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Journal of Occupational Safety and Health

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- Publishes original research reports, topical article reviews, book reviews, case reports, short communications, invited editorial and letter to editor.
- Welcomes articles in occupational safety and health related fields.

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Contents

Introducing the Journal of Occupational Safety and Health

The National Institute of Occupational Safety and Health (NIOSH), Malaysia is delighted to announce the publication of Journal of Occupational Safety and Health (JOSH).

JOSH is devoted to enhancing the knowledge and practice of occupational safety and health by widely disseminating research articles and applied studies of highest quality.

JOSH provides a solid base to bridge the issues and concerns related to occupational safety and health. JOSH offers scholarly, peer-reviewed articles, including correspondence, regular papers, articles and short reports, announcements and etc.

It is intended that this journal should serve the OSH community, practitioners, students and public while providing vital information for the promotion of workplace health and safety.

Apart from that JOSH aims:

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JOSH is poised to become an essential resource in our efforts to promote and protect the safety and health of workers.

From the Chief Executive Editor

Workplace safety and health is a priority. However, there is still more to be done to foster the safety culture and awareness among us. The imperative focus is our commitment to take action and make the necessary changes to ensure that safety and health is the top priority for everyone.

Journal of Occupational Safety and Health (JOSH) - plays significant roles in disseminating and promoting good practice of safety and health at workplace.

For this edition, it is important to highlight the article titled "Risk Assessment and Roles of Stakeholders for Frame Scaffolding Procedures in Construction Projects". This will help reduce the occurrence of scaffolding accidents on construction sites that may result in fatalities or severe injuries. DOSH's report shows that between 2012 and 2020, a total of 13 scaffolding-related fatalities were reported. Of the total number, 8 cases were caused by the lack of Safe Operating Procedure (SOP). This study can help reduce the number of accidents in the future as it has recommended ways to improve the SOP. Among others, the improved SOP should include risk assessment on the scaffolding system which may prevent the collapse of the whole structure. Based on the study, four categories for the cause of scaffolding collapse are the organisational, technical, human and environmental factors.

We hope that the journal's contents will be referred to and reviewed by a wider audience, allowing for a vast academic base to further expending the subject for the betterment of workers and working environment. We aspire that the journal will be advantageous to all readers, as our objective is to serve the interest of everyone across all industries. Therefore, the prime focus will be on issues that are of direct importance to our everyday practices at workplace.

Haji Ayop Salleh
Chief Executive Editor

Original Article

Risk Assessment and Roles of Stakeholders for Frame Scaffolding Procedures in Construction Projects

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ABSTRACT : *Scaffolding accidents occur every year on construction sites in Malaysia, and most of these accidents result in fatalities or end with severe injury. Department of Occupational Safety and Health (DOSH) declared that between 2012 and 2020, 13 scaffolding-related fatalities were reported, and 8 cases were caused by the lack of Safe Operating Procedure (SOP). This study aims to recommend an improved SOP that prevents the collapse of the scaffolding system based on the risk assessment on the failure of the scaffolding structure. This study applied a qualitative design by conducting semi-structured interviews with selected parties that their daily work routine relates to scaffolding works. The data were analyzed using ATLAS.ti to detect network failures and factors related to the causes of scaffolding collapse. The result showed that one of the hazards of scaffolding collapse is caused by unstable structures, which are associated with Organization, Technical, Human, and Environment factors. Based on the 14 hazards caused by unstable structures, ten hazards were identified in the category of non-compliance with SOP. Therefore, an improved SOP with an emphasis on compliance with all requirements is recommended ensuring the safety of all riggers, workers, and project team members. In addition, five checklists are recommended, which include two relevant additional procedures obtained during the data collection.*

Keywords - *Construction, Defect Component, Frame Scaffolding, Risk Assessment, Safe Operating Procedure*

1.0 INTRODUCTION

Cases of scaffolding accidents at construction sites in Malaysia are most often published in local newspapers and are searchable through online mediums (Hamdan, 2015). According to Bozena Hola et al. (2017), 43% of scaffold accidents resulted in fatal results, and 23% ended with severe injury. As reported in The Star Online on 10th March 2018, a foreign worker died caused by falling scaffolding at the Jinjang MRT Project site (Online, 2018). Two months before, on 10th January 2018, one worker was injured at the Kajang construction site due to scaffolding collapsing. (Malaymail, 2018). Department of Occupational

Safety and Health (DOSH) has declared that there were 13 fatal cases from the year 2012-2020 related to scaffolding, and 8 cases were due to the absence of Safe Operating Procedure (SOP) (DOSH, 2020a). Besides investigating fatality cases, DOSH also takes legal action against companies that violate the acts and requirements. There were 11 prosecution cases on scaffolding offenses recorded for 2014-2020, and 2 cases were fined due to the failure to provide the SOP. According to DOSH (2008), a hazard is defined as a source or situation with the potential to harm which may cause injury or ill health to humans, damage to properties, damage to the environment, or any combination of these. Hazards do appear during the operational works of scaffolding and identifying the potential hazards is important as effective control measures during the construction process could be implemented to prevent losses (Herda Balqis Ismail, 2012). The operational works of scaffolding during the construction phase can be divided into three stages. It starts with the erection stage, operation stage and end with the dismantle stage. As stated in Building Operations and Works of Engineering Construction (BOWEC) Regulations, Regulation 74 and Clause 5.4.3 (1) of Construction Industry Standard (CIS) (CIDB, 2017), any erection, modification, and maintenance of scaffolding shall be done by qualified or competent scaffolders with direct supervision from a competent designated person who engaged by the contractor.

1.1 Operational Hazards for Scaffolding

A few studies (Hamdan, 2015; Herda Balqis Ismail, 2012; Salim Mkubwa Salim, Fairuz I. Romli, Jailani Besar, & Aminian, 2017) have found that potential for a fall is the common hazard for scaffolding. According to the study done by Herda Balqis Ismail (2012), there are seven types of potential fall hazards. There is a risk of falling while erecting or dismantling a scaffold, depending on the environmental conditions, such as stepping on other tools, falls due to limited area, falls due to material handling and equipment, and falls due to unstable structure. The potential hazards of falling from a scaffold occur due to numerous functions and applications of scaffolding during the erection, operation, and dismantling.

In another study done by Kim et al. (2016), accidents related to scaffolding or staging account for a large number of the causes of safety hazards. The study states that in 2009, there were 54 fatalities of falling from scaffolds and making it one of the leading causes of fatalities and injury cases. In addition to falling, other types of hazards such as objects falling from scaffolds, electrocution, and spatial conflicts with construction activities are also caused by improper planning and use of scaffolds. This is supported by Shou et al. (2015), where fall and item dropping are the common hazards while working on a scaffold. Another study conducted by Hsiao (2008) found five major categories for the most common causes of falls, known as hazards related to the scaffold usage during its operation. They are: (1) Scaffold tipping or failure of the structure such as insufficient anchoring into the walls, improper assembly of the scaffold, unsecured bracing, loading beyond designed capacity, and failure under the stress of scaffold components, (2) breaking of planks, gapping, and slipping which caused by heavy loads, physical damage to the plank, misinformation about the type or rating of the plank, insufficient overhang of the bearers, unsecured planks, lateral movement of the planks and missing planks, (3) unguarded scaffold that contains a missing guardrail and insufficient cross bracing, (4) complicated access or transition to or from a scaffold, and(5) problems with scaffold erection and dismantling resulting from environmental conditions, scaffold unit weight, and handhold availability. It is shown that most of the studies listed above have found that falling is the most popular hazard during the operation of scaffolding works.

1.2 Factors of Scaffolding Collapsed

Several factors influence accidents in construction sites, and they vary from time to time, which is challenging to be identified. In some cases, the collapses were due to improper assembly, while some failed to support loads placed on it (Hamdan, 2015). According to Safe Operating Procedure (SOP), a proper erection must prevent collapse as the collapsed structure becomes hazardous. The falling objects may harm the people who work below the scaffolds. Lack of appropriate knowledge and skills of the responsible person who was assigned to look after the safety and health issue is the major cause identified (Norzalili Abu Bakar, 2008). Another study states that the main factors which contribute to scaffolding accidents are the lack of appropriate scaffold components, body movement while working on the scaffolding, inadequate capacities, and failure to comply with the usage of personal protective equipment (PPE) (Chi, Chang, & Ting, 2005; Hamdan, 2015; Herda Balqis

Ismail, 2012). For working at height, complying with PPE usage becomes very important as part of the Safe Operating Procedure (SOP). The study conducted by Hamdan (2015) concludes that scaffold accidents are categorized into four main elements: technical factors, environment, organization, and human. Technical aspects become the most common factors for scaffold accidents (Hamdan, 2015). It is supported by Anna Hola (2018), the most common technical factors in scaffolding accidents are the use of faulty components, uninformed modification of the structure, lack of barriers, and easily detectable structural errors. It is concluded that those technical factors are contradicted by SOP. The human element is in line with a study done by Soane (2016), as common reasons for collapses have been identified caused by human factors such as ignorance, lack of supervision and training, negligence, and corruption. Supervision during the work is part of the SOP required by Regulation 74 of BOWEC Regulations (DOSH, 2011). The environment factor is caused by weather, working surface, ground conditions, material handling, and falling objects. This is supported by Bozena Hola et al. (2017), where a strong wind gust causes the scaffolding structure's collapse. According to I. Szer (2018), the unfavorable environmental conditions that influence workers' behavior on scaffolding may also lead to untoward incidents.

Based on the operational hazards of the scaffold and the factors that cause the collapse of the scaffolding, this study was conducted to assess the risk of damage to the scaffold structure and propose improved Safe Operating Procedures (SOP) to prevent the collapse of the scaffold system.

2.0 METHOD

2.1 Data Collection

This study applied a qualitative design to explore risk assessments and stakeholder roles for frame scaffolding procedures in construction projects. A semi-structured interview was conducted with selected Project Managers, Safety Personnel, Scaffold Inspectors, Scaffold Riggers, and officers from the Department of Occupational Safety and Health Department (DOSH), whereby their daily work routine was related to the scaffolding works. This study involved 15 personnel with three project sites, as shown in Table 1, and Table 2 shows the questions sent to these five parties. As a result, operational hazards for scaffolding systems and factors that contribute to scaffolding collapse have been identified. In addition, a review of legal requirements, standards, guidelines, and a directive letter was issued to recommend an improved Safe Operating Procedure (SOP) to prevent the collapse of scaffolding. Those requirements such as Factory and Machinery Act (FMA) (BOWEC) Regulations, CIDB CIS 22:2017, and MS 1462 are mandatory requirements for scaffolding works in Malaysia. Other than that, guidelines and a directive letter from DOSH’s Director-General serve as additional requirements for the scaffolding works.

Table 1 Informant Profile for Semi-Structured Interview

Organization/ Project Title	Informant	Designation / Role
Contractor of project: Cadangan Membina 120 Unit Rumah Teres 3 Tingkat	1	Project Manager
	2	Site Safety Supervisor
	3	Scaffold Inspector
	4	Scaffold Rigger
	5	Project Manager
	6	Site Safety Supervisor

Contractor of the project: Proposed Design and Build of Reinforced Concrete Open Sequential Batch Reactor (SBR) Sewerage Treatment Plant	7	Scaffold Inspector
	8	Scaffold Rigger
	9	Project Manager
Contractor of the project: Proposed Elevated Water Tank	10	Safety and Health Officer
	11	Scaffold Inspector
	12	Scaffold Rigger
DOSH Negeri Sembilan	13	Section Head of Construction Site Unit
DOSH Wilayah Persekutuan Kuala Lumpur & Putrajaya	14	Section Head of Construction Site Unit
	15	Officer of Investigation and Prosecution Unit

Table 2 Questions for Semi-Structured Interview

Personnel/ Party	Question
Project Manager	1) Why is scaffold SOP important?
	2) Who can erect, alter and dismantle the scaffold other than the scaffolder?
	3) How many times do incidents related to scaffolding occur during this project?
Safety and Health Officer/ Site Safety Supervisor	1) How many scaffolding incidents have been investigated?
	2) How do you ensure that the Scaffold Inspector is competent?
	3) How fast is the action taken after receiving any comments from the inspection?
Scaffold Inspector	1) Which legal requirements and standards do you refer to for scaffold works?
	2) What is your reference during the inspection?
	3) What are the most common issues when a scaffold is red-tagged?
Scaffold Rigger	1) What is your reference during erection, alteration, and dismantling works?
	2) What level of competency do you obtain from DOSH?
	3) How do you ensure that all materials used are in good condition?
DOSH Officer	1) Why did the scaffold accident keep occurring every year?
	2) What type of scaffold normally collapses or is involved in an accident?

3) How many scaffolders are currently registered with DOSH?

2.2 Data Analysis

ATLAS.ti is a tool used to visualize the connection for all findings gathered from interviews. The abbreviation ATLAS.ti stands for “Archiv für Technik, Lebenswelt und Alltagssprache” (Archive for Technology, the Life World and Everyday Language) and the extension “ti” stands for “text interpretation.” (Susanne Friese, Jacks Soratto, & Pires, 2018). ATLAS.ti supports the researcher during the data analysis process, where texts are analyzed and interpreted using codes and annotations. This software also has a network-building feature, where it allows one to visually connect selected texts, memos, and codes using diagrams (Smit, 2002). Through ATLAS.ti, the researcher can perform process analysis at different study phases and validate the data collected through informant interviews to identify major and minor categories or themes. In addition, ATLAS.ti facilitates the code-recode method, which is a means to increase the credibility and reliability of the study (Mohamed Amin Embi, Chooi Kean Ang, & Yunus, 2016). Codes assist in organizing, structuring, and retrieving data, supporting the identification of a theme (Smit, 2002; Susanne Friese et al., 2018). After the coding process, the data are compared, and related events are grouped with the same conceptual label. The process of grouping the data is termed categorization. A phenomenon can represent a category, for example, a problem, an event, or an issue defined as important by the respondents or informants. It is related to its subcategories to form a more precise and wide-ranging explanation of the phenomena. Categories can also be found through relationships between where, how, when, why, and who (Smit, 2002). In general, capital letter codes such as ORGANIZATION, HUMAN, TECHNICAL, and ENVIRONMENT based on this research represent most categories whereby most are no longer coded. The idea is for the category label to be served as a title, and all data are distributed in the sub-codes of that category (Susanne Friese et al., 2018). The researcher can form network views among the codes and categories by using Network View and Family Manager functions. The files for each subject case can be saved as graphic files (Mohamed Amin Embi et al., 2016).

3.0 RESULTS

3.1 Network of Failure Factors by ATLAS.ti

Based on findings from the interview, there are 47 codes derived using the ATLAS. The software. All codes and categories are first recorded in the theme table. Four factors set as categories for the cause of scaffolding collapse are the organization, human, technical, and environment.

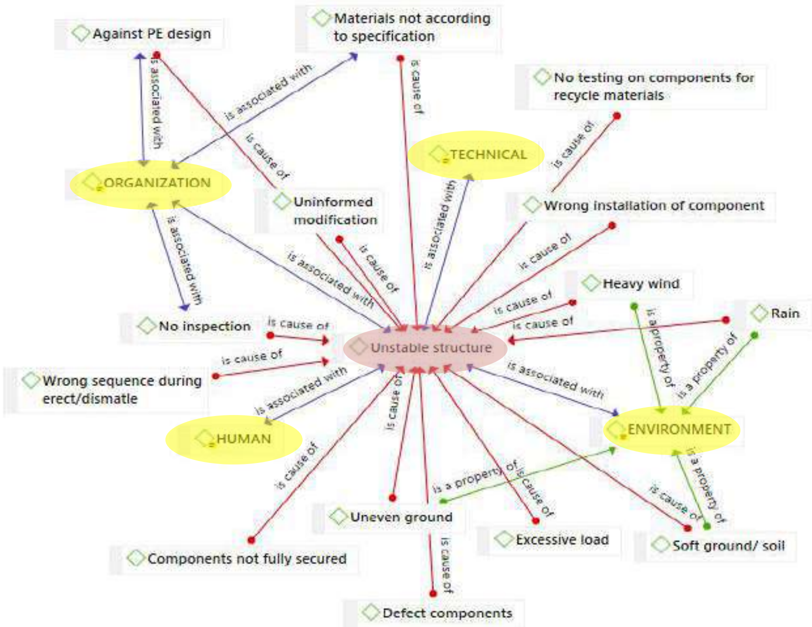

Figure 1 Failure Factors Which Associate with Unstable Structure

As shown in Fig. 1, four categories and factors are associated with unstable structure, while 14 codes or hazards cause unstable structure. Under environmental factors ' properties, there are four potential hazards: uneven ground, heavy winds, soft ground/soil, and rain. As for technical factors, the four potential hazards are failing to carry out a test for recycled components, non-sequential for the erection and dismantling process, installation of wrong components, and excessive load that causes unstable structure. Excessive load is attributed to organizational factors. It is due to less supervision and permits workers to carry out materials that exceed the permitted load. The other four hazards associated with organization factors are materials not according to specification, defect components, fails to carry out inspections, and against PE design. Other than appearing in the organization factor, against PE design is one of the hazards associated with human factors that cause the unstable structure. The other four hazards related to human factors are components not fully secured, the wrong sequence during erect or dismantle, incorrect component installation, and uninformed modification, which leads to an unstable structure.

3.1.1 Organization Factors

There are ten codes or hazards associated with organizational factors. The unstable structure is caused by the five hazards: against Professional Engineer (PE) design, excessive load, defective components, materials that do not meet specifications, and failure to perform the inspection. Against the PE design, which is also supported by several studies (Chi et al., 2005; Hamdan, 2015; Herda Balqis Ismail, 2012) caused by the urgency of works (Informant 5, 7) and the absence of PE during on-site installation, which sometimes the design does not apply to the site conditions (Informant 7, 11, 14). The unstable structure, which is caused by the excessive load (Informant 14) and defective components (Informant 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15) (Anna Hola, 2018; Hsiao, 2008) is due to less supervision during work. Less supervision that causes the collapse of scaffold structure is also found in several studies (Chi et al., 2005; Hamdan, 2015; Herda Balqis Ismail, 2012). In terms of technical factors, excessive load is caused by poor PE design due to the lack of scaffolding components installed (Informant

9). Materials that do not comply with specifications are using different sizes of components that do not fit each other (Informant 4, 10, 13) and using thinner components that do not comply with MS 1462. According to Informant 2, 6, 7, and 11, failure to inspect as required is also one of the causes of unstable structures (Błazik-Borowa & Szer, 2015; Hamdan, 2015; Hsiao, 2008; Soane, 2016). Another hazard related to organizational factors is inappropriate planning stated by Kim et al. in his study and violated the SOP and Regulation in another study (Amall Raihan Abdul Razak, 2017). In addition, incompetent scaffolders and workers' failure to comply with scaffolding rules are due to a lack of training, as mentioned in several studies. (Norzalili Abu Bakar, 2008; Soane, 2016).

3.1.2 Human Factor

Three codes or hazards are associated with human factors, while unstable structures cause five. Based on studies (Soane, 2016), corruption exists in scaffolding works, and it is associated with the human factor. Ignorance is another hazard that associated with human, and it happens due to low awareness of SOP compliance (Informant 3, 7, 9) and on the use of PPE (Informant 4, 7). Less awareness about PPE usage was also proven in several studies (Norzalili Abu Bakar, 2008; Soane, 2016). The unstable structure is also associated with human factors, where uninformed modification caused by humans is tremendously supported by 11 informants (Informant 1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 12) and in a few studies (Anna Hola, 2018; Błazik-Borowa & Szer, 2015; Hamdan, 2015). The other hazards that cause unstable structure are where components are not fully secured due to human negligence (Informant 1, 4, 10). This is supported by few studies (Hsiao, 2008; Soane, 2016). As admitted by Informant 3 in the study, against PE design is related to humans (Hsiao, 2008). As declared and supported in a study, falling objects are caused by human action (Shou et al., 2015).

3.1.3 Technical Factor

According to few studies, the technical factor contributes to the scaffolding accident during construction (Anna Hola, 2018; Hamdan, 2015). The unstable structure is the only code or hazard associated with technical factors. Operating work without SOP is part of the technical factor. Based on this study, two hazards that occur due to the absence of SOP is improper installation of the scaffold component (Informant 9, 15) and wrong sequence of erection and dismantling (Informant 1, 5, 6, 7, 9, 11, 14, 15) which lead to an unstable structure. Apart, the excessive load due to poor design by PE also caused an unstable structure whereby an accident occurs for this reason, as declared by informant 9. Besides, failure to conduct testing on the recycle component (Informant 11, 13) is also related to technical factors, leading to an unstable structure.

3.1.4 Environment Factor

There are three codes or hazards associated with environmental factors. Four of the hazards are rain (Informant 4, 5, 7, 8, 9, 11, 12, 13, 14, 15), soft ground or soil (Informant 1, 2, 3, 5, 8, 11), uneven ground (Informant 1, 3, 5, 8, 9, 10, 11, 13) and heavy winds (Informant 3, 8, 9, 10, 11, 14, 15). As described, environmental properties also cause unstable structures (Bozena Hola et al., 2017). According to Informant 1, 3, 4, 5, 11, and 13, working at height is associated with the environment, the main cause of falling from height is supported by several studies (Hamdan, 2015; Herda Balqis Ismail, 2012; Salim Mkubwa Salim et al., 2017). Slippery surfaces of rain and objects falling due to heavy winds are hazards reported by Informant 12. Poor housekeeping is also one of the hazards associated with the environment where it is found that components are scattered or hung up to others (Informant 13). In some situations, Hsiao stated in his study that the difficult access could be due to poor housekeeping.

4.0 DISCUSSION

From this study, the unstable structure was found as a hazard that led to a scaffolding accident. It relates to 15 hazards interrelated in four factors: Organization, Human, Technical, and Environment (Hamdan, 2015). One of the hazards that causes unstable structure is component defects. Based on this study, 93% of the informants (Anna Hola, 2018; Hsiao, 2008) supported by the research found that component defects are a common hazard of scaffold collapse. Defect components associated with the Organization factor are also one of the elements related to SOP compliance. Data (DOSH, 2020a, 2020b) showed fatality and prosecution cases related to SOP ignorance. The investigation outcome shows that some of the organizations were found operating their business totally without SOP while some were non-compliance with the developed SOP. It is strongly supported by DOSH officers, Informant 13, 14, and 15 during the interview session that scaffold accident is commonly due to violation of SOP and requirements. Therefore, all parties, especially those from the site, the project owner, the project management team, and the authorities, must develop a comprehensive SOP, implement the SOP at the best standard, and enforce the regulations related to the SOP for frame scaffold works.

4.1 Roles of Stakeholders

The project owner is generally known as the client in a project. The project owner refers to the person or group who provides financial resources for project delivery, approves project milestones and completion, is accountable for project investment, and obtains value from the operation of the facility delivered (J. Rodney Turner & ller, 2004). In the planning and design stage, the project owner is responsible for providing the design team with a site, project scope, and any required information needed to complete the project design. The project scope and requirements must be clearly communicated to the design team to ensure that the design meets the owner's goals, expected quality and is within the prescribed budget. Usually, the owner works closely with the design team to ensure that the desired design is achieved. To ensure the designers address safety aspects in their designs, the project owner must communicate with the designer during the design phase (Gambatese, 2000b). While, during the construction phase, the project owner’s responsibilities are different from the planning and design phases. In the construction phase, the duties of the project owners included selecting qualified contractors, providing the necessary construction documents, coordinating the project team, and paying the contractor for the work completed. Conventionally, construction site safety has become the individual concern of contractors (Gambatese, 2000a) and the responsibility of safety personnel (Mohanad K. Buniya et al., 2020). Owners and other consultants did not play an active role in safety as to a great extent that there is no teamwork and cooperation in safety implementation. This makes the contractor's role become the primary employer in the job site and control the means and methods. (Gambatese, 2000a).

Conventionally, design professionals usually focus on the end user's safety for a product only and do not address the safety aspects in their project designs during the construction stage (Gambatese, 2000b). Although time flies, unfortunately, this culture continues to exist in several projects until now. The OSHA standard specifically includes requirements in which the services of professional engineers are mandatory for the analysis and design of temporary building structures such as scaffolding, shoring, and earth-retaining structures (T. Michael Toole, 2005). In Malaysia, the relevant laws and regulations may refer to the 1967 FMA, Article 28, and Article 75 of the BOWEC. During the interview, experiences were shared from informant nine, and an accident occurred in which the scaffolding collapsed due to the poor design by Professional Engineers. The design influences construction means and methods and directly affects the construction safety hazards that exist in the workplace. If designers are aware of the safety implications of their designs and pay attention to them, they can improve the inherent safety of construction projects. The designer's consideration of safety on the construction site can reduce accidents and related costs, such as redesign costs and operating costs for special procedures and protective equipment (Gambatese, 2000b). Communication between the designer and other project team members, such as project managers and security personnel, is also important because it can enhance safety during the design stage. Providing designers with information about how design affects workplace hazards will allow safety aspects to be included in the design process.

When enforcing any law, there must be a set of jurisdictions that will enable individuals or agencies to take action. Jurisdiction also gives rights to each person or agency by taking their authority according to the limits. Occupational Safety and Health (OSH) law in Malaysia is enforced by the Department of Occupational Safety and Health under the Ministry of Human Resources. Continual efforts are needed to improve the quality of administration and management of systems related to the implementation of OSH law, particularly the implementation in the BOWEC Regulations, Regulations 72-98, which focuses on scaffolding requirements for construction works. Any weaknesses and shortcomings of the laws need to be addressed. Thus, every action can be carried out professionally and prudently.

4.2 Improved Safe Operating Procedure

The enhanced SOP was generated from this study in the form of a checklist. Non-compliance in the checklist indicates the non-compliance to SOP, which must be rectified accordingly at the specified stage. Five checklists are drawn from this study, each of which includes requirements for frame scaffolding works in that particular stage. The main elements of the checklist are Requirements for Frame Scaffolding, Components Inspection (Checklist 1), Erection, Alteration and Dismantle of Scaffolding (Checklist 2), Operation on Frame Scaffolding (Checklist 3), Structure Inspection (Checklist 4), and Maintenance and Storage of Frame Scaffolding (Checklist 5).

The data gathered during the interview show that it is important to add several relevant procedures to enhance the existing SOP. Most of the additional procedures were proposed by an authorized representative, DOSH officers. The procedures concern continuing education and refresher program for scaffolders and the attendance requirements of a Professional Engineer (PE). Both requirements are added to checklist 2, which requires the latest date of scaffolding training participated by the designated person and. PE and to acknowledge the work performed on-site. As stated in the Guidelines on the Role and Responsibilities of Professional Engineers for Temporary Work during the construction stage (BEM, 2015), PE shall design and supervise Temporary Works according to the relevant standards, codes of practice, and good engineering practice, as stated in Section 5.0 (4). In addition, PE needs to be presented during the installation process to ensure the design meets with the on-site installation. This is to encounter any problems during the installation, such as the suitability of the design with actual conditions.

As shown in Fig. 2, the availability of design drawings and calculations that PE endorses is very important. This will be a reference at the site and is mandatory in CIS 22 Clause 5.3.3. When the scaffolding components and materials arrive on site, the components and materials will be received and recorded by a designated person appointed by the contractor. The designated person then inspects the components. As required in BOWEC 74(2), all materials used for scaffolding construction shall be inspected by the designated person before use. In CIS 22:2017 Clause 5.4.1, all scaffolding components and materials arrived at the construction site must be physically inspected, and the designated person must carry out proper marking. In other requirements, MS 1462-1, Clause 9. 3 states that the frame scaffolding components used at the site must be well inspected, and the conditions of the components should be recorded by qualified personnel or a competent scaffolder. PETW must approve this inspection.

In the case of damaged components, they will be discarded as required in CIS 22, Clause 5.4.1. If the result of the quality checking on random sampling complies with MS 1462-1, the components can be used for the erection of the structure at the site. Components that fail to meet the quality standard will be discarded. The inspection and maintenance of the scaffolding structure are carried out appropriately during the operation of the work by a designated person. This is to ensure that the structure is safe for the workers working on it. If any non-compliance with the procedures, the structure shall be altered, re-inspected by the designated person, and approved safe by PETW before being used. After completing the scaffolding work, the scaffolding structure can be dismantled. However, it is suggested that the structure be inspected before dismantling to ensure its stability. Upon completing the dismantling stages, all components shall be properly stored according to the procedure outlined in Checklist 5. It may be necessary to clean and dry the components before storage. Those components that are badly corroded, damaged, and cannot be repaired must be disposed of and adequately recorded.

5.0 CONCLUSION

Working on a frame scaffolding system for riggers or workers is a high-risk job, where most accidents cause fatality. From this study, there are 26 hazards found in scaffolding works. With a risk score of 25, the defective component ranked top among all other hazards. There are three risk levels of hazards. Ten hazards are at high risk, 12 are at medium risk, and four are at low risk. There were 12 hazards found during erection, 13 during operation, and 11 during the dismantling process. The unstable structure is considered one of the hazards that cause the scaffolding to collapse and is associated with four factors, Organization, Technical, Environment, and Human factors. A defective component is one of the hazards that cause an unstable structure and is one of the non-compliance with SOP. Therefore, an improved SOP is recommended for this study by emphasizing the compliance of all requirements to ensure the safety of all riggers, workers, and project team members. As an improved SOP, five checklists are recommended, including two relevant additional procedures obtained during data collection. It is hoped that the improved SOP can achieve the important goal of this study. The enhanced SOP will be a reference in construction to prevent the collapse of the scaffolding system and reduce the number of losses, injuries, and property damage.

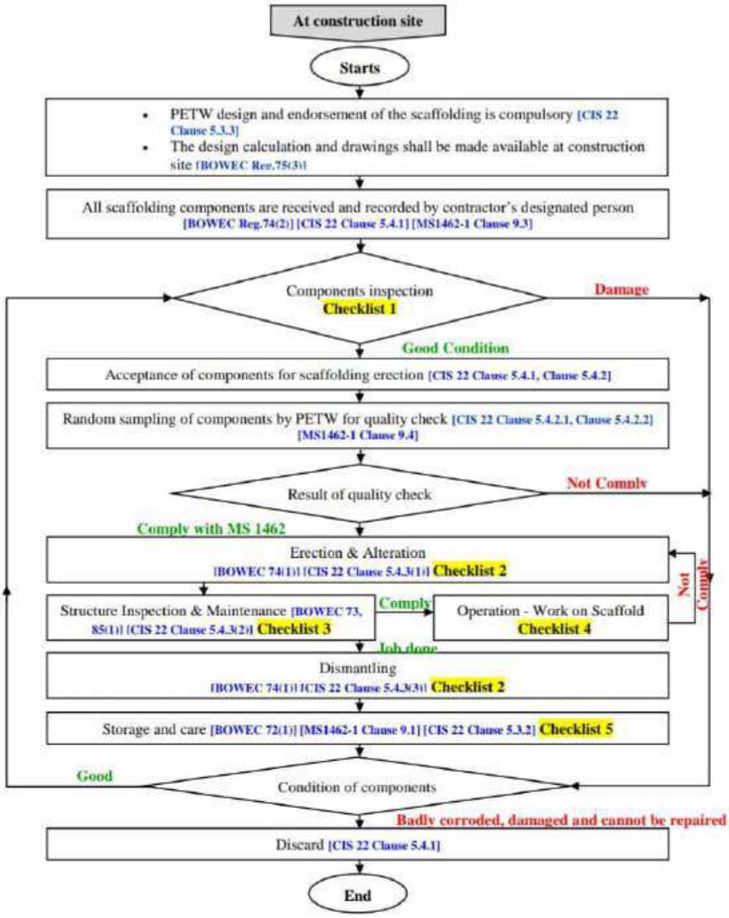

Figure 2 Process Flowchart for Scaffolding Works

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Original Article

Hearing Conservation Program for Vector Control Workers: Short-Term Outcomes from a Randomized – Cluster Controlled Trial

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ABSTRACT : *Noise-Induced Hearing Loss (NIHL) is one of the highest recorded occupational diseases, despite being preventable. The purpose of this study was to determine the effectiveness of a Hearing Conservation Program (HCP) in preventing or reducing audiometric threshold changes among vector control workers. This is a cluster randomized controlled trial involving 183 vector control workers. The HCP was implemented among participants of the intervention group. Audiometric threshold changes observed in the intervention group showed improvement in hearing threshold levels for all frequencies except 500 Hz and 8000 Hz for the left ear. The hearing threshold changes range from 1.4 dB to 5.2 dB, with the largest improvement at higher frequencies, mainly 4000 Hz and 6000 Hz. Meanwhile, the mean hearing threshold level remained similar for the right ear at 4000 Hz and 6000 Hz after three months of intervention. Thus, the HCP is effective in preserving the hearing of vector control workers involved in fogging activities.*

Keywords - *Audiometry, Hearing Conservation, Noise-Induced Hearing Loss, Program Evaluation, Vector Control Worker*

1.0 INTRODUCTION

The burden of occupational Noise-Induced Hearing Loss (NIHL) remains on the rise, especially in developing countries. It has been reported that 16% of the global adult-onset hearing loss or over 4 million Disability-Adjusted Life Years (DALYs) is attributed to occupational noise exposure (Dobie, 2008; Nelson, Nelson, Concha-Barrientos, & Fingerhut, 2005). In Malaysia, NIHL was the highest reported occupational disease in 2017, accounting for 63.7% of all occupational diseases (Department of Occupational Safety and Health, 2018). The burden of NIHL in the manufacturing sector showed workers were at high risk of developing NIHL, with the highest risk of 32% seen in the motor vehicle parts industry (Noraita, Syed Mohamed, Jamal Hisham, & Jaseema, 2014). Although NIHL is preventable, it remains of high public health importance due to the increasing burden.

Vector control workers are responsible for carrying out fogging activities as part of an integrated vector control approach recommended by the World Health Organisation (WHO) for dengue prevention and control (World Health Organization, 2012). They are exposed to noise emitted by fogging machines putting them at risk of developing NIHL. It has been reported that the fogging machines emit noise levels above 90 dB(A) at a distance of 0.5m (Masilamani, Rasib, Darus, & Ting, 2014). Furthermore, exposure to ototoxic chemicals such as organophosphate pesticides and diesel (diluent) during fogging activities may synergistically exacerbate hearing loss (Hoshino, Pacheco-Ferreira, Taguchi,Tomita, & Miranda, 2008; Sheikh, Williams, & Connolly, 2016). In addition to the auditory effects, mainly hearing loss, noiseexposure may also cause non-auditory effects on health such as anxiety, hypertension, cardiovascular diseases, and impaired cognitive performance (Basner et al., 2014). Furthermore, NIHL is associated with reduced quality of life due to social, emotional communication hindrance (Mulrow et al., 1990).

Many local studies have been conducted to determine the prevalence and associated factors of NIHL among various occupation groups such as quarry workers (57%), airport workers (33.5%), dental staff nurses (5%), traffic police personnel (80%) and vector control workers (26.5%) (Daud et al., 2011; Habib, 2012; Ismail, Daud, Ismail, & Abdullah, 2013; Masilamani et al., 2014; Thomas, Mariah, Fuad, Kuljit, Hnorl, et al., 2007). Although NIHL is a highly preventable disease and HCPs are in place in the industries, it remains a major occupational health problem in Malaysia and is of high public health importance. Another local study reported a lack of compliance towards HCP among industries and required improvement to prevent NIHL among workers (Nor Saleha & Noor Hassim, 2006).

Despite its known implications on health, safety, cost, and productivity, there still lacks research in Malaysia to prevent NIHL (Fuente & Hickson, 2011; Girard et al., 2015). In Malaysia, the Permissible Exposure Limit (PEL) is set at 85 dB(A) under the Occupational Safety and Health (Noise Exposure) Regulations 2019, and measures to reduce excessive noise are needed if this limit is exceeded (Department of Occupational Safety and Health, 2019). Furthermore, according to US Occupational Safety and Health Administration (OSHA) regulations, a HCP is to be implemented if employees are exposed to levels higher than an 8-hour Time-Weighted Average (TWA) of 85 dB(A) (US Department of Labor,2013). Therefore, the purpose of this study is to evaluate the effectiveness of a Hearing Conservation Program (HCP) in preventing or reducing audiometric threshold changes among vector control workers.

2.0 METHOD

2.1 Participants

The sample size for this study was 183 participants, determined using OpenEpi version 3.01 with reference to outcome from a study by Davies et al. (Davies, Marion, & Teschke, 2008). Participants were recruited voluntarily from nine District Health Offices (DHO) in Perak, Malaysia. Participants comprised both permanent and contract basis vector control workers under the Ministry of Health (MOH). The latter is directly involved in fogging activities and can read and understand the Malay language. Vector control workers with hearing loss were excluded from other causes besides work, such as ear infection, perforated tympanic membrane, and other conductive hearing loss conditions. The Medical Ethics Committee approved this study, University Malaya Medical Centre (MREC ID: 2017220-4936) and registered with the National Medical Research Register (NMRR-17-375-34724) as well as Thai Clinical Trials Registry (TCTR2019010900).

2.2 Study Design

A cluster-randomized design was used, with DHO as the unit of randomization. Nine out of 11 DHOs were randomly assigned to either the intervention or control group using a computer-generated random numbers. Each DHO was first coded before randomization to ensure allocation concealment, and all vector control workers from each selected DHO were included in this study. A single blinding method was applied where data collectors and outcome assessors, mainly personnel performing the audiometry test to measure hearing threshold levels, were unaware of the participant's group allocation. Given that the intervention involved a training and education program delivered by the researcher, it was impossibleto blind the participants and researchers. However, since both intervention and control groups consist of DHOs that were geographically separated, it is not necessary to blind the participants in this trial.

The intervention period lasted for three months in which the HCP was implemented, and participants were given a training and education program described further under the intervention section. The workers' annual audiometry for 2017 (pre-intervention) was used as the baseline audiometry for this study. The outcome measured participants' hearing threshold levels at the frequencies 500, 1000, 2000, 3000, 4000, 6000, and 8000 kHz assessed using calibrated audiometric booths. Participants were required to have 14 hours of the silent period before the audiometric testing, and participants who had any upper respiratory tract infection symptoms were rescheduled. In addition, socio-demographic information and the job characteristics data of participants were collected during the baseline screening using a brief questionnaire. Meanwhile, participants' environmental factors, lifestyle, past occupational history, and medical condition information were gathered during the following three months using a hearing assessment form.

A total of 183 participants with baseline audiometry testing were enrolled in this study, with 154 participants repeating the audiometry test for the next three months. The follow-up rate for both intervention and control groups was above 90% at one-month post-intervention, with the intervention group achieving a 100% response rate. Meanwhile, during the final follow-up at three months post-intervention, the follow-up rate was well above 80% for each group.

2.3 Hearing Conservation Program (Intervention)

The Hearing Conservation Program (HCP) was developed by incorporating information obtained from three key domains; systematic literature review, comparing local and international guidelines, and interviews with key stakeholders. This HCP aims to prevent NIHL among vector control workers exposed to noise emitted from fogging machines. The HCP was implemented in four DHOs from the intervention group for three months.An HCP coordinator oversaw the program that the safety committee elected in each DHO. It consists of the following eight elements:

- Safety and Health Policy

  A documented safety and health policy by the Ministry of Health was made available at DHOs. Awareness of this policy was also raised among participants by establishing a safety and health committee during the training and education program.

- Noise Monitoring

  A noise survey which included personal noise monitoring, area noise monitoring, and noise mapping, was conducted.

- Noise Control

  Administrative control measures were implemented using an equipment preventive maintenance checklist for each fogging machine to ensure that maintenance is conducted according to recommended intervals. Besides that, a safe distance of seven meters from the fogging machine during fogging activities were recommended (based on noise mapping findings)

- Provision of Hearing Protection

  Appropriate Hearing Protection Devices (HPD) that provide adequate protection were made available to participants.

- Training and Education Program

  This training and education program involved a two-hour presentation, a video presentation on proper care and use of earmuffs (five mins), and hands-on training on the appropriate use of earmuffs (25 mins). It contains general information about NIHL and hazard communication of noise exposure monitoring results and was delivered by the researcher.

- Audiometry Testing

  Participants underwent ear examination and audiometric testing before implementing HCP (pre-intervention) and three months after (post-intervention). In addition, participants received an appointment card to serve as a reminder of upcoming medical examinations and audiometric testing.

- Record Keeping

  All records (personal details of the vector control worker, job title, audiometric test results, training, and noise exposure results) were filed systematically and maintained in a confidential manner by the HCP coordinator.

- Monitoring and Evaluation

  Monitoring and evaluation of the program were done annually to assess the progress and success of the HCP.

The data were analyzed using the Statistical Package for Social Science (SPSS) software desktop version 20.0. The level of significance was set at 0.05, with all variables being tested for normality. All analyses were done according to Per-Protocol (PP) principles to avoid overestimating the effect of HCP on the hearing threshold levels of the participants. The effectiveness of the program was evaluated by comparing the mean difference of hearing threshold levels between pre-and post-intervention within (intragroup) and between (intergroup) the intervention and control groups using an independent t-test.

3.0 RESULTS

3.1 Recruitment and Participant Flow

A total of 183 vector control workers were recruited voluntarily from nine DHO to participate in this study based on a 95% confidence interval and a 5% margin for error. The recruitment process commenced three months, from November 2017 till January 2018 (Fig. 1). Part of the intervention included a training and education program delivered to participants from the intervention group, and the response rate was 100%. After three months, this study's loss to follow-up rate is 3.3% for the intervention group and 22% for the control group. Participants faced difficulties with follow-ups primarily due to being transferred to different units or simply not being present during the outcome measurement, but the numbers wereminimal. A couple of steps were taken to keep the loss to follow-up rate to a minimum. For example, they used an appointmentcard for audiometry testing and contacted their supervisors before the follow-up to serve as a reminder.

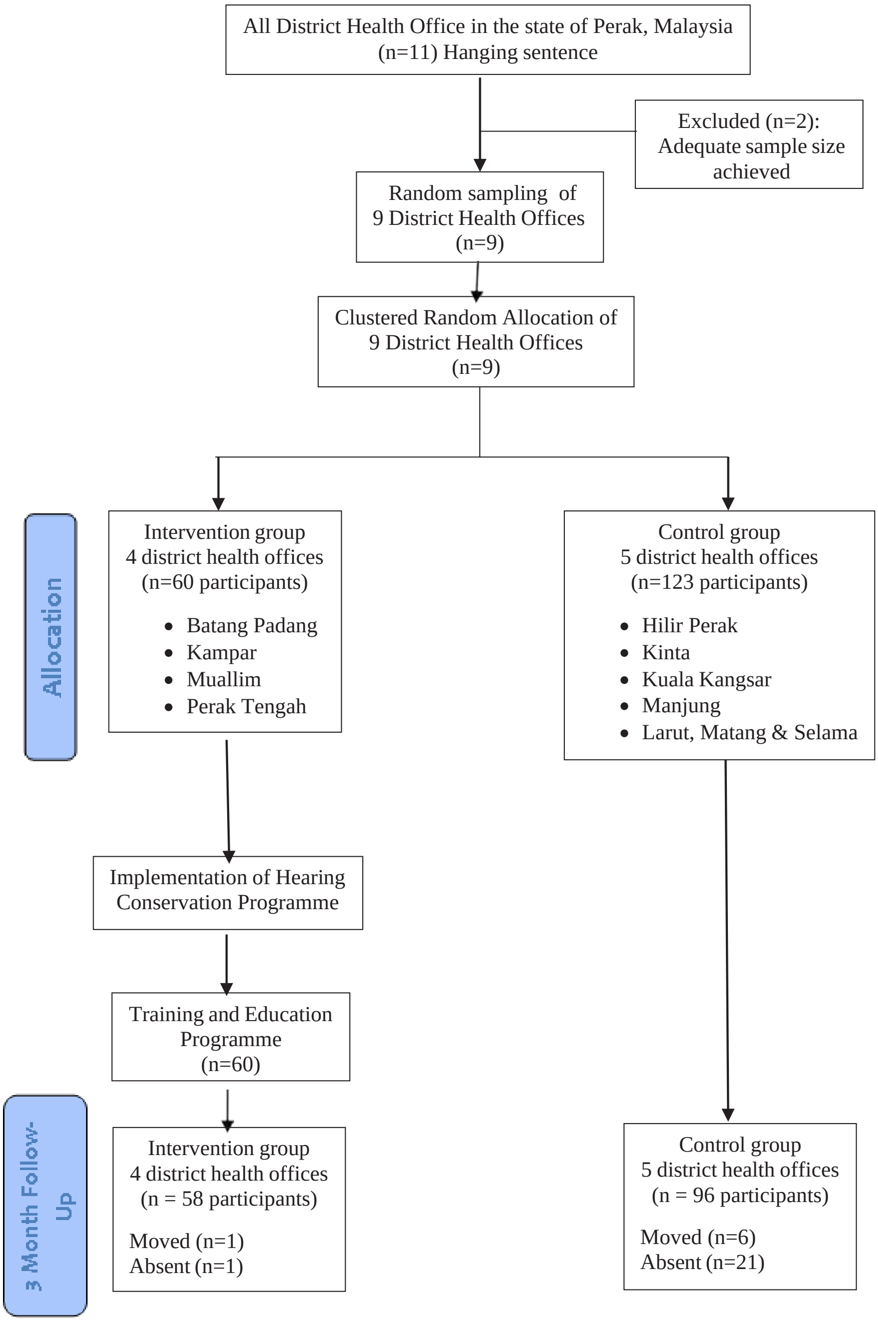

Figure 1 Participant Flowchart

3.2 Characteristics of the Sample

Summary of participants' characteristics, including their job and noise exposure characteristics, is presented in Table 1. Most of the participants were male (99.5%) with an average age of 37 years and classified as general workers (78%) based on their job title. In terms of noise exposure, about half of the participants (48.6%) were exposed to noise from their previous occupations, and the majority handled fogging machines currently (83.6%). In addition, a small percentage of participants live in a noisy residential area (7.1%) and indulge in activities that may cause hearing loss, such as diving and the use of guns or explosives (9.1%).

Table 1 Socio-Demographic Characteristics of Participants

	All Frequency (%)	Intervention (n=60)	Control (n=123)	p-value
Gender				
Male	182 (99.5)	60 (100.0)	122 (99.1)	1.000
Female	1 (0.5)	-	1 (0.9)	
Age (years) (Mean±SD)	37.3±8.4	37.7±1.3	36.6±7.0	0.279
Duration of employment (years) (n=179) (Mean±SD)	8.6±11.2	7.5±0.9	9.3±1.3	0.656
Job title (n=154)				
i. General worker	78 (50.6)	25 (43.1)	53 (55.2)	
ii. Public Health Assistant	55 (35.7)	21 (36.2)	34 (35.4)	
iii. Senior Public Health Assistant	3 (1.9)	1 (1.7)	2 (2.1)	
iv. Assistant Environmental Health Officer	4 (2.6)	2 (3.4)	2 (2.1)	0.162

v. Senior Assistant Environmental Health Officer	1 (0.7)	1 (1.7)	-	
vi. Health Inspector	2 (1.4)	1 (1.7)	1 (1)	
vii. Driver	9 (5.8)	7 (12.2)	2 (2.1)	
viii. Contract worker	2 (1.3)	-	2 (2.1)	
Past occupational exposure to noise (n=183)				
Yes	89 (48.6)	33 (55)	56 (45.5)	0.271
No	94 (51.4)	27 (45)	67 (54.5)	
Use of fogging machine (n=183)				
Yes	153 (83.6)	45 (75)	108 (87.8)	
No	30 (16.4)	15 (25)	15 (12.2)	0.034
Living in a noisy residential area (n=154)				
Yes	11 (7.1)	3 (5.2)	8 (8.3)	0.537
No	143 (92.9)	55 (94.8)	88 (91.7)	
Smoking history (n=183)				
Yes	54 (29.5)	21 (35)	33 (26.8)	0.301
No	129 (70.5)	39 (65)	90 (73.2)	
History of diving/ using guns or explosives (n=154)				
Yes	14 (9.1)	5 (8.6)	9 (9.4)	1.000
No	140 (90.9)	53 (91.4)	87 (90.6)	

3.3 Noise Exposure Monitoring Results

Two types of fogging machines were used during fogging activities, mainly the thermal fogging machine and ultra-low volume (ULV) fogging machine. As for workers using the ultra-low volume (ULV) fogging machine, personal noise exposure level for an 8-hour Time Weighted Average (TWA) was well below the permitted daily noise exposure level of 85 dB(A). Meanwhile, the personal monitoring results of workers handling the thermal fogging machine from each group showed an 8-hour Time Weighted Average (TWA) of 87.3 dB(A) and 93.1 dB(A), respectively.

3.4 Effectiveness of Hearing Conservation Program (HCP)

Fig. 2 and 3 show the trend in hearing threshold level changes for the left and right ears after three months of intervention by a randomized group. Both intervention and control groups showed a reduced hearing threshold for all frequencies after three months for the left ear. However, the intervention group showed an increase of hearing threshold levels three months post-intervention for the frequencies 500 Hz and 8000 Hz. The most significant reduction in hearing threshold post-intervention was observed at 6000 Hz (5.4 dB) for the intervention group and 500 Hz (3.5 dB) for the control group. Meanwhile, for the right ear, the intervention group showed a trend of higher hearing threshold levels at all frequencies three months post-intervention, mainly involving lower frequencies (500, 1000, 2000, and 3000 Hz). The control group showed a reduction in hearing threshold levels after three months for all frequencies except 6000 Hz. The level of hearing threshold remained similar after three months at 8000 Hz for the control group.

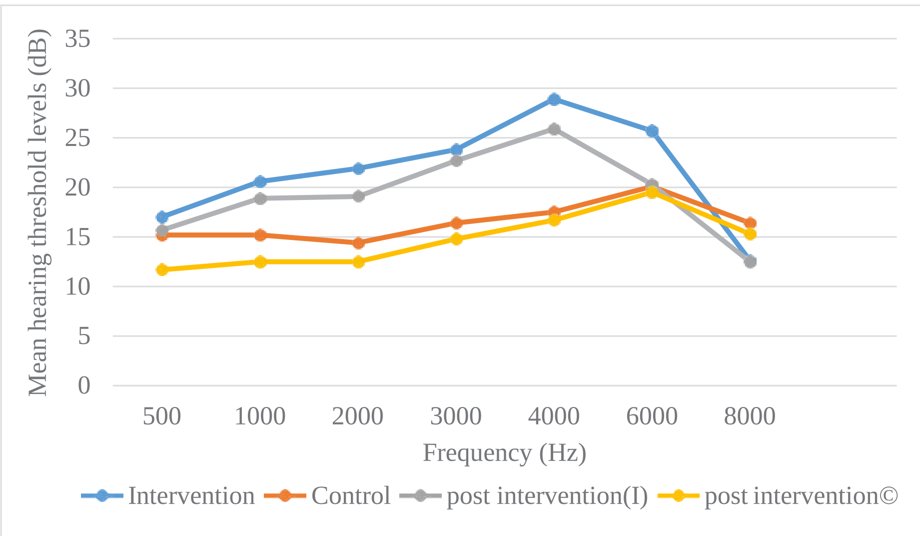

Figure 2 Changes in Mean Hearing Threshold Levels for The Left Ear After 3 Months for the Intervention and Control Group

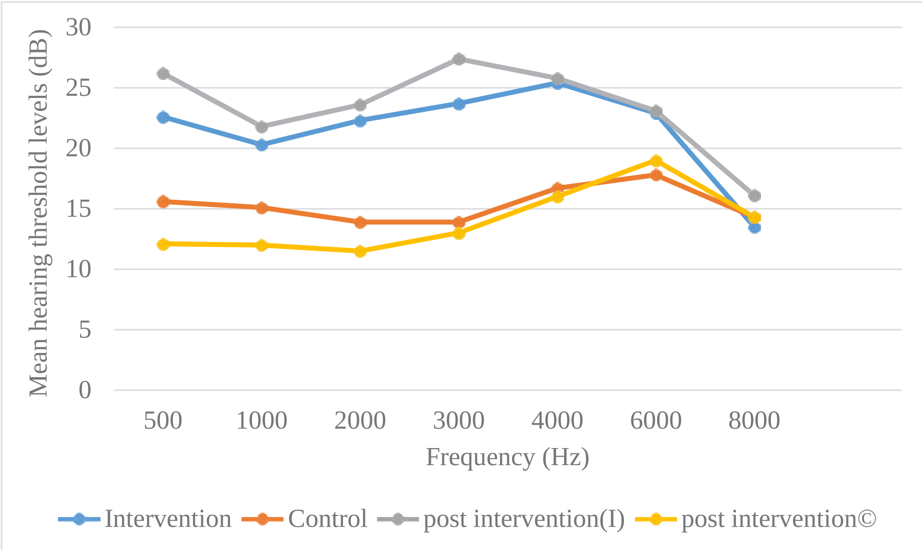

Figure 3 Changes in Mean Hearing Threshold Levels for The Right Ear After 3 Months for the Intervention and Control Group

The effectiveness of the HCP was determined by comparing the difference in mean hearing threshold levels between the control and intervention groups. A positive intergroup mean difference indicates a more significant improvement in the intervention group than the comparison group. The intragroup and intergroup hearing threshold changes in bilateral ear for all frequencies after three months for both control and intervention groups are shown in Table 2 and 3. The left ear means hearing threshold in the intervention group showed significant improvement for all frequencies post-intervention, with the most considerable reduction seen at 6000 Hz with a 5.4 dB reduction and is statistically significant ($p<0.05$). At 8000 Hz, the mean hearing threshold remained similar post-intervention, with only a 0.2 dB reduction observed. The control group also showed a reduction in the left ear mean hearing threshold for all frequencies, with the most significant reduction seen at 500 Hz with a 30 dB reduction and is statistically significant ($p<0.05$). After three months, the mean hearing threshold remained similar for 4000 Hz and 6000 Hz with only a 0.8 dB and 0.6 dB reduction. Positive values of intergroup mean difference were observed at 2000 Hz (0.97 dB) and 4000 Hz (2.24 dB), with the most significant improvement seen at the latter frequency even though it was statistically not significant.

Meanwhile, for the right ear, the intervention group showed an increase in the mean hearing threshold for all frequencies, with the most significant increase observed at 3000 Hz with a 3.7 dB increase that was statistically significant. The mean hearing threshold remained almost similar at 4000 Hz and 6000 Hz with only a minimal 0.4 dB and 0.2 dB increase after three months of post-intervention. The control group showed a reduction in mean hearing threshold after three months for all frequencies except 6000 Hz and 8000 Hz, with the most significant reduction seen at 500 Hz with a 3.5 dB reduction and found to be statistically significant ($p<0.05$). However, the mean hearing threshold remained almost similar at 3, 4, and 8 kHz after three months. As for the intergroup mean difference, negative values were observed at all frequencies except 6000 Hz (1.08) but not statistically significant.

Table 2 Participants' Left Ear Hearing Threshold Level Changes After Three Months

Frequency (Hz)	Intervention group (n=58)			Control group			Intergroup	
	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Intragroup mean difference (SD)	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Intragroup mean difference (SD)	Intergroup mean difference (95% CI)	p-value
500	17.0#(6.7)	15.7#(11.9)	-1.3 (10.3)	15.2##(7.3)	11.7##(8.7)	-3.5* (8.2)	-2.27 (-5.64, 1.11)	0.186
1000	20.6(8.5)	18.9 (10.7)	-1.7 (6.7)	15.2 (7.4)	12.5 (9.3)	-2.6* (8.7)	-0.90 (-3.53, 1.73)	0.500
2000	21.9(9.3)	19.1 (11.5)	-2.8* (5.8)	14.4 (8.2)	12.5 (10.1)	-1.9* (8.3)	0.97 (-1.49, 3.43)	0.437
3000	23.8(11.9)	22.7 (13.4)	-1.1 (7.4)	16.4 (9.4)	14.8 (13.6)	-1.6 (9.9)	-0.44 (-3.41, 2.53)	0.769
4000	28.9(16.4)	25.9 (15.5)	-3.0* (8.2)	17.5 (11.1)	16.7 (15.9)	-0.8 (11.3)	2.24 (-1.13, 5.60)	0.191
6000	25.7(20.3)	20.3 (19.8)	-5.4*(12.4)	20.1 (13.8)	19.5 (16.6)	-0.6 (11.6)	4.86 (0.95, 8.77)	0.015
8000	12.6^(22.7)	12.5^(19.3)	-0.2 (11.5)	16.7 (15.5)	15.3 (18.4)	-1.4 (11.1)	-1.18 (-4.90, 2.54)	0.532

*statistically significant intragroup mean difference ($p<0.05$); # n=43; ## n=79; ^ n=57
Intragroup mean difference = mean post-intervention – mean pre-intervention
Intergroup mean difference = mean difference control group – mean difference intervention group

Table 3 Participants' Right Ear Hearing Threshold Level Changes After Three Months

Frequency (Hz)	Intervention group (n=58)			Control group (n=96)			Intergroup	
	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Intragroup mean difference (SD)	Pre-intervention Mean (SD)	Post-intervention Mean (SD)	Intragroup mean difference (SD)	Intergroup mean difference (95% CI)	p-value
500	22.6#(8.1)	26.2#(18.1)	3.6 (17.3)	15.6##(6.1)	12.1##(8.4)	-3.5*(9.4)	-7.15 (-11.92, -2.38)	0.004
1000	20.3(7.8)	21.8(16.7)	1.5(14.4)	15.1(6.9)	12.0(8.7)	-3.0*(9.2)	-4.49 (-8.24, -0.73)	0.019
2000	22.3(12.4)	23.6(19.1)	1.3(12.6)	13.9(8.2)	11.5(8.7)	-2.3*(8.7)	-3.64 (-7.04, -0.24)	0.036
3000	23.7(13.8)	27.4(20.4)	3.7*(12.7)	13.9(7.6)	13.0(10.4)	-0.8(10.0)	-4.55 (-8.20, -0.90)	0.015
4000	25.4^(15.7)	25.8^(22.4)	0.4(16.2)	16.7(10.7)	16.0(14.4)	-0.7(11.3)	-1.12 (-5.53, -3.30)	0.618
6000	22.9(21.5)	23.1(26.0)	0.2(17.0)	17.8(11.0)	19.0(15.5)	1.3(12.3)	1.08 (-3.60, 5.75)	0.650
8000	13.5^(22.2)	16.1^(24.4)	2.6(19.3)	14.3(13.5)	14.3(16.6)	0(12.5)	-2.63 (-7.70, 2.44)	0.307

*statistically significant intragroup mean difference ($p<0.05$); # n=43; ## n=79; ^ n=57
Intragroup mean difference = mean post-intervention – mean pre-intervention
Intergroup mean difference = mean difference control group – mean difference intervention group

4.0 DISCUSSION

A marked improvement in hearing threshold levels was observed three months post-intervention, especially at higher frequencies, despite the control group having a better baseline mean hearing threshold level in the bilateral ear than the intervention group. This may not be due to age-related changes since the mean age of participants in both the intervention (37.7 years) and control group (36.6 years) were almost similar. It has been reported that in the early stages of NIHL, the average hearing thresholds at the lower frequencies (500, 1000, and 2000 Hz) are better than the average thresholds at higher frequencies (3000, 4000, and 6000 Hz) (Kirchner et al., 2012). The role of extended high-frequency audiometry testing in the early detection of NIHL with employment duration has been studied. It has been reported that the frequencies 12500, 14000, and 16000 Hz are first affected during the first decade of employment. Changes at 2000 and 4000Hz were only observed during the second decade of employment. Hearing threshold changes at lower frequencies (250, 500, and 1000Hz) were observed after two decades of employment (Riga, Korres, Balatsouras, & Korres, 2010). The mean duration of participants' employment in this study was less than ten years, causing hearing threshold changes to be less evident since the extended higher frequencies were not tested as only conventional audiometry was used.

In this study, mean hearing threshold shift changes were observed for all frequencies evaluate the effectiveness ofthe HCP. The American National Standards Institute (ANSI) also recommends a similar method to evaluate the effectivenessof an HCP. Therefore, changes in mean hearing threshold levels (threshold shifts) from individual audiometric frequencies (0.5, 1, 2, 3, 4, 6, and 8 kHz) and grouped frequency combinations (0.5-3 kHz and 2-4 kHz) were measured and compared. This way, one can rule out systematic threshold shifts due to variation in audiometric calibration. Hence, this method serves as a reliable early indicator of the HCP performance besides indirectly reflecting the audiometric testing program integrity (Simpson, Stewart, & Kaltenbach, 1994). However, there is also a risk of false-positive threshold shifts during audiometric testing caused by various factors such as calibration errors, test-retest variability, absence of baseline audiogram, and absence of detailed case-history information (Schlauch & Carney, 2010).

The changes in mean hearing threshold observed for both grouped frequencies (2-4 kHz and 0.5-3 kHz) showed dominant positive changes in the left ear compared to the right ear. Thus, NIHL commonly presents as bilateral symmetrical hearing loss. However, it has been reported that up to 80% of audiometric shifts meeting the OSHA standards were found to be unilateral (Simpson, McDonald, & Stewart, 1993).

This is mainly attributable to asymmetric individual baseline hearing threshold levels and participants from the control group showing better average hearing thresholds for each frequency than the intervention group. This could be caused by various factors such as varying individual susceptibility to age-related hearing loss and noise damage and other non-occupational noise sources (power tools, attendance at sporting events, motor races, and loud concerts) (Franks, 2001; Royster, 2017).

In terms of evidence-based practice, this study's randomized cluster methodological design provides the highest level of evidence, especially in determining a causal relationship between an intervention and the desired outcome. Randomization reduces the risk of selection bias and facilitates blinding by masking the identity of the participants' groups from the outcome assessors. The risk of selection bias was also reduced by ensuring allocation concealment during group assignments of the DHO. While there were reported improvements in hearing threshold levels, especially for most frequencies inthe intervention arm, the long-term impact of this HCP remains unknown, especially with the progressive nature of NIHL.

5.0 CONCLUSION

Vector control workers in the Ministry of Health (MOH), Malaysia, are exposed to hazardous noise emitted by the thermal fogging machines well above the 85 dB(A) daily noise exposure level recommended by the Malaysian Occupational Safety and Health Act (OSHA) (Noise Exposure) Regulations 2019. Therefore, there is a need for a comprehensive HCP to be implemented at all DHO for vector control workers. There were improvements in participants' average hearing threshold levels three months after implementing the HCP. A significant reduction in the proportion of participants with hearing loss was also observed, especially for higher frequencies (3000 – 8000 Hz). This indicates the program is effective in preventing NIHL. This HCP will prevent vector control workers from developing NIHL and, in turn, reduce the overall burden of NIHL in Malaysia. Similar studies are needed to look into the long-term effectiveness of this program in hearing conservation of workers, especially since the NIHL is a progressive occupational disease that takes five to 10 years to occur.

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Original Article

Anthropometric of Adult Workers at Kota Kinabalu, Sabah, Malaysia

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ABSTRACT : *Anthropometry is among the critical aspects of ergonomic design tools, computing devices, and reducing the risk of musculoskeletal problems. The design needs to fit the users. Therefore, anthropometric properties were considered during the design stage. However, there are no studies that develop the Sabah population database as a function of anthropometric dimensions. Hence, the main objective of this study is to measure 55 body dimensions and three static strengths. This study measured 276 Sabahan to achieve the objectives, composed of 150 adult males and 126 females. The tools used in this study were the NIOSH anthropometric grid, a standard set of anthropometers and a standard measuring tape, a pinch gauge, handgrip dynamometer, back-leg, and a strong dynamometer. Fifty-eight anthropometric dimensions have been measured in this study. The information collected was standing and sitting position, static strength, body weight, and circumference measurements. The result shows the mean, standard deviation, the 5th, 50th, and 95th percentile values. This finding indicates the importance for product designers to understand anthropometric measurements to create ergonomic products that account for special needs. In addition, the results help provide information for the development of an anthropometric database in Sabahan to design a safer workplace product.*

Keywords *- Anthropometrics, Ergonomics, Sabah Malaysian Workers, Safe Workplace, Standard Measuring*

1.0 INTRODUCTION

Ergonomics are key elements in the design process of any product. Research in ergonomics has led to an interest in expanding the work and furniture design based on human body biomechanics. Anthropometry is a very important element for ergonomic products to create a safer, comfortable and healthy workplace, as it collects information to design a product (Ariful Islam et al., 2013); (Bhattacharjya & Kakoty, 2020).

Anthropometry refers to the measurements of the human body dimensions, which can either be taken in static or dynamic states (Khadem & Islam, 2014);(Zaki et al., 2020). Anthropometric data are essential since they provide designers with knowledge of the user's physical dimensions, which will enable designers to propose design solutions that fulfill special needs (Taifa & Desai, 2017). It has been shown that consumers experience discomfort and, in worse cases, accidents and injuries due to unsuitable products and workspace dimensions.

In general, anthropometry is the element in ergonomic that contributes to the size, form, and strength of human biomechanics. The problem of "fitting people to machines" can be considered a center for ergonomics (Mohamad et al., 2010). Anthropometric is the part in ergonomics to specify the physical dimensions of the job, workplace, workstations, and types of equipment. The design of the tools and the product's structure significantly influence the overall performance and safety. The adjustment range for each tool and other accessories is important to meet the needs of different users (McDaniel, 1991); (Y. C. Lee et al., 2019). Adequate use of anthropometry may enhance the health and well-being of the human body (Sims, 2003). However, anthropometry may also include postural data and a person's reach capability. The user's abilities, such as strength or psychological data, are sometimes measured for specific applications and are also referred to as anthropometric data (Nurul Shahida et al., 2015). Besides, health problems such as musculoskeletal disorders are the most important consequences of mismatching anthropometric dimensions (Sadeghi et al., 2015); (Castellucci et al., 2019).

In Malaysia, musculoskeletal disorders linked to work (WMSD) have gradually increased rises over four years (Hassan et al., 2015);(Alias et al., 2020). The relationship between muscle and skeletal dysfunction in the human body usually triggers muscle disorders. Back pain, knee pain, arm, and wrist pain are the primary issues of humans that become common Musculoskeletal Disorders (MSDs). MSDs are damage to soft tissues of the back, shoulder, arm, elbow, wrist, and fingers (Tittiranonda et al., 1999). Inflammation of tendonitis, epicondylitis, bursitis, and nerve compression disorders, such as carpal tunnel syndrome, sciatica, and osteoarthritis (Punnett & Wegman, 2004). Carpal tunnel syndrome and tendonitis are the most common injuries among workers (Statistics, 2020).

Carpal tunnel syndrome is caused by nerve compression in carpal tunnel wrist syndrome. Symptoms include wrist pain and pinching in the median region of the nerves (Tittiranonda et al., 1999). The injuries are related to occupational factors like tension, repeated elbow movements, an awkward posture, mechanical stress, and vibration (Punnett & Wegman, 2004);(Alias et al., 2020). Many musculoskeletal disorders (WMSD) related to the workplace are tendonitis, including tendons and sheath injuries. This injury occurs due to highly repetitive activities or hard work, requiring uncomfortable positions over long working hours (Tittiranonda et al., 1999). Local pain, sensitivity, and swelling are the symptoms.

There are several studies done by past researchers in constructing an anthropometric database. According to (Barroso et al., 2005), the data collected will serve as a basis for the design of industrial tools, equipment, and clothing. Also, the data establish as an essential element for the ergonomic design of workplaces. (Wang et al., 1999) has constructed a static and dynamic anthropometric database for local workers for use by designers and engineers. The database consists of data for 266 static-body dimensions and 42 dynamic ranges of motion. It is expected that designers and engineers can use the data to create ergonomically designed equipment, devices, and work environment for local workers, thereby ensuring a safe work environment.

Concurrently, (H. P. Lee et al., 2015) have also put up a Singaporean anthropometric database that includes 2000 Singapore citizens and permanent residents in a total of 5 age groups. (Hassan et al., 2015) had conducted a study of the development of anthropometric data for the Malaysian population database. This study has been conducted with 23 static anthropometric dimensions of 1134 Malaysian workers comprising of 863 males and 261 females' measurements from 10 industrial sectors. In West Malaysia, the ethnic study of foot anthropometric had been conducted with 320 respondents on Murut adult ethnic groups. At present, there are no comprehensive anthropometric data for the adult working population in Sabah. For several of the Sabahan populations, anthropometric data relevant for anthropometric have either been lacking. This lack of data can jeopardize the match between workers and the workplace and products used by the workers.

Therefore, there is a need to collect and combine anthropometry measurements of the Sabahan population. As mentioned in the abstract, the objective of this study was to i) measure fifty-five body dimensions, ii) measure three static strengths. To create an ergonomic product, anthropometry plays the main role in design development. Appropriate anthropometry in product design may improve users' well-being, health, comfort, and safety (Mohamad et al., 2010).

2.0 METHOD

2.1 Study Design and Subject Selection

A descriptive convenience cross-sectional study was conducted among Sabahan workers in February 2020. The respondents were selected using non-probability convenience sampling. Invitations for this study were sent through email, social media, instant messaging applications, and prospective advertisement participants.

2.2 Inclusion and Exclusion Criteria

The inclusion criterion is that the participants should be Malaysian citizens aged between 18-54 years old. Meanwhile, the exclusion criteria included pregnancy or any neurological and musculoskeletal diseases that may affect the measurement process.

2.3 Study Tools

A questionnaire was used to gather information based on the participant's demographic background, such as age, gender, ethnicity, marital status, and occupational category. For example, participants involved with manual handling at work were categorized as operations workers. In contrast, those not involved were categorized as operations workers, whereby those who did not fall under these two categories were classified as management workers. Next, their waist circumference and waist-hip ratio were measured using a calibrated measuring tape. Five measurements were collected from two males and three females for each measurement session. Each participant was asked to wear minimal clothing during the measurement sessions.

2.4 Research Ethic

Before anthropometric measurement, the researcher had obtained ethical approval for the study from the National Institute of Occupational Safety and Health Malaysia (NIOSH Malaysia) Ethics Committee. Therefore, all the information obtained shall be handled confidentially in compliance with the Malaysian Personal Data Act 2010. The anthropometry dimension of the respondents will be measured by using NIOSH anthropometric grid (Hassan et al., 2015) and a calibrated standard anthropometric set (TTM Martin's Human Body Measuring Kit, Mentone Educational Centre Carnegie, and Vic, Australia).

2.5 Anthropometric Dimensions Selection

The selection of anthropometric dimensions was based on the previous studies (Hassan et al., 2015), Malaysian Standard 2017: MS ISO 7250:2017-Basic Measurement for Technological Design, and existing guidelines for the design of BIFMA.

2.6 Anthropometry Measurements Procedure

This study used three main equipment: the TTM Martin anthropometer, NIOSH anthropometric grid (Hassan et al., 2015), and measuring tape. An anthropometric grid measuring 213.36cm x 274.32cm standing and sitting body dimension was designed and developed to facilitate the measurement. For the NIOSH anthropometric grid, the measurement will be marked using an erasable color marker pen, and respondents will stand erect depending on the measurements. The dimensions of measurement are divided into 25 dimensions on NIOSH anthropometric grid, 27 dimensions with TTM Martin anthropometer, and three static strength measurements, which is handgrip strength test, were used (Baseline Digital Smedley Dynamometer), pinch grip test was used (Baseline Pinch Gauge). In addition, a back strength test was used (Baseline back, leg, and chest Dynamometer), circumference measurement, and body weight. For circumference measurement, researchers used measuring tape as a standardized method. IBM SPSS version 24 was used. In this study, the development of the anthropometric database on the Sabah population, the mean, standard deviation (SD), 5^{th}, 50^{th}, 95^{th} percentile is being calculated.

2.7 Technical Error Measurement (TEM)

Technical Error Measurement (TEM) was the method to clarify the precision and accuracy of any anthropometrist, which may result in data accuracy (Perini et al., 2005). Before the TEM session, each measurer must go through an essential anthropometric measurement to be familiarized with the equipment and body landmark. The TEM in this study uses similar equipment for real data collection. The method of TEM was adapted from (Jamaiyah et al., 2010); (Knapp, 1992); (Perini et al., 2005).

2.8 Statistical Test

All collected data were analyzed using IBM SPSS Statistic Software Version 19 (IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp). The categorical variables were presented as frequency (percentage), while the continuous variables were presented as mean (M) and Standard Deviation (SD). Furthermore, an independent t-test was used to determine the statistical difference between male and female respondents in each dimension. The study significance level was set at $P < 0.05$.

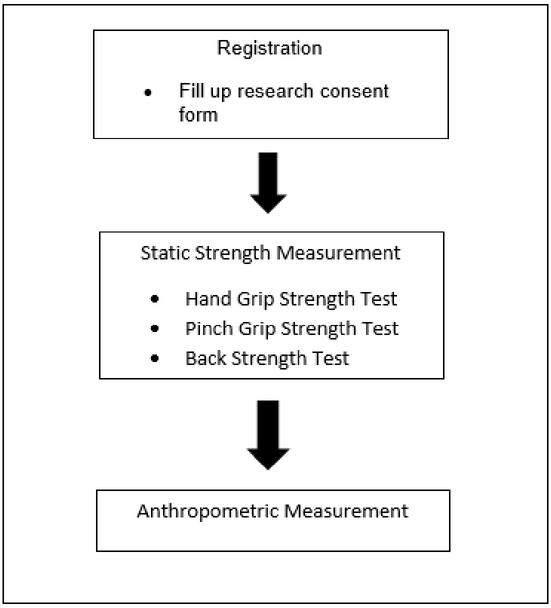

Figure 1 Flow of Data Collection

Figure 2 Anthropometric Grid Measurement (Vertical Grip Reach)

Figure 3 Anthropometer Measurement (Shoulder Elbow Length)

Table 1 Anthropometric Measurement Landmarks

Standing Posture	Cervical height	**Circumference measurement**
Vertical grip reach	Buttock popliteal height	Bodyweight
Fingertip reach height	Popliteal height	Head circumference
Stature	Knee height	Arm circumference
Eye height	Sitting hip breadth	Wrist circumference
Shoulder height	Thigh clearance	Waist circumference
Armpit height	Thight-thight breadth	Hip circumference
Elbow height	Knee-knee breadth	Ankle circumference
Hip height	Ankle height	
Knuckle height	Foot breadth (right)	**Sitting Posture**
Fingertip height	Foot breadth (left)	Vertical reach seated
Tibial height	Foot length (right)	

Biacromial	Foot length (left)	Sitting height
Bideltoid	Hand length (right)	Sitting eye height
Elbow span	Hand length (left)	Sitting shoulder height
Arm span	Handbreadth (right)	Sitting elbow height
Grip reach	Handbreadth (left)	
	Palm length (right)	**Static Strength**
Anthropometer	Palm length (left)	Hand Grip Test
Standing hip breadth	Palm breadth (right)	Pinch Grip Test
Chest depth	Palm breadth (left)	Back Dynamometer
Elbow fingertip length	Head length	
Shoulder elbow length	Head breadth	

Table 2 Demographic Background of Respondent (n: 276)

Variable	Number (n)	Percentage (%)
Age		
<19	1	0.4
20-29	50	18.1
30-39	100	36.2
40-49	72	26.1
50-59	50	18.1
60-69	3	1.1
Gender		
Male	150	54.3
Female	126	45.7
Marital Status		
Married	197	71.4
Single	74	26.8
Widowed	5	1.8
Ethnicity		
Malay	5	1.8
Chinese	4	1.4
Sabah	22	8.0

Others	2	0.7
Malay Sabah	36	13.0
Chinese Sabah	17	6.2
Indian Sabah	1	0.4
Kadazan	56	20.3
Bajau	20	7.2
Dusun	45	16.3
Sungai	3	1.1
Rungus	1	0.4
Brunei	21	7.6
Sino-kadazan/dusun	15	5.4
Idahan	3	1.1
Murut	2	0.7
Iranun	5	1.8
Bisaya	2	0.7
Suluk	3	1.1
Tidong	1	0.4
Kedayan	3	1.1
Bugis	1	0.4
Jawa	1	0.4
Kadazan-Singh	1	0.4
Kadazan-Dusun	1	0.4
Kedayan-Dusun	1	0.4
Iban	1	0.4
Banjar	1	0.4
Position		
Management	194	70.3
Operation	81	29.3
Sectors		
Manufacturing	2	0.7
Electricity, gas, steam, and air conditioning supply	120	43.5
Transportation and storage	7	2.5
Information and communication	7	2.5
Financial and insurance/takaful activities	13	4.7
Administrative and support service activities	19	6.9
Public administration and defense; compulsory social security	10	3.6
Water supply and waste management	1	0.4
Construction	1	0.4
Professional, Scientific, and technical activities	4	1.4
Other Service activities	57	20.7

Table 3 Mean and Standard Deviation for Sabah Male and Female Workers

	Male		Female	
Anthropometry Dimension (cm)	**Mean**	**SD**	**Mean**	**SD**
Standing Posture				
Vertical grip reach	194.4	8.4	181.6	7.3
Fingertip reach height	206.9	8.5	193.3	7.6
Stature	166.0	6.4	156.5	6.0
Eye height	154.6	6.0	145.1	5.3
Shoulder height	138.3	5.4	129.2	5.0
Armpit height	122.3	5.5	113.3	5.2
Elbow height	102.1	5.0	95.2	5.4
Hip height	77.5	5.1	77.6	6.4
Knuckle height	68.8	3.8	64.9	3.6
Fingertip height	60.3	3.7	57.6	3.7
Tibial height	45.7	3.8	41.2	3.7
Biacromial	34.3	3.1	30.4	3.4
Bideltoid	47.1	4.2	44.2	3.8
Elbow span	85.4	4.0	79.6	4.0
Arm span	169.4	6.9	156.6	6.7
Grip reach	70.4	5.5	62.8	6.8
Sitting Posture				
Vertical reach seated	129.2	6.0	120.6	5.9
Sitting height	87.1	3.9	83.8	3.0
Sitting eye height	76.0	4.1	72.4	3.4
Sitting shoulder height	59.9	3.1	57.1	3.3
Sitting elbow height	24.4	3.3	22.7	2.9
Anthropometer				
Standing hip breadth	32.7	2.8	33.2	2.9
Chest depth	21.6	2.6	23.4	3.2
Elbow fingertip length	45.8	2.3	42.0	2.4
Shoulder elbow length	35.7	2.2	34.0	1.9
Cervical height	63.4	3.0	60.0	3.0
Buttock popliteal height	45.6	2.4	45.0	2.2
Popliteal height	40.0	1.6	37.3	1.9
Knee height	51.3	2.8	49.0	2.2
Sitting hip breadth	35.2	3.1	36.2	3.1
Thigh clearance	15.2	2.2	15.1	2.3
Thight-thight breadth	34.6	3.1	32.5	3.7
Knee-knee breadth	25.1	4.5	23.1	4.7
Ankle height	9.3	1.2	9.0	0.9
Foot breadth (right)	9.8	0.5	9.0	0.5
Foot breadth (left)	9.8	0.5	9.0	0.5
Foot length (right)	24.7	1.2	23	1.1
Foot length (left)	24.7	1.4	23	1.1
Hand length (right)	17.9	0.8	17	0.8
Hand length (left)	18.1	0.8	17	0.7
Handbreadth (right)	10.0	0.6	9.0	0.5
Handbreadth (left)	9.9	0.5	9.0	0.5

Palm length (right)	10.2	0.5	9.0	0.5
Palm length (left)	10.2	0.5	9.8	6.9
Palm breadth (right)	8.5	0.5	7.6	1.5
Palm breadth (left)	8.4	0.5	7.5	1.5
Head length	18.4	0.9	17.6	0.9
Head breadth	16.0	0.9	15.6	0.7
Static Strength Measurement (Kg)				
Handgrip strength test (left)	38.9	8.6	23.8	5.60
Handgrip strength test (right)	41.1	8.4	25.6	6.29
Pinch grip strength test (left)	8.3	1.9	5.6	1.51
Pinch grip strength test (right)	8.4	1.8	5.6	1.65
Isometric back strength test	80.0	24.6	43.8	15.0
Circumference measurement				
Bodyweight (Kg)	76.0	14.8	65.0	12.3
Head circumference	56.3	2.19	55.1	2.1
Arm circumference	30.7	3.52	28.5	3.6
Wrist circumference	18.3	2.2	17.1	2.1
Waist circumference	92.3	11.2	86.6	10.7
Hip circumference	101.6	8.8	102.4	9.1
Ankle circumference	24.0	2.2	22.9	2.2

Table 4 Percentile Values (P) of Anthropometry Dimensions of Sabah Male Workers (n=150)

	Male		
Anthropometry Dimension (cm)	**P5**	**P50**	**P95**
Standing Posture			
Vertical grip reach	181.0	194.5	209.1
Fingertip reach height	192.4	206.1	221.5
Stature	156.7	166.0	177.8
Eye height	145.1	154.5	165.4
Shoulder height	129.4	138.0	149.0
Armpit height	115.7	122.1	131.6
Elbow height	95.3	102.0	110.6
Hip height	69.8	77.0	86.7
Knuckle height	63.0	68.5	75.0
Fingertip height	54.2	60.0	66.0
Tibial height	39.0	45.7	51.5
Biacromial	29.7	33.7	40.7
Bideltoid breadth	41.0	46.5	55.1
Elbow span	79.5	85.6	92.6
Arm span	158.5	170.0	181.5
Grip reach	61.9	70.0	79.3

Sitting Posture			
Vertical reach seated	119.0	129.2	139.7
Sitting height	81.3	87.0	93.9
Sitting eye height	69.7	76.1	82.6
Sitting shoulder height	54.2	60.0	65.0
Sitting elbow height	18.9	24.2	30.8
Anthropometer			
Standing hip breadth	28.6	32.4	37.7
Chest depth	17.6	21.5	26.5
Elbow fingertip length	42.1	46.1	49.5
Shoulder elbow length	32.5	35.6	39.1
Cervical height	58.2	63.3	68.6
Buttock popliteal height	41.5	45.4	49.3
Popliteal height	36.7	40.0	42.5
Knee height	47.3	50.9	55.5
Sitting hip breadth	30.4	35.0	40.8
Thigh clearance	11.6	15.1	19.1
Thight-thight breadth	29.8	34.3	40.2
Knee-knee breadth	20.0	24.1	32.8
Ankle height	7.81	9.3	10.9
Foot breadth (right)	8.80	9.8	10.7
Foot breadth (left)	8.90	9.8	10.8
Foot length (right)	22.8	24.8	26.9
Foot length (left)	22.8	24.8	27.1
Hand length (right)	16.4	18.1	19.7
Hand length (left)	16.6	18.2	19.6
Handbreadth (right)	8.9	10.1	10.9
Handbreadth (left)	9.0	10.0	11.0
Palm length (right)	9.2	10.3	11.2
Palm length (left)	9.2	10.3	11.2
Palm breadth (right)	7.7	8.5	9.5
Palm breadth (left)	7.6	8.4	9.4
Head length	16.4	18.5	19.8
Head breadth	14.8	15.9	17.5
Static Strength Measurement (Kg)			
Handgrip strength test (left)	25.7	38.8	53.3
Handgrip strength test (right)	29.1	40.2	55.7
Pinch grip strength test (left)	5.00	8.00	12.0
Pinch grip strength test (right)	5.00	8.00	11.5
Isometric back strength test	40.0	80.0	120.0
Circumference measurement			
Bodyweight (Kg)	54.7	73.8	107.0
Head circumference	52.5	56.5	60.0
Arm circumference	26.0	30.0	36.8
Wrist circumference	15.1	18.0	22.4
Waist circumference	76.0	91.0	113.4
Hip circumference	88.1	100.6	120.0
Ankle circumference	21.0	24.0	27.8

Table 5 Percentile Values (P) of Anthropometry Dimensions of Sabah Female Workers (n=126)

	Female		
Anthropometry Dimension (cm)	**P5**	**P50**	**P95**
Standing Posture			
Vertical grip reach	169.0	181.7	194.0
Fingertip reach height	181.0	192.9	206.6
Stature	146.7	156.0	165.9
Eye height	136.7	145.5	153.7
Shoulder height	121.0	129.0	137.7
Armpit height	106.2	112.4	122.0
Elbow height	87.0	95.0	103.8
Hip height	69.2	76.5	92.9
Knuckle height	58.6	65.0	70.0
Fingertip height	51.0	58.0	63.0
Tibial height	33.5	41.5	47.3
Biacromial breadth	25.3	30.1	35.2
Bideltoid breadth	38.0	44.0	51.5
Elbow span	73.3	79.6	86.0
Arm span	146.3	156.0	167.4
Grip reach	54.3	62.0	73.8
Sitting Posture			
Vertical reach seated	110.62	121.10	130.82
Sitting height	77.66	84.00	89.44
Sitting eye height	68.00	72.50	77.66
Sitting shoulder height	52.83	56.80	63.97
Sitting elbow height	18.29	22.80	26.97
Anthropometer			
Standing hip breadth	28.5	33.4	37.9
Chest depth	18.2	22.9	29.1
Elbow fingertip length	38.0	42.0	45.4
Shoulder elbow length	30.4	33.6	36.7
Cervical height	54.4	59.9	64.4
Buttock popliteal height	40.8	45.0	48.5
Popliteal height	34.4	37.5	40.1
Knee height	44.8	49.0	51.7
Sitting hip breadth	31.6	36.3	41.8
Thigh clearance	11.0	15.2	18.8
Thight-thight breadth	26.8	32.2	40.1
Knee-knee breadth	18.0	22.2	30.6
Ankle height	7.5	9.0	10.6
Foot breadth (right)	8.2	9.0	10.0
Foot breadth (left)	8.1	8.9	10.0
Foot length (right)	21.2	22.9	24.8
Foot length (left)	21.0	22.9	24.7
Hand length (right)	15.0	16.4	17.9
Hand length (left)	15.2	16.6	17.8
Handbreadth (right)	7.9	8.7	9.6
Handbreadth (left)	8.0	8.6	9.5

Palm length (right)	8.1	9.0	10.2
Palm length (left)	8.4	9.3	10.3
Palm breadth (right)	6.8	7.4	8.4
Palm breadth (left)	6.7	7.4	8.2
Head length	16.1	17.6	19.4
Head breadth	14.53	15.6	17.0
Static Strength Measurement (Kg)			
Handgrip strength test (left)	13.5	24.2	32.2
Handgrip strength test (right)	16.1	25.5	38.0
Pinch grip strength test (left)	3.1	5.5	8.0
Pinch grip strength test (right)	3.5	5.5	8.5
Isometric back strength test	20.0	45.0	73.0
Circumference measurement			
Bodyweight (Kg)	46.2	65.5	88.4
Head circumference	51.0	55.0	58.7
Arm circumference	23.0	29.0	34.7
Wrist circumference	13.5	17.0	21.0
Waist circumference	70.0	86.0	104.0
Hip circumference	86.6	102.0	120.4
Ankle circumference	19.1	23.0	27.0

3.0 RESULTS

The results obtained from the anthropometric database collection are shown in the table above. The data analyses were 5th percentile, 50th percentile, 95th percentile, mean (M), and standard deviation (SD). The anthropometric data were collected from 276 Sabah adults comprised of 150 males and 126 females, ranging from 19 to 69 years old.

Table 2 shows the majority of respondents between 30 and 39 years of age (36.2 %). With a ratio of 54.3%, the majority of genders indicate males are higher than females (45.7 %). The marital status was dominated by the married person with (71.4%), and the marital status minority was widowed (1.8%). In terms of ethnicity, the majority of the subjects were Kadazan (20.3%), followed by Dusun (16.3%), Malaysia Sabah (13.0%), and others (0.4%). The majority of respondents worked in the power plant industry (43.5%). And most of the participants were from the category of administration (70.3 %).

Table 3 shows the mean and standard deviation of the standing and sitting postures. First, the mean and standard deviation for the stature of males was (M=166.0, SD=6.47), and the stature of females was (M=156.5, SD=6.01). Next, the mean and standard deviation of the eye height of males was (M=154.6, SD=6.06), and the eye height of females was (M=145.1, SD=5.36). Finally, the mean and standard deviation of elbow height of males was (M=102.1, SD=5.02), and elbow height for females was (M=95.2, SD=5.40).

The mean and standard deviation for a seated vertical reach of males was (M=129.2, SD=6.03) and seated vertical reach for females was (M=120.6, SD=5.93). For sitting height, the mean and standard deviation of males was (M=87.1, SD=3.99), and females were (M=83.8, SD=3.07). For circumference measurement, the mean and standard deviation of body weight for males was (M=76.0, SD=14.89), and body weight for females was (M=65.0, SD=12.34). For waist circumference, the mean and standard deviation for males was (M=92.3, SD=11.25), and waist circumference for females was (M=86.6, SD=10.73).

4.0 DISCUSSION

Malaysia is a multi-cultural nation, multi-racial and multi-ethnic. It consists of the two (West Malaysia) and (East Malaysia) separated by the South China Sea (Khan & Moorthy, 2014). East Malaysia is less populated with a landmass (Khan & Moorthy, 2014). In East Malaysia, the documentation in anthropometric research is still lacking compared to West Malaysia. Unsurprisingly, the number of dimensions between West Malaysia and East Malaysia does not have a huge difference in the anthropometric measurements around East Malaysia.

This finding supported the previous study on the Malaysian working-age population database. The male respondent in all dimensions, including stature, vertical grip, arm width, sitting height, diameter, and static strength, is higher in all dimensions as shown in Tables 3, 4, and 5. Gender is the main factor influencing workplaces, household products, and tools for industrial designers (Tittiranonda et al., 1999). Good designs and products are important for the comfort of both genders based on the current data in this study. This shows that for the adult working population at Kota Kinabalu, Sabah's gender may have an important impact on anthropometric measurements. The present study results align with the previous research in which males are higher than females in anthropometry measurement (Nurul Shahida et al., 2015).

A comparison of the findings of Hassan et al. (2015) shows that anthropometric measurement in standing position on the peninsula of Malaysia is larger in comparison with East Malaysian where the vertical grip reach of the peninsula of Malaysia male was (M=200.85, SD=10.71) and vertical grip reach of East Malaysian male was (M=194.40, SD=8.40). Same as for the female in the peninsula of Malaysia, the female was (M=184.27, SD=9.38), and the vertical grip reach of East Malaysian females was (M=181.6 SD=7.36). As the comparison of the previous study on Asian regions of Malaysia, Japan, Taiwan, China, and Korea also shows, the height value of the stature and sitting height for both male and female data are among the highest of all Asian regions (Mohamad et al., 2010).

The results of the present study indicate similar patterns with the previous studies. The measurement data is higher among males than females for standing postures such as standing knee height, arm span, and elbow span. It is because the 5th percentile value of males is greater than the 5th percentile of female respondents. According to BIFMA standard, the cover occupants up to the 95th percentile of males for safety and good performance. BIFMA G1 Ergonomic Guidelines recommend fit and comfort for the 5th percentile female to the 95th percentile male (Bellingar & Haworth, 2016). In general, it can be deduced that the anthropometric dimension differs significantly between males and females.

However, the limitation of the present study is that it used convenience sampling as a sampling method. As a result, the study respondents are mostly from the Power Plant Industry. So, the data cannot be generalized to the whole workers' population in Kota Kinabalu, Sabah. However, the data from the present study can be used as one of the data to build a comprehensive anthropometric database in the Sabah population. Consequently, anthropometry is considered one of the crucial criteria in designing products and facilities for the Malaysian population. Therefore, this study provides the latest information to construct a comprehensive anthropometric database that will fulfill this need.

5.0 CONCLUSION

Anthropometry is the measurement of body parts. Previous studies show that anthropometric data used in the workstation, equipment, and workplace design can reduce musculoskeletal injury among workers. As shown in the results section, this present study successfully constructs an extensive anthropometric database of the Sabah population. The anthropometric data gathered from this study could provide industrial designers in Malaysia with references.

The industrial designer will use this anthropometric database to develop an ergonomic product, workstation, or facility for all employees. It may help avoid long-term health problems for employees and reduce muscular-skeletal problems amongst workers in Malaysia. Therefore, all industrial designers need to include anthropometric considerations in their design. Furthermore, the workplace arrangement by the individual properties will increase productivity and life quality by decreasing the tiredness in tasks performed either in standing or sitting positions.

The authors have done the most demanding part of the work, which provides the key to a safer, healthier, and more comfortable work environment for Sabahan workers. With this project, a valuable anthropometric database for Sabahan workers is available. Further, studies should induce more respondents and more dimensions to build a comprehensive database for the Sabahan working population.

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Original Article

Safety Devices Compliances Study: Liquid Fuel Dispenser Area of Petrol Stations in Terengganu

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ABSTRACT : *There were several cases of industrial accidents recorded at petrol stations recently. The need for a standard guideline for Occupational Safety and Health (OSH) compliance has become vital to petrol station operators. Among the aspects of OSH to be considered are installing safety devices on every hardware or equipment associated with fuel loading, storage, and distribution systems at petrol stations. Therefore, a study was conducted on petrol station operators in Kuala Terengganu to assess compliance with installing safety devices using the Department of Occupational Safety and Health Malaysia (DOSH) checklist. In addition, the factors behind the non-compliance were also reviewed and used as the basis for the establishment of a standard guideline for petrol station operators throughout the country. The study's outcome found that the safety device installation compliance is good at fuel loading. In contrast, some important safety devices were not installed and maintained well in the storage and distribution section. The current procedures for the construction of petrol stations should be reviewed to ensure that all required safety devices are installed before the station begins to operate.*

Keywords - *Fuel Dispenser, Occupational Safety and Health (OSH), Petrol Station, Safety Devices*

1.0 INTRODUCTION

In the United States, petrol stations are known as gas stations, and there is a total of 121,446 stations throughout the country as in 2012 (Pierce, 2014). Meanwhile, in 2014 China had some petrol stations of 99,000 operating in the country (Research in China, 2015). Based on a report by the Ministry of Domestic Trade, Co-operatives and Consumerism Malaysia (MDTCC), there were a total number of 2,883 petrol stations as of December 2017. Fig. 1 shows the number of petrol stations in Malaysia as of December 2017. The increasing number of vehicles every year reflects the high demand for petrol stations.

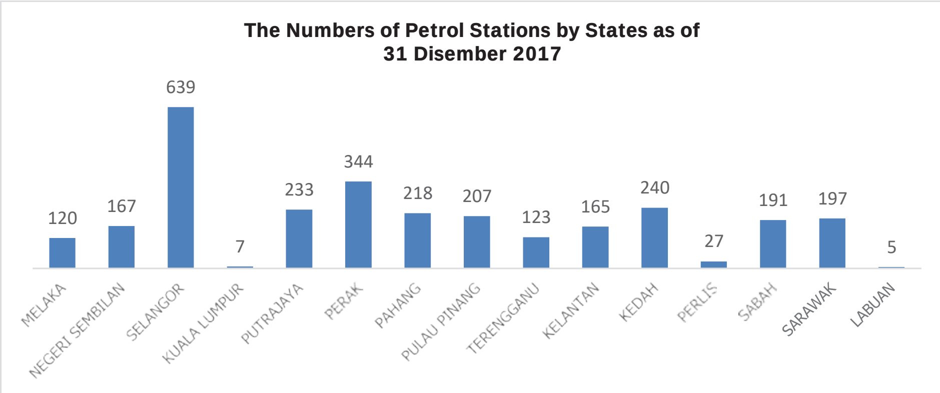

Figure 1 The Number of Petrol Stations in Malaysia by States in 2017 (MDTCC, 2017)

Petrol stations are considered hazardous and high-risk areas, whether aboveground or underground. Most research focused on chemical exposure, such as Volatile Organic Compound (VOC), Toluene, and Xylene (Zhang, 2014). Shamsuri et al. (2017) elaborated on the workers' perception of the fire risk and there is a need among workers to understand the fire risk perception towards petrol stations. An experimental study was conducted by Frobese et al. (1995) on the underground tanks during the unloading process at the petrol station. The experiment found that the air entering the tank during fuel delivery diluted the gas atmosphere in the tank, and the upper explosion limit is not reached in explosive partial volumes. The explosive characteristics of the partial volumes were influenced by the impulse created by the incoming airflow. Therefore, the maximum permissible rate of 200 L/min is required to ensure a smaller explosive material partial volume created during fuel transfer to the underground tank (Frobese, 1995).

In one of the published standards, the US-based National Fire Protection Association (NFPA), (NFPA 30 Section 21.3.4) stated that the tank designed aboveground should not be used as an underground tank (NFPA, 2018). Petrol station incidents can be disastrous if there is a lack of safety measures during construction planning and operation. From 2004 to 2008, the United States Fire Department responded to an average of 5000 fire cases in petrol stations. These fires caused an annual average of two civilian deaths, 48 injuries, and 20 million dollars in indirect property damage (Evarts, 2011). The gas station explosion in Ghana killed around 100 people (The Guardian, 2015). The accident at a petrol station in Gua Musang, Kelantan, in April 2016 claimed one fatality and injured several others. The failure of the level indicator in an underground storage tank during the fuel unloading process from the road tanker caused the oil spillage to flow to the adjacent food stall, and it suddenly caught fire. The flame burnt the customers eating at the kiosk, causing one death and injuring several others (The Star Online, 2014). Currently, in Malaysia, there is no study conducted on the compliances and the fitting (please check factual context) of the safety devices at the fuel filling station. In addition, there is no standardization regarding the installation of safety devices at a petrol station. Therefore, this study was undertaken to evaluate the noncompliance factor by petrol station operators.

2.0 METHOD

Data collection involved all petrol station operators in Kuala Terengganu as of December 2017 through a survey using the inspection checklist on the installation of safety devices. A total of 32 petrol stations operators in the district of Kuala Terengganu, represented by five oil companies; PETRONAS, SHELL, PETRON, Caltex, and BHP Petrol, were involved in this study.

The proportion of operating petrol stations in Kuala Terengganu is shown in Fig. 2, which clarified that 31.3% or ten operators chose SHELL as their brand, 28% or nine picked PETRONAS, 22% or seven chose Caltex, and 3% or one operator chose BHP Petrol. SHELL, PETRONAS, and Caltex have been involved in Malaysia's petroleum retail market for decades, and this is proven by the number of petrol stations carrying their brand.

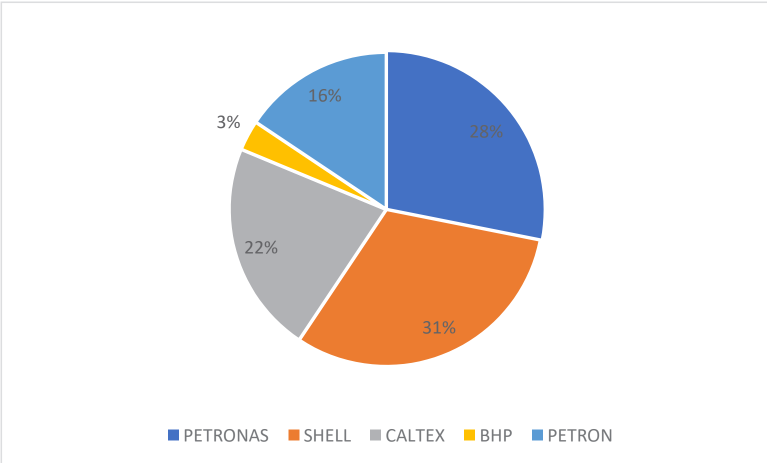

Figure 2 Brand of Petrol Stations in Kuala Terengganu

2.1 DOSH Inspection Checklist

This study emphasized the use of DOSH's inspection checklist as one of the tools for data collection. The data extracted from the same checklist was used as a stand-in for the site visit for data collection. The inspection checklist was issued by the Petroleum Safety Division (PSD) of the Department of Occupational Safety and Health (DOSH) Malaysia. The output of each element in the checklist was divided into 'Yes' or 'No'. If the petrol station complies with the element, the output will be marked as 'Yes', and if it contradicts, the output is 'No'.

2.2 Checklist for Data Collection

The checklist used for data collection is the simplified version compared to the inspection checklist used by DOSH. The data collected for the compliances of safety devices was divided into five sections: Part A: Demographic Profile, Part B: Unloading from Tanker, Part C: Underground Storage System, Part D: Fuel Dispensing Area, and Part E: NGV Dispensing Area.

2.3 Statistical Analysis

Statistical analysis is used to analyze the collected data from the study. Generally, two types of research can be conducted in descriptive and inferential statistics (Saunders & Brown, 2008). Descriptive statistical analysis is preferred to analyze the collected data since the data is captured in binary types of output, which are 'Yes" or 'No'. The frequency analysis, which is part of a descriptive statistic, will be conducted using the collected data to see the pattern of the safety devices compliances by comparing it with the demographic profile of the study. Data analysis will be conducted using the IBM SPSS Software version 21.0.

3.0 RESULTS AND DISCUSSION

The study found that most petrol stations in Kuala Terengganu have been in operation for more than ten years. For example, Fig. 3 shows that 69% or 22 petrol stations were in operation for more than ten years, 25% or eight have operated between 6 to 10 years, and only 6.3% or two petrol stations started their operation in the last five years.

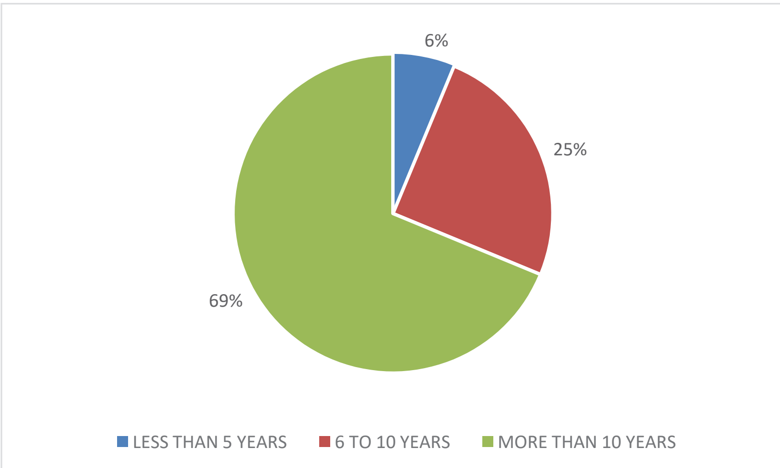

Figure 3 Years of Operation of Petrol Stations in Kuala Terengganu

Some of the owners of the petrol stations, which have operated for more than ten years, inherited the ownership from their parents as most of the petrol stations in Kuala Terengganu are set up as a family business.

Fig. 4 portrays the overall type of petrol station ownership in Kuala Terengganu arranged by the brand. In Malaysia, there are three types of petrol station ownership available: Company Owned Company Operated (COCO), Company Owned Dealer Operated (CODO). The DODO and CODO ownership type shared an equal portion in the total numbers of petrol stations 16 to 16. In addition to that, there are no COCO ownership type petrol stations in Kuala Terengganu. PETRONAS has the highest CODO ownership, and BHP Petrol and Caltex only have DODO-type petrol stations.

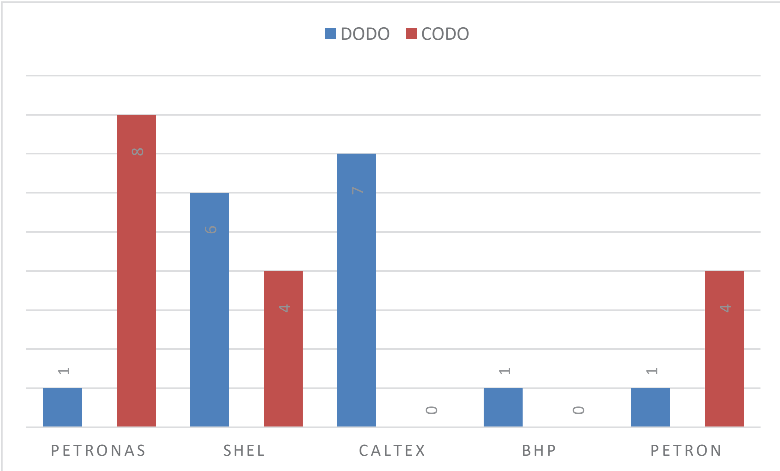

Figure 4 Types of Ownership for Petrol Stations in Kuala Terengganu

PETRONAS does not offer DODO ownership in Malaysia (Kiat, 2014), but the data collected shows that one PETRONAS petrol station has DODO in Kuala Terengganu. The petrol station has been in operation since 1990. Further research found that it was an initiative by the government of Malaysia through PETRONAS to adopt independent (no brand) local bumiputra petrol station operators that serve the rural community. However, the program was not available anymore since companies are focusing on small outlets in rural areas, such as Buraqoil (IPTB Sdn. Bhd.) and Smart Stream Resources Sdn. Bhd. There is no COCO-type ownership in Kuala Terengganu. This is in line with the study conducted by T. Kiat in 2014,which indicated no COCO typed petrol stations in Malaysia (Kiat, 2014).

Part D of the checklist evaluates the safety devices at the liquid fuel dispensing area. The fuel dispensing area is the point of fuel distribution to the public from the underground storage tank. The frequency analysis of data is listed in Table 3.

Table 3 Frequency Analysis Results of Elements in Part D

Part D: Fuel Dispenser Area			
No.	Inspection Element	Compliance (%)	
		Yes	No
D1	Dispenser / Pump Anchoring Grounding to Earth	100	0
D2	Dispenser / Pump Anchoring Free from corrosion damage	97	3
D3	Dispenser Sump Containment Integrity (free from cracks, bulges, holes)	100	0
D4	Emergency Stop Button at each dispenser availability	63	37
D5	Emergency Stop Button clearly labelled	59	41

D6	Emergency Stop Button at each dispenser functionality	31	69
D7	Nozzle sensor functioning properly.	100	0
D8	Nozzle Splash Guard availability	81	19
D9	Valid breakaway (expired date) Manufacturer: (OPW / etc.)	69	31
D10	Bollards are in place to protect against vehicle impact	59	41
D11	Oil floor trap available at each dispenser and flow is not interrupted to oil interceptor.	47	53
D12	Oil floor trap is available, and flow from oil floor trap is not interrupted	81	19

All of the petrol station operators in Kuala Terengganu complied with items D1, D3, and D7, while more than 80% complied with items D8 and D12. Item D4 stated that 37% or 12 petrol station operators did not install the emergency stop button at each dispenser unit. Most of the emergency buttons were only located at the cashier counter inside the sales building. The latest model of fuel dispensers is equipped with the emergency stop button both at the counter inside the sales building and the dispensers' point.

Item D5 indicated that 41% or 13 of the petrol stations did not clearly label the emergency stop button at their premises. Most of the petrol stations which did not label the emergency button were equipped with the old model of the fuel dispensers, where the emergency buttons were located inside the sales building at the cashier's section.

The functionality of the emergency stop button must frequently be tested to ensure readability when it is needed. However, based on the collected data in item D6, 69% or 22 of the petrol stations failed to ensure the functionality of the emergency button for the fuel dispensing system. It will become a catastrophic event if the emergency stop button is not working when an accident occurs.

Item D9 evaluates the breakaway hose integrity at the dispenser point. There were 31% of non-compliance recorded for item D9. Evaluation on item D10 indicated that 41% or 13 petrol stations did not have a bollard at their premises. A bollard is the passive safeguarding to protect against vehicle impact to the dispenser's pump unit. The bollard can be made of concrete or steel structure. In Malaysia, no requirement or regulation emphasizes bollard installation during the construction of a petrol station building. There were several cases reported involving vehicles ramming into dispenser pumps which led to injury and property damage. The most recent case was reported in Melaka, where a car accidentally rammed into a petrol pump and caused fuel spillage, but no injury was reported (Nur Saliawati Salberi, 2018).

Lastly, Item D11 assessed the availability of the oil floor trap at each dispenser. The flow from the oil floor trap to the oil interceptor must not be blocked to ensure the best functionality of the system. The data collected for Item D11 indicated that 53% of 17 petrol stations failed to ensure the oil floor trap system was in good condition. The function of the oil floor trap is to prevent any fuel spillage during the filling process is not directly discharge to the environment. Therefore, proper maintenance programs need to be established and supervised to ensure the system functions per designated purposes.

A cross-tabulation analysis was conducted for item D4 to see the significant relationship between the compliances and the population's demographic profile. Table 4 shows the Cross-tabulation Data of Item D4 and Demographic Profile for Item D4. The analysis result indicated only PETRONAS and SHELL brand operators have 100% compliance for emergency stop button availability at each dispenser point. While Caltex and BHP Petrol branded operators were 100%, PETRON branded operators stated 80% non-compliance for item D4.

Table 4 Cross-tabulation Data of Item D4 and Demographic Profile for Item D4: Emergency Stop Button at Each Dispenser Availability

	Brand of Petroleum Product					Total
	PETRONAS	SHELL	CALTEX	BHP	PETRON	
NO	0	0	7	1	4	12
YES	9	10	0	0	1	20
Total	9	10	7	1	5	32

	Types of Ownership		Total
	DODO	CODO	
NO	9	3	12
YES	7	13	20
Total	16	16	32

	Years of Operation			Total
	Less Than 5 Years	6 To 10 Years	More Than 10 Years	
NO	0	1	11	12
YES	2	7	11	20
Total	2	8	22	32

The cross-tabulation analysis was conducted for item D5 to see the significant relationship between the compliances and demographic profile of the population. Table 5 shows the Cross-tabulation Data of Item D5 and Demographic Profile for Item D5. The analysis result indicated only SHELL brand operators have 100% compliance for emergency stop button labeling. While Caltex and BHP Petrol branded operators were 100%, PETRON branded operators stated 60% non-compliance for item D5. The CODO petrol stations have a better non-compliance at 25% than DODO at 56% non-compliance for item D5.

Table 5 Cross-tabulation Data of Item D5 and Demographic Profile for Item D5: Emergency Stop Button Clearly Labelled

	Brand of Petroleum Product					Total
	PETRONAS	SHELL	CALTEX	BHP	PETRON	
NO	2	0	7	1	3	13
YES	7	10	0	0	2	19
Total	9	10	7	1	5	32

	Types of Ownership		Total
	DODO	CODO	
NO	9	4	13
YES	7	12	19
Total	16	16	32

	Years of Operation			Total
	Less Than 5 Years	6 To 10 Years	More Than 10 Years	
NO	1	1	11	13
YES	1	7	11	19
Total	2	8	22	32

Based on the cross-tabulation analysis, SHELL branded petrol station operators are better at 30 % non-compliance with the emergency stop button functionality. Table 6 indicates the Cross-tabulation Data of Item D6 and Demographic Profile for Item D6. While another operator; - PETRONAS 89%, CALTEX 100%, BHP Petrol 100% and PETRON 60% of non-compliances.

Table 6 Cross-tabulation Data of Item D6 and Demographic Profile for Item D6: Emergency Stop Button at Each Dispenser Functionality

	Brand of Petroleum Product					Total
	PETRONAS	SHELL L	CALTEX	BHP	PETRON	
NO	8	3	7	1	3	22
YES	1	7	0	0	2	10
Total	9	10	7	1	5	32

	Types of Ownership		Total
	DODO	CODO	
NO	10	12	22
YES	6	4	10
Total	16	16	32

	Years of Operation			Total
	Less Than 5 Years	6 To 10 Years	More Than 10 Years	
NO	2	6	14	22
YES	0	2	8	10
Total	2	8	22	32

The cross-tabulation analysis stated that the petrol stations operators that did not comply with item D9 were PETRONAS 44%, SHELL 30%, and Caltex 43 %. Table 7 shows the result of cross-tabulation analysis for Item D9 and Demographic Profile. In addition to that, BHP Petrol and PETRON operators were all complied with item D9.

Table 7 Cross-tabulation Data of Item D9 and Demographic Profile for Item D9: Valid Breakaway

	Brand of Petroleum Product					Total
	PETRONAS	SHELL L	CALTEX	BHP	PETRON	
NO	4	3	3	0	0	10
YES	5	7	4	1	5	22
Total	9	10	7	1	5	32

	Years of Operation			Total
	Less Than 5 Years	6 To 10 Years	More Than 10 Years	
NO	0	4	6	10
YES	2	4	16	22
Total	2	8	22	32

	Types of Ownership		Total
	DODO	CODO	
NO	5	5	10
YES	11	11	22
Total	16	16	32

The cross-tabulation analysis was conducted for item D10 to see the significance of compliance and the demographic profile. Table 8 shows the Cross-tabulation Data of Item D10 and Demographic Profile for Item D10. PETRONAS and SHELL branded operators contributed to most of the non-compliance to the item at 67% and 50% operators, respectively. At the same time, nine CODO operators contributed to the non-compliance of bollard availability at dispensers' island.

Table 8 Cross-tabulation Data of Item D10 and Demographic Profile for Item D10: Bollards are in Place to Protect Against Vehicles Impact

	Brand of Petrol Station					Total
	PETRONAS	SHELL L	CALTEX	BHP	PETRON	
NO	6	5	1	1	0	13
YES	3	5	6	0	5	19
Total	9	10	7	1	5	32

	Years of Operation			Total
	Less Than 5 Years	6 To 10 Years	More Than 10 Years	
NO	2	4	7	13
YES	0	4	15	19
Total	2	8	22	32

	Type of Ownership		Total
	DODO	CODO	
NO	4	9	13
YES	12	7	19
Total	16	16	32

The cross-tabulation analysis was conducted to see the pattern of non-compliance of item D11. Table 9 shows the Cross-tabulation Data of Item D11 and Demographic profiles for Item D11: The oil floor trap available at each dispenser, and flow is not interrupted to oil interceptor. Based on the data, 12 or 38% of total non-compliance was contributed by the petrol operation are in operation for more than ten years.

Table 9 Cross-tabulation Data of Item D11 and Demographic Profile for Item D11: Oil Floor Trap Available at Each Dispenser and Flow is Not Interrupted to Oil Interceptor.

	Brand of Petrol Station					Total
	PETRONAS	SHELL L	CALTEX	BHP	PETRON	
NO	7	5	2	1	2	17
YES	2	5	5	0	3	15
Total	9	10	7	1	5	32

	Years of Operation			Total
	Less Than 5 Years	6 To 10 Years	More Than 10 Years	
NO	1	4	12	17
YES	1	4	10	15
Total	2	8	22	32

	Types of Ownership		Total
	DODO	CODO	
NO	6	11	17
YES	10	5	15
Total	16	16	32

4.0 CONCLUSION

The need for a standardized guideline for installing a safety device is vital to ensure the level of compliances can be equally monitored and enforced by law enforcement agencies or the authorities. Besides that, it also helps the petrol station operators, oil companies, or independent retailers to have all required safety devices since currently, they are following the guidelines or requirements provided by the oil companies. Some critical elements such as overfill protection devices and emergency stop buttons at dispenser points indicated a low level of compliance. There was some significant pattern that can be outlined betweenthe element’s compliances and the population's demographic profile.

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Original Article

The Potential of Agro Based Nanomaterials for Nanofilters to Capture Suspended Titanium Nanoparticles in the Air

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ABSTRACT : *Nanomaterials have a wide range of new technologies and industrial use and have created many new products and employment opportunities. However, they can also pose unknown risks and specific uncertainties in occupational safety and health issues. The latest and most worrying issue involves the increasing production and nanoparticles, particularly titanium dioxide (TiO_2). Therefore, a rigorous study should be carried out to obtain more intensive information to develop a new technique for personal exposure monitoring. The commercially available nanoparticle respiratory deposition (NRD) sampler usually occupied with nylon filter contains TiO_2 background material and is rather expensive. As an alternative, agro based nanofilters were developed from nanomaterials synthesized from rice husks, namely, nanosilica and nanozeolite embedded on/in a polyvinylidene fluoride (PVDF) membrane. As a comparison, graphene was also used to produce nanofilters due to its outstanding performance in chemical absorption. Analysis using Field Emission Scanning Electron Microscope (FESEM) showed a formation of cracks on both nanofilters when embedded with 1% w/v of either nanosilica and nanozeolite compared to 0.1 and 0.5 % w/v. Agglomerate of nanosilica particles with the size between 20 – 40 nm and nanozeolite with the size between 18 – 30 nm were identified on the developed nanofilter. Energy Dispersive X-ray (EDX) confirmed the presence of functional groups such as silica, oxide, sodium, alumina, and carbon on the developed nanofilters, further confirming the deposition of the nanomaterials on the PVDF membrane. Further investigation on the ability to capture titanium nanoparticles using 0.1 % w/v nanofilters from both materials showed that all filters tested could capture titanium nanoparticles with nanozeolite filters showing the highest accumulation with 9170 mg/m^3. These results suggest that agro-based nanomaterials can be used as nanofilters to capture titanium nanoparticles in the air.*

Keywords - *Exposure Assessment, Nanofilter, Nanoparticle, Nylon, Personal Sampler, Titanium Dioxide*

1.0 INTRODUCTION

Exposure of the nanoparticle to workers and consumers has become a problem. TiO_2 is one of the substances which has been used excessively as a nanoparticle in many industries. TiO_2 is a chemically inert, semiconducting material. TiO_2 also exhibits photocatalytic activity in the presence of light with an energy equal to or higher than its band-gap energy. The increasing production of nano-sized TiO_2 powder has led to growing concerns about the consequences of exposure to workers' health. According to the National Institute of Occupational Safety and Health (NIOSH), the respirable dust concentration of TiO_2 was 0.10–0.141 mg/m^3. In comparison, the time-weighted average (10-h TWA) concentrations of TiO_2 was 2.4 mg/m^3 for fine and 0.3 mg/m^3 for ultrafine (Current Intelligence Bulletin 63, 2011). Despite the regulation that has been regulated, many cases reported that some industries already exceeded the permissible limit.

Consequently, some of the studies have shown the effect of TiO2 on human health, such as oxidative stress, genotoxicity, immunotoxicity, and dermal exposure. For example, Brun et al. (2014) demonstrated no visible dissolution of TiO2 particles for as long as 24 hours after the uptake by human gut epithelial cells grown in vitro monocultures. The result shows, the cytotoxic effect caused by TiO2 is more due to its size than the metallic ions being released from the particles absorbed by the cells. Due to the size, the nanoparticle is considered more toxic than the larger particles of the same composition. On the other hand, the study done by Lin Zhao et al. (2016) adopted off-line filter-based sampling combined with real-time activity-based monitoring to measure the concentrations in a selected workplace manufacturing workshop in China. This study found that mass concentrations of TiO2 were at a relatively low level in the packaging workshop (total TiO2: 46.4 µg/m3, nano TiO2: 16.7 µg/m3) and milling workshop (total TiO2: 39.4 µg/m3, nano TiO2: 19.4 µg/m3) by ICP-MS. The number concentration, surface area concentration of aerosol particles potentially deposited in alveolar, and tracheobronchial regions of lungs in the packaging workshop were (1.04 ± 0.89) X 10^5 particles/cm^3, 414.49 ± 395.07, and 86.01 ± 83.18 µm^2/cm^3, respectively, which were all significantly higher than those of the milling workshop [(0.12 ± 0.40) X 10^5 particles/cm^3, 75.38 ± 45.23, and 17.60 ± 9.22 µm^2/cm^3, respectively] as well as in the executive office and outdoor background ($p<0.05$). Activity-related characteristics were found in both workshops, and the time-variant characteristics showed very similar trends for three days in the packaging workshop.

The available nanoparticle personal sampler, a Nanoparticle Respiratory Deposition (NRD) sampler, as shown in Fig. 1, has some limitations towards analyzing the nanoparticles metal oxide such as TiO_2. The nylon filter used in the NRD sampler was discovered to contain titanium on the background level. A higher concentration of the element was detected during the quantitative analysis (Cena et al., 2011 and Mines et al., 2016). This would directly impact the actual measurement of the exposure level of the TiO_2 nanoparticles during the air sampling. It also highlighted that each session of the air sampling required eight nylon filters to be used in the sampler, which is very costly and its limitation suitability for high air temperatures and humidity in the employment sectors in Malaysia.

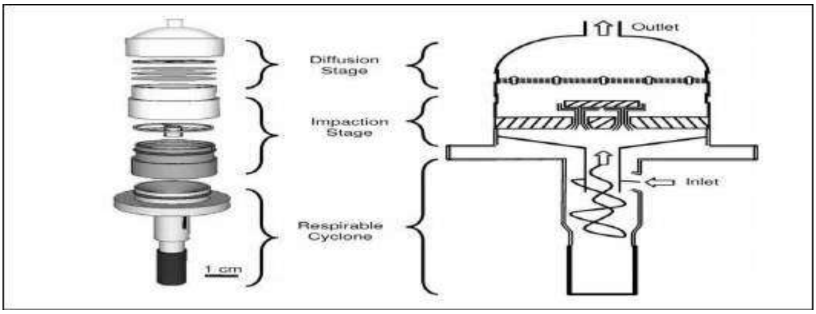

Figure 1 The Components and Schematic Drawing with Airflow Paths of the NRD Sampler (Cena et al., 2011).

Rice husk is an agro-waste material that can form different nanomaterials such as nanosilica and nanozeolite. Nanosilica has potentially great adsorptive material due to its promising properties, i.e., having a large surface area and porous structure (Liou & Yang, 2011). Furthermore, silica particles are also being used to isolate particulate matter fractions in other applications (Stillwell, 2016). Nanozeolite are nano-size hydrated porous crystalline aluminosilicates with an open-framework structure made up of tetrahedral SiO_4^{4-} and AlO_4^{3-} units capable of metal and ion-exchange activities (Ng et al., 2015). In this process, both nanosilica and nanozeolite were used as a precursor to developing nanofilters to capture titanium nanoparticles in the air. In addition, due to its outstanding performance in chemical adsorption, graphite in the form of graphene oxide was also used to produce nanofilter to compare its performance with the agro based nanofilters.

2.0 METHOD

The production of the nanomaterials was using rice husk ash and graphite as the precursors. As a part of previous work by Zuraidi et al., An experimental setup as shown in Fig. 2, the rice husk ash was used to prepare nanozeolite and nanosilica. In contrast, graphite was used to produce graphene oxide (GO). Three different concentrations of nanomaterials using nanosilica, nanozeolite, and graphene (0.1% w/v, 0.5% w/v & 1% w/v) were used to develop the nanofilter by using the layer deposition method that is facilitated by vacuum filtration adapted from Wang et al. (2019). The filters were produced in three steps. Firstly, five ml from each nanosilica solution were pipetted on PVDF membranes (0.22 µm). Then, the solutions were vacuum filtrated to produce a PVDF-nanosilica filter. Lastly, the filters were left to dry at room temperature. These steps were repeated until eight filters from each concentration were made.

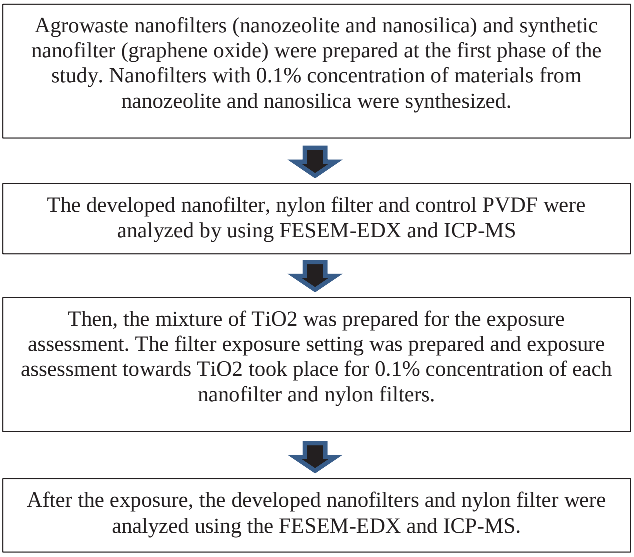

Figure 2 Overall Flowchart of the Study Methodology

The developed PVDF-nanofilters were imaged through Field-Electron Scanning Electron Microscopy-Energy Dispersive X-Ray Spectroscopy (FESEM-EDX – Jeol Ltd. Manufacturer, Japan) at University Malaysia Pahang (UMP). Sample preparation has been conducted before analysis. The raw PVDF filter and PVDF-nanofilters (0.1%, 0.5% & 1% w/v concentration) were cut and pasted on a metal plate using a carbon tape. Then, the sample was coated with platinum and exposed to an emitted electron beam.

The filters were placed inside the NRD sampler. The TiO2 nanoparticles were exposed to the filter using the air pump force to test the performance of nanofilters and capture titanium nanoparticles. Nanofilters were placed carefully on the last cassette (third cassette) of the NRD sampler with the side of the implemented filter against the airflow to collect the nanoparticles, as shown in Fig. 3 (a & b). All sampler components were correctly placed at the neck of the Buchner flask before sealing them properly with masking tape and parafilm. An air tube was connected from the outlet of the sampler to the vacuum pump. It will draw the air from inside the flask. Meanwhile, another tube connected from the sidearm tube of the flask to the flow rate controller, which connected to the air pump as well.

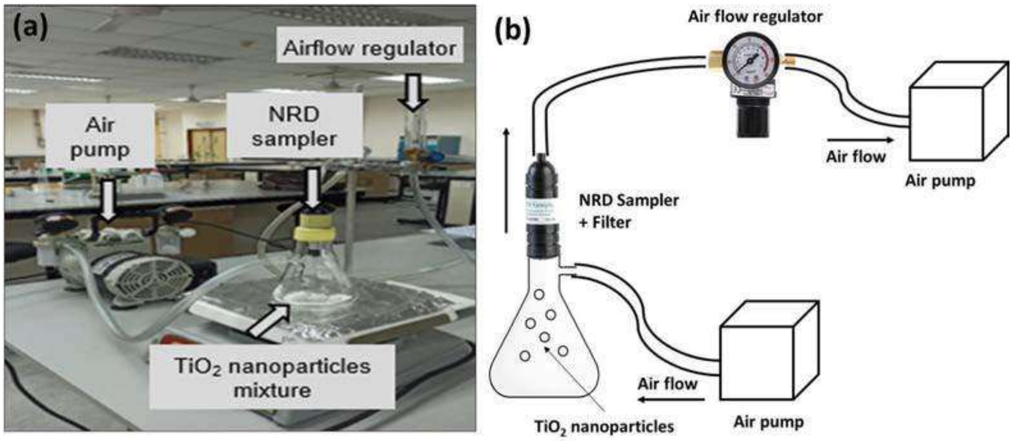

Figure 3 Overall Set Up for in Situ Exposure Assessment

The flow rate controller was adjusted to 2.5 Liters Per Minute (LPM), which followed the American Conference of Governmental Industrial Hygienists (ACGIH) after switching the vacuum pump and air pump. The exposure testing was conducted for 15 minutes. The flask was gently shaken after five minutes-interval to distribute the nanoparticle mixture simultaneously after 15 minutes before all the air tubes connected to the sampler, and the flask was detached completely.

The nanofilter was removed carefully from the cassette before being placed in a clean, dry petri dish. The petri dish was sealed correctly with parafilm to prevent the nanofilter from being contaminated. The petri dish was also labeled correctly based on the type of nanofilter and its concentration. The experiment continued by testing the nylon filter, PVDF membrane, and other new nanofilter already synthesized before. A triplicate sample for each type of nanofilters was submitted to UMP central lab to be quantified using an Inductive Coupled Plasma Mass Spectrometer (ICP-MS) for the presence of captured titanium element. The *in-situ* exposure assessment experiment was set up in the laboratory with precautions measures to reduce the risk of inhalation of TiO_2.

3.0 RESULTS AND DISCUSSION

Pre-analysis of nanofilters (before exposure to TiO_2) was done using FESEM-EDX to analyze the distribution and stability of each nanomaterial embedded on the PVDF membrane using the layer deposition method. Fig. 3 a) illustrates the pristine PVDF filter with intertwined fibers forming a porous network with a size around 0.3 – 0.6 µm. However, the porous network was successfully covered with nanosilica when deposited with 0.1, 0.5, and 1.0 % w/v nanosilica (Fig 4 b, c, and d). The nanosilica deposited on the surface of PVDF was seen to be in the form of agglomerates. Each nanoparticle is in the range of 20 – 40 nm. Fair distribution of silica on PVDF-silica composite membrane is also observed in other studies. Fernandes et al. (2017) utilized the immersion precipitation method, while Xiong et al. (2013) used the electrospinning method to prepare the composite filter for wastewater remediation. The good dispersion and distribution of silica nanoparticles suggest the interaction between the PVDF chains and the silanol groups of silica (Zhang, 2011). It is expected that incorporating silica into the PVDF membrane would improve PVDF surface structure by forming more pores and increase the efficiency of the composite filter in trapping contaminants (Fernandes, 2017). A similar process was observed when 0.1, 0.5, and 1.0 % w/v of nanozeolite was deposited on the PVDF membrane (Fig. 5 b, c, and d). Each nanozeolite particle embedded on the PVDF membrane was observed to be in the range of 18 – 30 nm. Recent work has shown that the surface modification of the PVDF membrane by nanozeolite could increase its porosity but did not compromise its permeability (Nassrullah et al. 2020). The modification of the hydrophilic

PVDF membrane with hydrophilic nanomaterials also increases the polarity on the surface, thus increasing the tendency for inorganic nanomaterials such as TiO2 to bind to the surface. The FESEM image of the GO-PVDF membranes indicates the presence of graphene oxide layering on top of the porous PVDF membrane surface based on the presence of a thin and wrinkle-like layer of the GO. The presence of wrinkle-like GO layering on the PVDF membrane increased with the increased amount of GO (Fig. 6 b, c, and d). The higher the concentration of GO used, the appearance of crumple and wrinkle structures become more accentuated on the surface of the composite filter prepared, which indicated thicker GO sheets were stacked on the surface.

EDX results of pristine PVDF membrane revealed the presence of high carbon (C) content followed by fluorine (F) and small amounts of oxygen (O) (Fig. 6 a). Meanwhile, nanosilica filters showed the presence of major elements in nanosilica, such as silica (Si) and oxygen (O), with a small concentration of carbon (C) impurities present (Fig. 7 b). As for nanozeolite, the presence of the leading chemical composition of the nanozeolite was observed, such as silica (Si), alumina (Al), oxide (O), and sodium (Na) (Fig. 6 c). The sodium present in this analysis is suggested to reduce the acidity of the zeolite acid sites (Saeed, Hamadi, and Sherhanm, 2019). As for the PVDF membrane embedded with GO, it was found that the weight of % of carbon and fluorine were higher in the control PVDF membrane as PVDF is a thermoplastic fluoropolymer with carbon-fluorine and hydrogen elongated chain. The presence of a high % of oxygen element indicates the successful oxidation and graphene oxide formation. In addition, the fluorine weight % was significantly reduced compared to the control PVDF membrane, which is also attributed to the increased thickness of GO that layered the PVDF membrane. In terms of nanomaterials film stability on the filter substrate, it can be observed that a high concentration of nanomaterials with 1% w/v showed an unstable deposition on the filter substrate. This is due to the formation of cracks on the nanoparticle layer (Fig. 8). It could be due to the excessive amount of nanomaterials added onto the membrane, which could cause leakage to the filter if it is being applied. The pressure caused by the airflow could also easily break the nanomaterials layer, affecting the accumulation of the titanium nanoparticles captured. Due to this, filters containing 0.1 % w/v of nanomaterials only were chosen to be tested following its stable deposition on the PVDF membrane.

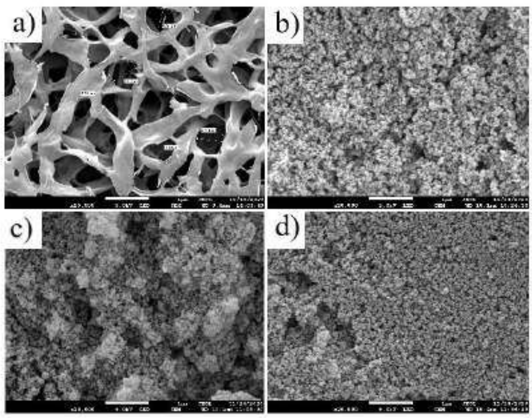

Figure 4 FESEM Images of Nanosilica Embedded on PVDF Membrane before Exposure to Titanium Under 20,000 Magnification A) PVDF Only B) 0.1% W/V Nanosilica - PVDF C) 0.5% W/V Nanosilica - PVDF D) 1.0% W/V Nanosilica – PVDF

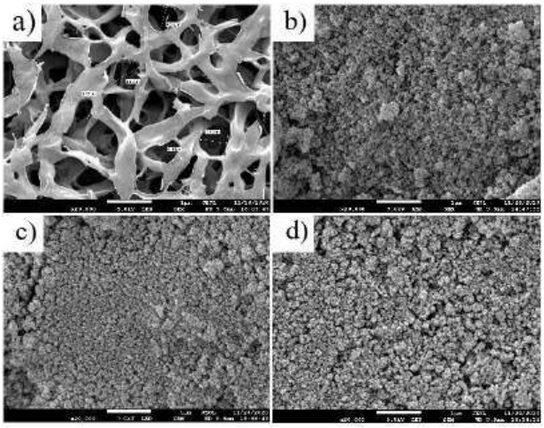

Figure 5 FESEM Images of Nanozeolite Embedded on PVDF Membrane before Exposure to Titanium Under 20,000 Magnification A) PVDF Only B) 0.1% W/V Nanozeolite - PVDF C) 0.5% W/V Nanozeolite - PVDF D) 1.0% W/V Nanozeolite – PVDF

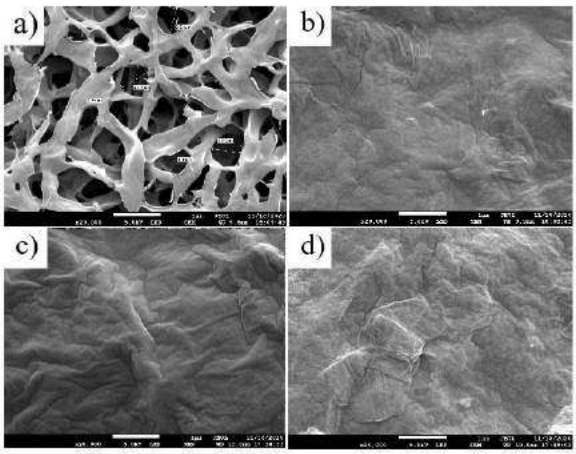

Figure 6 FESEM Images of Graphene Oxide Embedded on PVDF Membrane before Exposure to Titanium Under 20,000 Magnification A) PVDF Only B) 0.1% W/V Graphene Oxide - PVDF C) 0.5% W/V Graphene Oxide – PVDF D) 1.0% W/V Graphene Oxide – PVDF

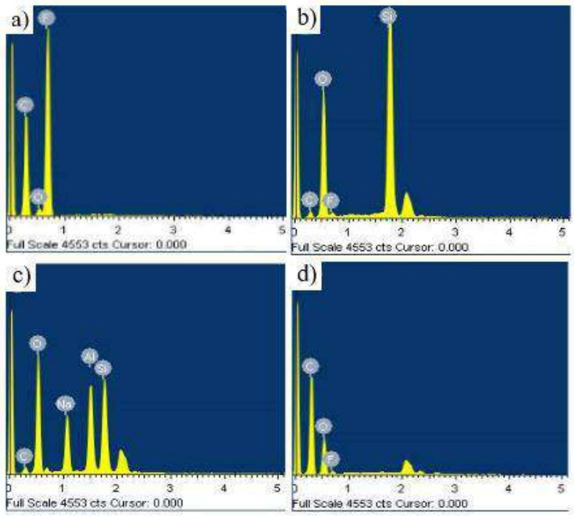

Figure 7 EDX Spectrum for A) PVDF B) Nanosilica - PVDF C) Nanozeolite - PVDF D) Graphene Oxide – PVDF

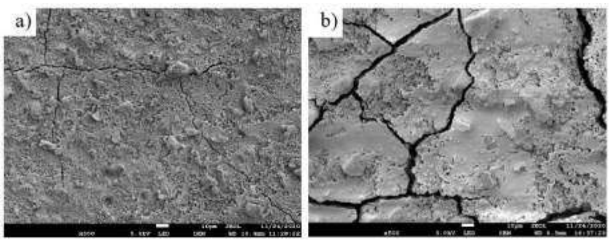

Figure 8 FESEM Images at 500x Magnification of A) 1.0% W/V Nanosilica - PVDF and B) 1.0% W/V Nanozeolite – PVDF Showing the Formation of Cracks on the Surface of the Membrane

From the ICPMS analysis, the result showed that nylon filters have the highest amount of TiO_2. The average amount of TiO_2 between the triplicate samples for nylon filters is 1326000 mg/m^3. However, this may be counted as invalid due to its composition of TiO_2, and each of the nylon filters may have a different concentration of TiO_2 (Mines et al., 2016). Interestingly, nanozeolite-PVDF has the highest amount of TiO_2 trapped among the developed nanofilter with an average of 9170 mg/m^3, followed by nanosilica-PVDF with 4590 mg/m^3 and GO-PVDF with 2330 mg/m^{3,} respectively, as shown in Table 1. On the other hand, the ability of GO-PVDF to trap the TiO_2 during exposure assessment was lower compared to the nanosilica-PVDF and the nanozeolite PVDF. This is due to the limited pores on the GO-PVDF. In addition, the trapping ability of GO-PVDF was not good as compared to others as the GO-PVDF might be lacking cavities with limited pores. However, GO-PVDF was still able to trap TiO_2 based on the ICP-MS analysis. Nanosilica-PVDF was the second-best material to capture TiO2.

In contrast to GO-PVDF, the nanosilica-PVDF has a large surface area and high porosity based on the FESEM image. This may also be due to the chemical interaction, such as the bonding between Ti-O-Ti, Ti-O-H, and Ti-O-Si. Other studies stated that chemical bonding occurred between the Si and Ti (Rasalingam et al., 2013; Dalod et al., 2017; Hakki et al., 2017). Other than that, dipole-dipole interaction between the negative charge of the silica and Ti may be contributed to the trapping ability of nanosilica-PVDF towards TiO_2. The best material for capturing TiO_2 is nanozeolite-PVDF, as stated in the result of ICP-MS. Nanozeolite, cheap and agro-waste made, shows a higher captured amount of TiO2 than nanosilica and graphene oxide. Besides its large surface area and the high porosity, interaction between zeolite and the Ti through the bonding of Ti-O-Na may also contribute to the trapping ability of TiO_2 (Kostrikin et al., 2017).

Table 1 ICP-MS Results on Ti Content from Pre and Post (Before and After Exposure to Tio_2) Filters Exposed to Tio_2. Results are Mean from Triplicates ± SEM.

Sample name	Pre-exposure Results (mg/m^3)	Post-exposure Results (mg/m^3)
PVDF	Not detected	Not detected
Nano silica	Not detected	4586 ± 419
Nano zeolite	Not detected	9170 ± 1123
Graphene	Not detected	2333 ± 239
Nylon	1212000	1326000 ± 28360

4.0 CONCLUSION

Newly developed nanofilters, consisting of 0.1% concentration (nanosilica-PVDF, nanozeolite-PVDF, and GO-PVDF) and nylon filter, were successfully tested after the exposure assessment towards TiO_2 under 15 minutes with a flow rate of 2.5 LPM. The developed nanofilters were tested in the setup of in–situ experiment using the NRD sampler. All the developed nanofilters and the nylon filters managed to capture TiO_2. Although the result showed that the nylon filter has the highest concentration of TiO_2, it is invalid to claim the nylon filter is the best as it already contained high background readings of TiO2, which affected the result of occupational exposure TiO_2 due to its composition of TiO_2. Moreover, the background reading in the nylon filter already exceeded the recommended exposure limit (REL) of ultrafine $TiO_{2,}$ which is 0.3 mg/m^3. Nanozeolite-PVDF was the best nanofilter as it captured the highest concentration of TiO_2 followed by nanosilica-PVDF and GO-PVDF, respectively. This showed that nanozeolite could potentially replace the nylon filters used in the NRD sampler. The objectives of this study were achieved. However, the exposure assessment method could be improved to test the actual condition of the industry setup. The usage of tape and parafilm to cover the air holes was not so practical. A good layout of the experiment can be done to make the exposure assessment more feasible. For the sample preparation of the ICP-MS analysis, the acid digestion was not fully digested. Suggestions to improve to have different concentrations and types of acid could be helpful to achieve complete digestion of the sample. This could achieve full recovery of TiO2 from the tested nanofilters.

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Short Article

Preventing Non-Authorized Access to Employee Medical Records at Worksites

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ABSTRACT : *Worksites may store medical records, and they may not be familiar with protecting medical data. An important aspect of medical data protection is the prevention of non-authorized access. Occupational health personnel are commonly responsible for this task. If they are not available, a suitable authorized person needs to be appointed. Types of medical data kept at worksites and measures required to prevent non-authorized access are described.*

Keywords *- Employee, Medical Records, Non-Authorized Access, Occupational Health, Worksites*

1.0 INTRODUCTION

It is common for worksites to store medical records of their employees to comply with local regulations or company procedures. As stated in the Department of Occupational Safety and Health, Ministry of Human Resource, Malaysia (DOSH) Guidelines on Occupational Health Services, one of the functions of Occupational Health Services would be to manage medical records (DOSH, 2005). Occupational Health (OH) personnel are usually familiar with medical data protection. However, many worksites in Malaysia do not have an on-site OH service. Therefore, an important aspect of medical data protection is the prevention of non-authorized access to medical records.

There are various types of laws or guidance on data protection. For example, in the European Union (EU), there is the General Data Protection Regulation (EU, 2016), whereas, in Malaysia, there is the Personal Data Protection Act 2010 (PDPA, 2010). The Malaysian Medical Council (MMC), which governs medical professionals in Malaysia, produced Guidelines on Confidentiality (MMC, 2011). BASF, a chemical company with approximately 110,000 employees in around 90 countries globally (BASF, 2020a), produced its guidance on medical data protection (BASF, 2020b). The BASF guidance document provides clarity to their sites globally on how to achieve the expected standards. In countries with higher national standards, the site must comply with the higher standard. We have used the BASF guidance as the main reference for this article.

This article aims to explain medical data and provide guidance on how to prevent non-authorized access to employees' medical records at worksites.

2.0 CONTENTS

2.1 What is Medical Data

Medical data is all information concerning the medical status of an individual, including medical history, physical examination findings, results of the mental status examination, medical test results, laboratory findings, diagnosis, and provision of medical health care which relates to past, present, or future physical or mental health or condition of an individual. Medical records are medical information physically recorded in any form, paper, or electronic form (e.g., medical files of patients, progress notes, consultations), also including particular media specific to the equipment or imaging study conducted (e.g., X-ray, ECG, audiometry or lung function print outs) (BASF, 2020b).

Medical records at worksites can either be generated on-site or off-site. For example, suppose a medical assessment is performed and recorded at the worksite. In that case, the document is generated on-site, whereas if the assessment is performed and recorded at an external facility, it is generated off-site. Medical records can also be stored either on-site or off-site. For example, if the medical assessment results are stored at the worksite, it is on-site, whereas if stored at an external facility, it is stored off-site.

2.2 How to Prevent Non-Authorized Access

Sites with or without OH personnel need to be familiar with medical data protection and take necessary measures to prevent non-authorized access to medical records. Given the lack of material and awareness at worksites on this subject, we share the recommendations from MMC and BASF.

2.2.1 Measures Recommended by MMC

Among the measures stated by MMC to prevent non-authorized access to medical records were enhancing physical and Information Technology security, limiting access to legitimate users, maintaining a log of access, antivirus protection, and proper hardware disposal (MMC, 2011).

2.2.2 Measures Recommended by BASF

BASF produced guidance on medical data protection to assist local management in ensuring good practices globally, including medical data protection.

2.2.2.1 Roles and Responsibilities of OH Personnel or Department

The BASF guidance emphasizes the role of OH personnel and department in medical data protection. Although not specified in the guidance document, it is understood that authorized persons would need to be appointed to this role if a site does not have OH personnel or a department. The criteria and responsibilities of authorized persons must be clearly defined. They need to be adequately trained on medical data protection and sign a written agreement to protect medical data. The guidance document does not state the necessary job level or title of the person performing this role. The manager of the OH department is responsible for ensuring data protection (e.g., awareness, responsibilities of the supporting medical staff (physician, paramedic, nurse, assistant) signed acceptance of the data protection regulation), and regular information sessions must be held to inform and remind all members of OH department. The principles of medical data protection should be communicated to the staff members of the OH department. They should be made accessible to employees, patients (also non-employees), and clients (also non-patients).

All medical information that arises from or concerning the interaction between individual and OH personnel should be:

i. kept confidential, recorded, stored, and transmitted following the individual's rights;

ii. not visible or accessible to non-authorized persons;

iii. secured and locked away if not in use or required;

iv. labeled as "strictly confidential" when sent or transmitted;

v. transmitted by email or fax only with measures taken by the sender to assure that the intended person may only view the content: use encryption for email transmission; fax transmission, ensure that the recipient is present and can promptly remove the faxed document from the machine; and

vi. sent back to the responsible department if received by the wrong addressee.

In medical studies, annual reports, and publishing documents, personal identifiers of subjects and patients must be thoroughly obscured beyond feasible attempts at reconstruction.

2.2.2.2 OH Facilities

The OH facilities should be designed to enable adequate medical data protection (e.g., separate treatment and consultation room).

2.2.2.3 OH Service Provision by External Provider

If an external provider provides OH services, equivalent data protection measures should be defined in the contractual agreements between the provider and the company. Generally, medical records generated by external OH providers for company purposes and at company premises are the company's property. They must be provided upon request to an authorized company physician or an appointed person of the OH department. Procedures should be in place that explicitly states which data is collected, who will access it, and how to handle the information.

2.2.2.4 Protection of Medical Records Against Disclosure

Medical records are protected against disclosure without the explicit consent of the concerned patient or client or some other overriding legal reason justifying disclosure. In the first instance, the patient or client should be informed about the medical information disclosed to obtain his explicit consent. In addition, attention should be paid when confidential information needs to be disclosed on extraordinary grounds without explicit consent (e.g., a requirement by law, public interest, orprevention of a serious crime). In all these situations and disclosing confidential data, the applicable laws and regulations must be observed.

2.2.2.5 Storage of Medical Data

Suppose storage of medical files on-site is mandatory according to legal requirements even without an internal OH department, and access for-authorities needs to be guaranteed at all times. In that case, there has to be a clear written procedure on how this access is managed and misuse is prevented. Proper measures should be reducing the number of person with an access to medical files; number of persons with access to medical files reduced to a minimum; persons with access must sign the confidential statement; storage must be-sealed, broken seal needs to be documented; four-eye-principle should be implemented; breach of confidentiality must be documented and reported. Medical records in all forms must always be stored securely and separately from the other personnel information. The head of the OH department should determine the media and the location for the storage of the medical records. The head of the OH department must authorize the destruction of medical records; the usual terms and conditions of data destruction apply (BASF, 2020b).

3.0 CONCLUSION

Various measures can be taken to ensure non-authorized access to employee medical records. Elements that need to be considered include the roles and responsibilities of OH personnel or department; OH facilities; OH service provision by an external provider; protection of medical records against disclosure; and storage of medical data. Those responsible for the medical records, i.e., OH personnel or authorized persons, need to be familiar with these measures.

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Book:

Perez, A.K., Little, T.H., & Brown, Y.J. (1999). Safety in numbers. Itasca, IL: National Safety Council.

On-line Publication:

National Institute of Occupational Safety and Health. Sick Building Syndrome. www.niosh.com.my/safetytips.asp?safetyid=1 (accessed October 2004)

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