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ORIGINAL RESEARCH ARTICLE

Common occupational machinery hazards in mechanical engineering workshops in TVET institutions in Nairobi metropolitan, Kenya

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Abstract
The metal fabrication sector involves a variety of processes, activities, products, and by-products. This involves various interventions such as milling, turning, welding, drilling, and grinding. Firms in this sector use one or a combination of these interventions where machinery is used, which can expose workers to machinery hazards if proper safety procedures are not observed. Occupational Safety and Health (OSH) is vital in Technical Vocational Education and Training (TVET) institutions, especially in mechanical engineering programmes where metal fabrication is practised. The objective of this study was to assess the awareness of occupational machinery hazards in mechanical engineering workshops in TVET Institutions. The study adopted a descriptive research design and employed a structured questionnaire for data collection. Purposive sampling was used to identify institutions participating in the study. SPSS version 25 was used to analyse the data and present it in tables and graphs. Noise (90.4%) and vibration (71.9%) were reported as the most common occupational hazards, respectively, in mechanical engineering workshops. Regarding workstations, the grinding section (39.4%) and milling section (15.8%) were reported as experiencing high levels of noise. The study recommends that adequate control measures be put in place to mitigate against these hazards.

Key Words: Noise, vibration, grinding, welding, drilling, milling, turning.

1.0 Introduction
Machinery hazards are those that happen at the point of operation and are created when components transmit energy. However, having safe machinery does not guarantee a reduction in work-related accidents. For example, an operator can use a machine to perform work but use it in the wrong manner. Consequently, this may amount to a hazard that can cause an injury; therefore, improved risk communication would negate such mistakes. Notably, metal fabrication is an example of a workplace environment characterised by a high risk of machinery hazards. The metal fabrication sector involves a variety of processes, activities, products, and by-products.

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Therefore, understanding what happens in the enterprise provides insight into the documentation of the hazards present in a work environment. Notably, knowledge of the happenings enables one to foresee possible incidents, injuries, and diseases (Abdalla et al., 2017). This, in turn, guides planning and putting in control measures such as machinery safety for those in the metal sector. Metal fabrication is the process of transforming metal into end or intermediate products such as metal parts or machinery (Abdalla et al., 2017). Hazards within the working environment can be classified as ergonomic, mechanical, electrical, thermal, noise and vibration, hazardous substances, and fire (Rout & Sikdar, 2017). Poor working posture is common in mechanical engineering workshops, which leads to lower back and neck pain. Exposure to these hazards may produce an instantaneous or delayed response, depending on the inherent features of frequency or exposure duration. With prolonged poor posture, workers can develop musculoskeletal disorders (Kipkurui, 2020).

The Occupational Safety and Health Act, 2007, is a provision that ensures Safety and Health for all people lawfully present in a place of work and related matters. Consequently, it is obligatory for an occupier to maintain and provide systems that are safe and pose no risk to the health of workers (Oluoch et al., 2017). Occupiers must ensure the absence of risks in connection with the handling, use, distribution, and storage of substances. Moreover, the dissemination of information, as well as training and supervision, is crucial in maintaining a healthy workforce. In operating plant machinery, protective and preventive measures should be taken to ensure all processes are safe and comply with the provisions of the Safety and Health Act.

While several studies have been undertaken highlighting machinery hazards in the metal fabrication sector, the metal fabrication in training institutions has not been adequately studied to determine the trainers and trainees' awareness of the hazards within the workshops. Inspection reports from the TVET Authority have shown minimal implementation of the Occupational Safety and Health Act, 2007 (OSHA, 2007) in TVET institutions in Kenya, and therefore, there was a need to examine awareness of the occupational hazards that exist within the mechanical engineering workshops in TVET Institutions in Kenya.

Of the few studies carried out on occupational safety and health management in Kenya, few have targeted mechanical engineering workshops in TVET institutions, despite these workplaces high-risk nature. Therefore, this study was important as it ought to establish which hazards commonly presented themselves within the mechanical engineering workshops in TVET institutions. The outcome of this study will provide stakeholders with information that will be useful and necessary in the implementation of workplace safety policies and standards.

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2.0 Materials and methods

2.1 Study design

The study adopted a descriptive research design and employed structured questionnaire for data collection.

2.2 Study population size and area

The study was conducted in Nairobi Metropolis, Kenya, comprising Nairobi, Kiambu, Kajiado, and Machakos Counties. In this study, the target population included all trainers and trainees in Mechanical Engineering programmes, from craft level to diploma level. There were a total of 18 TVET Institutions under the Ministry of Education, State Department of TVET within the Nairobi Metropolitan Region, 7 of which offer mechanical engineering programmes, with a population of 120 trainers and 1648 trainees.

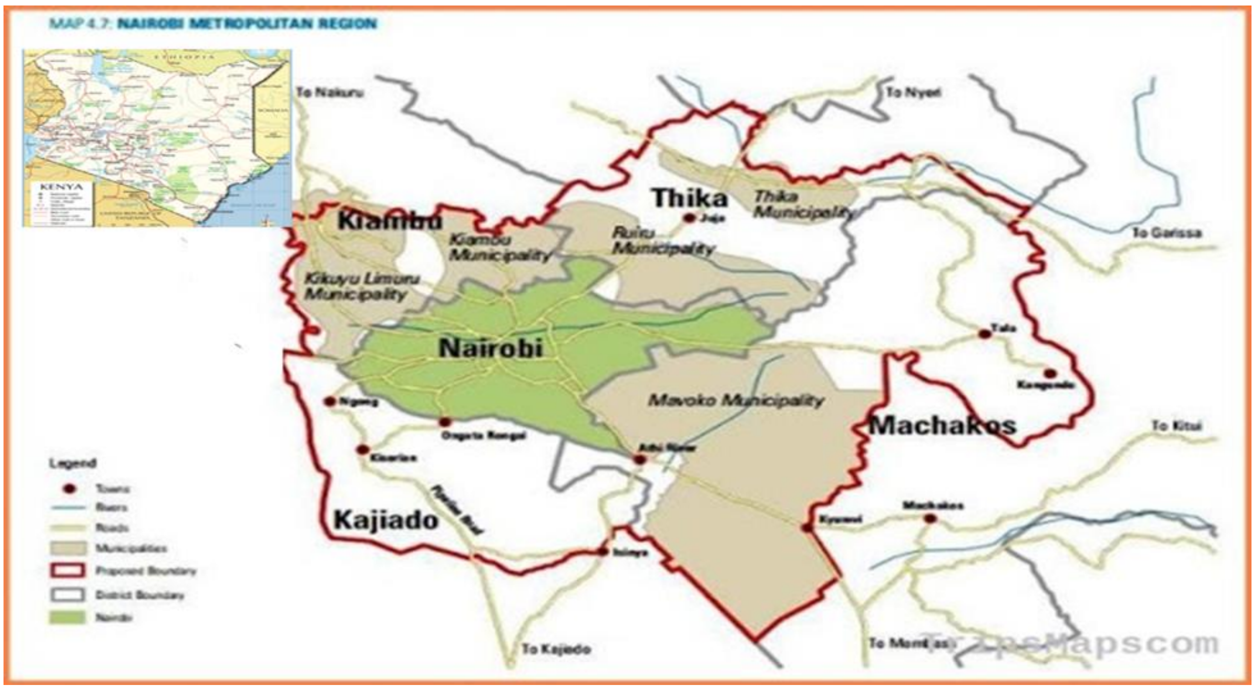

Figure 1: Nairobi Metropolitan Map (source: Google Maps)

2.3 Sample size determination

The sample size was determined using Fischer et al.'s (1998) equation, which takes into account prevalence. However, in the current study, the prevalence of occupational machinery hazards in TVET institutions is unknown, so an assumed proportion of 50% was used.

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2.4. Sampling procedure

Purposive sampling was used to identify TVET Institutions that offer programmes in mechanical engineering. To select participants in each Institution, stratified sampling was done from the sample of each Institution. The strata were in the grinding, welding, drilling, turning, and milling section, with random sampling being applied to select trainers and trainees in each stratum.

2.5 Data collection methods

The study used a structured questionnaire to collect qualitative data. The questionnaire data was coded into the ODK application platform to generate links for the respondents.

2.6. Data analysis and presentation

Cleaned-up qualitative data was coded and entered into SPSS version 25. The data was expressed in terms of tables and graphs.

3.0 Results and Discussion

3.1 Response rate

The study targeted a sample size of 306 respondents, and the response rate was 100%. The methods applied in the data collection process of this study typically have a high response rate due to their convenience and ease of use for the participants.

3.2 Socio-demographic characteristics

The majority of the respondents were male, consisting of 61% trainees, 89.7% trainers, and 75% administrators. With respect to the age of the respondents, the majority of the trainees and trainers were aged between 18 and 35 years, constituting 90.7% and 65.5%, respectively. On the other hand, 100% of administrators were aged over 30 years. Slightly more than half (54.6%) of the trainees reported that they were studying craft courses, whereas the rest (45.4%) were studying diploma courses. With respect to the level of education, most trainers and administrators revealed that a bachelor's degree was the highest education level. At least one trainer reported having attained a PhD, as shown in Table 1.

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Table1. Demographic characteristics of the respondents

	Trainees	Trainers	Administrative Staff (HoDs/ Principals)
	n (%)	n (%)	n (%)
Gender of the respondent			
Female	80 (39.0%)	9 (10.3%)	3 (25.0%)
Male	125 (61.0%)	78 (89.7%)	9 (75.0%)
Age of the respondent			
18-35 years	186 (90.7%)	57 (65.5%)	0
Above 35 years	19 (0.3%)	30 (34.5%)	12 (100%)
Course Level for Trainees			
Craft	112 (54.6%)	NA	NA
Diploma	93 (45.4%)	NA	NA
Level of education for Trainers/Administrative staff (HoDs/Principals)			
Diploma	NA	13 (14.9%)	0
Bachelors	NA	62 (71.3%)	8 (66.7%)
Masters	NA	11 (12.6%)	4 (33.3%)
PhD	NA	1 (1.1%)	0

NA= Not Applicable, n= Number of respondents, HoD = Head of Department

3.3 Awareness of occupational machinery hazards

3.3.1 Common machinery hazards in the workshops

The trainers and trainees were asked to indicate on a Likert scale how they identified the common machinery hazards in the workshop. Generally, trainees (88.3%) and trainers (95.4%) reported noise as the most common machinery hazard found in the working area. Almost three-quarters (71.9%) of trainees (70.7%) and trainers (74.7%) reported vibrations as the most common machinery hazard.

A greater proportion (60.5%) of trainees reported heat/thermal as a common machinery hazard. On the contrary, only a small proportion (29.9%) of trainers had a similar opinion.

Poor ergonomic practises (46.6%), electrical (41.4%), and mechanical (36.6%) were reported as the least common machinery hazards by both trainees and trainers, as shown in Table 2.

A study conducted by Kipkurui reports that poor working posture is common in mechanical engineering workshops, which leads to lower back and neck pain. With prolonged poor posture, the workers, especially the trainers, can develop musculoskeletal disorders. (Kipkurui, 2020)

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Table 2: Machinery hazards reported within the mechanical workshops

	Trainee		Trainer	
	Least Common	Most Common	Least Common	Most Common
	n (%)	n (%)	n (%)	n (%)
Noise	24(11.7%)	181(88.3%)	4(4.6%)	83(95.4%)
Vibrations	60(29.3%)	145(70.7%)	22(25.3%)	65(74.7%)
Heat/Thermal	81(39.5%)	124(60.5%)	61(70.1%)	26(29.9%)
Poor Ergonomic Practices	110(53.7%)	95(46.3%)	46(52.9%)	41(47.1%)
Electrical	121(59.0%)	84(41.0%)	50(57.5%)	37(42.5%)
Mechanical (abrasion)	130(63.4%)	75(36.6%)	55(63.2%)	32(36.8%)

3.3.2 Workstation experiencing elevated noise in the workshops

Regarding workstations experiencing high levels of noise, both trainees and trainers reported grinding sections (39.4%), milling sections (15.8%), drilling sections (13.0%), welding sections (7.2%), or turning sections (7.2%) in that respective order to be experiencing high levels of noise. Trainees reported the grinding section (49.3%), milling section (16.1%), drilling section (15.6%), turning section (7.3%), and welding section (6.3%) to be experiencing high noise in that respective order. On the other hand, trainers reported grinding sections (16.1%), milling sections (14.9%), welding sections (9.2%), turning sections (6.9%), or drilling sections (6.9%) in that respective order as the most common workstations experiencing high-level noise, as shown in Table 3 below.

Table 3: Workstations experiencing high level of noise

	Trainee		Trainer	
	Most Common n (%)	Least Common n (%)	Most Common n (%)	Least Common n (%)
Welding section	13(6.3%)	192(93.7%)	8(9.2%)	79(90.8%)
Turning Section	15(7.3%)	190(92.7%)	6(6.9%)	81(93.1%)
Milling Section	33(16.1%)	172(83.9%)	13(14.9%)	74(85.1%)
Drilling Section	32(15.6%)	173(84.4%)	6(6.9%)	81(93.1%)
Grinding Section	101(49.3%)	104(50.7%)	14(16.1%)	73(83.9%)

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Hand-arm vibration exposure (HAV) causes direct injury to the fingers and hands, affecting dexterity and grip, while Whole-body vibration (WBV) is associated with lower back pain (House, 2016).

A high proportion (87%) of the respondents indicated that they use hand tools that generate vibration while at work, constituting 83.4% of trainees and 95.4% of trainers, as shown in Figure 2.

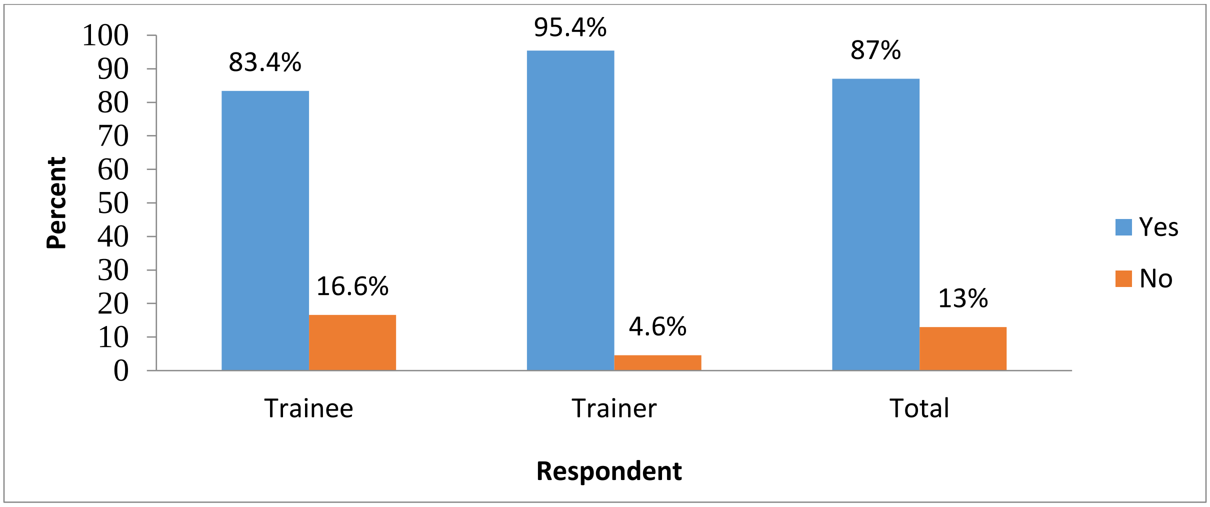

Figure 2: Use of hand tools (Hand-arm body vibration)

4.0 Conclusion

The study established that most trainees and trainers were aware of the various hazards within the workstations, with noise and vibration being the most common reported hazards.

5.0 Recommendation

The institutions should put in place control measures as provided by the Factories and Other Places of Work Act (Noise Prevention and Control) Rules L.N. 25 of 2005.

6.0 Acknowledgement

6.1 General acknowledgement

By outlining the goals and the method of the study, informed consent was ensured. TVET institutions were given the assurance that the information would only be used for academic reasons.

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6.2 Declaration of interest

A research licence was obtained from the National Commission for Science, Technology, and Innovation (NACOSTI), and ethical approval was received from the ethical review committee at Jomo Kenyatta University of Agriculture and Technology.

6.3 Conflict of interest

None.

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