (m/s^2)	Exposure Duration	A(8) (m/s^2)
1	119.3	4 hours	84.3
2	119.3	2 hours	59.6
3	119.3	8 hours	119.3
4	119.3	1 hour	42.2
5	119.3	3 hours	73.1
6	119.3	5 hours	94.3
7	119.3	2 hours	59.6
8	119.3	6 hours	103.3
9	119.3	2 hours	59.6
10	119.3	2 hours	59.6
11	119.3	4 hours	84.3
12	119.3	3 hours	73.1
13	124.3	3 hours	76.1
14	124.3	2 hours	62.1
15	124.3	4 hours	87.9
16	124.3	3 hours	76.1
17	124.3	3 hours	76.1
18	124.3	3 hours	76.1
19	124.3	3 hours	76.1
20	124.3	2 hours	62.1
21	124.3	1 hour	43.9
22	124.3	2 hours	62.1
23	124.3	2 hours	62.1
24	124.3	1 hour	43.9
25	124.3	2 hours	62.1
26	124.3	1 hour	43.9
27	160.3	2 hours	80.2
28	160.3	4 hours	113.3
29	160.3	1 hour	56.7
30	155.6	3 hours	95.3
31	155.6	2 hours	77.8
32	155.6	1 hour	55.0
33	140.5	2 hours	70.5
34	140.5	1 hour	49.6
35	140.5	4 hours	99.3
36	140.5	2 hours	70.5
37	140.5	1 hour	49.6

38	140.5	2 hours	70.5
39	160.3	2 hours	80.2
40	160.3	1 hour	56.7
41	160.3	2 hours	80.2
42	160.3	1 hour	56.7
43	160.3	1 hour	56.7
44	160.3	3 hours	98.2
45	160.3	1 hour	56.7
46	140.5	3 hours	86.0
47	140.5	4 hours	99.3
48	140.5	2 hours	70.5
49	140.5	2 hours	70.5
50	140.5	3 hours	86.0

Table 2 shows the calculation result of daily exposure intensity for workers, in Table 7 it can be seen that the minimum daily exposure intensity is 42.2 m / s² and the maximum value is 119.3 m / s².

Univariate Analysis Result

Table 3. The respondent frequency distribution among the studied variable

Variable	Amount (n= 50)	Percentage (%)
HAVS Complaint		
No Complaint	21	42
Complaint	29	58
Age		
≤ 37 Years Old	27	54
> 37 Years Old	23	46
Daily Vibration Exposure Intensity		
≤ 72 m/s^2	25	50
> 72 m/s^2	25	50
Duration of Work		
≤ 1 Year	35	70
> 1 Year	15	30
Time of Exposure		
≤ 2 Hours	30	60
> 2 Hours	20	40
PPE Usage (Gloves)		
Use	18	36
Not use	32	64
Vibration Education and Socialization		
Ever	16	32
Never	34	68

Table 4. The respondent frequency distribution with HAVS complaint

Syndrome	Amount (n= 29)	Percent (%)
Vascular	0	0
Sensorineural	11	22
Musculoskeletal	6	12
Vascular Accompanied with Sensorineural	0	0

Vascular Accompanied by Musculoskeletal	0	0
Sensorineural Accompanied by Musculoskeletal	11	22
Vascular Accompanied by Sensorineural and Musculoskeletal	1	2

Table 3 shows that the respondents who experienced HAVS complaints were 29 out of 50 respondents (58%) while those who did not experience complaints were 21 out of 50 respondents (42%). Respondents stated that they had complaints if they experienced only one complaint from vascular or sensorineural or muscoloskeletal symptoms. Based on Table 4 of 29 respondents who experienced complaints, 11 people experienced sensorineural symptoms in the form of tingling and numbness accompanied by muscoloskeletal symptoms, 11 people experienced sensorineural symptoms only, 6 people experienced only muscoloskeletal symptoms, and 1 person experienced vascular symptoms accompanied by sensorineural symptoms and symptoms. muscoloskeletal.

Bivariate Analysis Result

Table 5. The association of each variable with HAVS complaints

Variable	**HAVS Complaints**				**Total**		**P-Value**	**POR**	**95%CI**
	Yes		No						
	n	%	n	%	n	%			
Age									
≤ 37 Years	10	37.0	17	63.0	27	100			
> 37 Years	19	82.6	4	17.4	23	100	0.003	8.08	2.13-30.57
Daily Vibration Exposure Intensity									
≤ 72 m/s^2	10	40.0	15	60.0	25	100			
> 72 m/s^2	19	76.0	6	24.0	25	100	0.022	4.75	1.41-16.05
Duration of Work									
≤ 1 Years	19	54.3	16	45.7	35	100			
> 1 Years	10	66.7	5	33.3	15	100	0.617	1.68	0.47-5.95
Time of Exposure									
≤ 2 Hours	13	43.3	17	56.7	30	100			
> 2 Hours	16	80.0	4	20.0	20	100	0.023	5.23	1.41-19.43
PPE Usage (Gloves)									
Use	5	27.8	13	72.2	18	100			
Not use	24	75.0	8	25.0	32	100	0.003	7.80	2.11-28.77
Vibration Education and Socialization									
Ever	9	56.2	7	43.8	16	100			
Never	20	58.8	14	41.2	34	100	1.000	1.11	0.33-3.69

Table 5 shows that there is a significant relationship between age and complaints of HAVS (POR = 8.08; 95% CI = 2.13-30.57), there is a significant relationship between the intensity of daily exposure and complaints of HAVS (POR = 4.75; 95% CI = 1.41-16.05), there was no significant relationship between tenure and complaints of HAVS (POR = 1.68; 95% CI = 0.47-5.95), there was a significant relationship between exposure to complaints of HAVS (POR = 5.23; 95% CI = 1.41-19.43), there was a significant relationship between the use of PPE and complaints of HAVS (POR = 7.80; 95% CI = 2.11-28 , 77), and there was no significant relationship between socialization about vibration and complaints of HAVS (POR = 1.11; 95% CI = 0.33-3.69).

Table 6. Differential test between daily vibration exposure intensity and HAVS complaints

Group	**N**	**Mean**	**SD**	**95%CI**	**Mean Difference**	**P-Value**
Complaints	29	77.42	18.54	2.53-22.44	12.49	0.015
No Complaints	21	64.93	15.35			

Table 6 shows that based on the Independent T test conducted, the p-value was 0.015, which means that there was a significant difference in the average intensity of daily vibration exposure between the groups that had HAVS complaints and those who did not have HAVS complaints. The average intensity of daily vibration exposure in the group of respondents who had HAVS complaints was higher than in the group who did not have HAVS complaints.

It can be seen from Table 1 that the measured concrete vibrator show a very high vibration. We calculated the daily vibration exposure intensity among the workers and compared them to the Indonesian Minister of Labour Regulation Number 5 the Year 2018. The regulation stated that the threshold limit value for 6-8 working hours is 5 m/s^2 and 14 m/s^2 for 0,5-1 working hours. Table 2 shows that all of the workers' HAV exposure is above the standards. Immediate action control must be taken to tackle these issues.

Chi-Square test was implemented to each variable involving age, daily exposure vibration intensity, duration of work, time of exposure, PPE usage, and vibration education and socialization to the HAVS complaints (see Table 5). Table 5 shows a significant association between age (POR=8,08; 95%CI=2,13-30,57) and HAVS complaints. The workers who are above 37 years old have an 8,08 higher risk of having a HAVS complaint. Similar results were also reported by several studies that show a significant association between age and HAVS complaints [9], [19]. It is stated that older people tend to have more HAVS complaints because of their bone strength, muscle strength, joints strength, and the elasticity of blood vessels, so the ability to muffle the vibration is decreased as well [15].

We found a significant association between daily vibration exposure intensity (POR=4.75; 95%CI= 1.41-16.05) and HAVS complaints. The workers exposed at > 72 m/s^2 have 4.75 higher risk of having a HAVS complaint. The normality test from the daily vibration exposure intensity variable shows that the data is normally distributed, so we conduct the independent T-test. Table 6 shows a significant differential, which informs the HAVS complaint group that there is a higher daily vibration exposure intensity than the no HAVS complaint group. Similar to the results, some studies inform that HAVS complaints often found in the high HAV exposure workers [12], [21]. Chani and Kurniawan (2018) stated that some causes of HAVS complaints are prolonged and above standard exposure. The effect that can be felt by the workers are vascular, sensory, and musculoskeletal disorders [4].

Table 5 shows that there is no significant association between duration of works (POR=1.68; 95%CI= 0.47-5.95) and HAVS complaints. Several previous studies reported the same results [9], [5]. Non-significant results might due to workers exposed to vibration in their previous jobs. We found a significant association between time of exposure (POR=5.23; 95%CI=1.41-19.43) and HAVS complaints. The workers who have > 2 hours for exposure have 5.23 greater risk of having HAV complaints. Similar to our results, previous studies also found the same outcome [12], [18].

The study shows a significant association between PPE usage (gloves) (POR=7.80; 95%CI=2.11-28.77). It can be seen that the workers who did not wear the PPE are at 7.8 bigger risk of having HAV complaints. We also found that the low usage of PPE due to the lack of management support. It is found that the project did not provide the PPE. Although PPE usage is considered the least effective control to hazard, it is advisable to wear it since the PPE can reduce the exposure risk. Our study result similar to the study conducted by Nabila et al. (2019), which stated that there is a significant association between PPE usage and HAVS complaints. The project must provide adequate PPE to tackle these issues [14].

Table 5 indicates that there is no significant association between vibration education and socialization (POR=1.11; 95%CI= 0.33-3.69) and HAVS complaint. It can be said that the workers who never get the information at all are at 1,11 higher risk of having HAV complaints. The cause of these results must be further investigated. However, the non-significant result might because of the socialization and education method dissonance.

A cross-sectional study design was implemented in this study. We choose the method to simplify the data collecting process and enable the collection of all the variables simultaneously. However, as a limitation of the study, the cross-sectional study design cannot comprehend the cause and outcome between variables. To understand the causality relationship between variables, another study design must be implemented in the future research.

Conclusions

It can be concluded from this study that there is a significant association between age, daily vibration exposure intensity, time of exposure, and PPE usage with HAVS complaint. We also found that there is no significant association between duration of work, vibration education, and socialization with HAVS complaint. The company must prioritize these issues since it is also found that the workers' daily vibration exposure intensity is above the permitted regulation. The muffled machine can be installed around the vibration source, which is a concrete vibrator. The project also advised to provide adequate PPE and obligate the workers to wear them during work. Further investigation must be conducted to understand the appropriate education and socialization method.

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