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Journal of Occupational Safety and Health

The Journal

- Aims to serve as a forum for sharing research findings and information across broad areas in occupational safety and health.
- 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:

• To promote debate and discussion on practical and theoretical aspects of OSH

• To encourage authors to comment critically on current OSH practices and discuss new concepts and emerging theories in OSH

• To inform OSH practitioners and students of current issues

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 "Process Safety Management as A Sustainable Safety Process in Managing Chemical Accidents in Malaysia". For years, the chemicals and chemical products subsector is one of the largest contributors to investments in the manufacturing and petrochemical sector in Malaysia. In the country, continuous increment in the amount and complexity of industrial plants had been clearly apparent throughout the years, especially in the chemical processing industries (CPI), in line with the current industrial progress and development. However, these developments had also brought about an inevitable increment in the risk of major accident hazard occurrence as mismanagement of these facilities and plants could lead to the catastrophic effect of large-scale major accident hazards. The paper focused on reviewing the effectiveness of the process safety management (PSM) system based on the fourteen PSM elements in Chemical Process Industries (CPI) in country. This research paper highlighted that the Incident Investigation (II) element was important in defining the root causes of accidents in the Chemical Process Industry (CPI). Simultaneously, the paper also presented several tools and techniques to further improve effective performance and this evidence provides clear industry-specific advantages of PSM adoption and implementation. As the industrial processes become even more complex and the number of conditions to be controlled exceeds existing safety management procedures in facilities or plants and impacts human safety and health, an evolving PSM system should be more practical to prevent major industrial accidents.

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

Application of Bayesian Network in Occupational Safety and Health: Prediction of Health Hazards from Nanosilver Exposure

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ABSTRACT : *Nanosilver has been widely used in industries due to its antibacterial, antifungal, and antioxidant properties. However, prolonged exposure to nanosilver imposes negatively upon human health and may cause conditions such as argyria, argyrosis, and DNA damage. In recent times, the rapid diversification of industrial nanosilver without accompanying risk assessment exercises has contributed to a lack of understanding of such hazards, thus leading to negligence in safe work practices and exposing workers to danger. This work demonstrates the Bayesian network (BN) model application to predict the hazards of nanosilver. The model characterises the relationship between the physicochemical properties of nanoparticles and their biological effects on the human body based on expert elicitation and data from independent publications. For hazard prediction purposes, three nanosilver variants of different particle sizes, shapes, surface coatings, administration routes, and applications were chosen. Predictions obtained using the BN model are in line with published experimental studies. The potential health hazard of a nanosilver variant was shown to depend heavily on its physicochemical properties. Resultantly, the BN model developed in this work can make such predictions accurately, even with limited information. The outcome of this work will be useful in supporting the improvement of occupational safety and health practices in the industry.*

Keywords - *Occupational Safety and Health, Health Hazard, Nanomaterials Exposure, Prediction of Health Hazard, Workplace*

1.0 INTRODUCTION

The International Organisation for Standardisation (ISO) defines “nanomaterial” as a “material with any external dimension in the nanoscale or having an internal structure or surface structure in the nanoscale”. “Nanoscale” is a length ranging “approximately from 1 nm to 100 nm” (The International Organization for Standardization (ISO), 2015). The European Commission in 2011 defined “nanomaterial” as a “material containing particles in an unbound state or as aggregate or as an agglomerate and where, for 50% or more of the particles in the number size distribution, one or more external dimension is in size range 1–100 nm” [Commission recommendation of 18 October 2011 on the definition of nanomaterial (Text with EEA Relevance) (2011/696/EU), 2011]. Due to their scale, nanoparticles behave and function differently in their bulk form, influenced by quantum and surface effects. Quantum effects refer to changes in optical, electrical, thermal, mechanical, and magnetic properties, whereas surface effects refer to increased reactivity due to increased exterior surface area (Azoulay et al., 2013). As a result, nanomaterials are often regarded as a new form of material with a wide range of applications in the healthcare, textile, cosmetics, agriculture, and construction industries.

Of several metallic nanomaterials, silver nanoparticles (AgNPs) are one of the most vital. They are known for their antibacterial, antifungal, and antioxidant properties. Previous studies indicated that AgNPs limit the progression and growth of many bacteria, including *Bacillus cereus* and *Citrobacter koseri*, and the fungus *Candida albicans*. In particular, their antibacterial capacity is achieved as Ag/Ag+ from AgNPs binds the biomolecules present in microbial cells, thus preventing the replication of bacteria by inducing oxidative stress and cell death (Siddiqi et al., 2018). Consequently, AgNPs have been utilized mainly in the production of housecleaning products and medication.

Although such studies extolled the benefits of AgNPs, they often also emphasise that overt exposure to these particles could deteriorate human health. Numerous *in vivo* studies determined that AgNPs are toxic to the mammalian skin, vascular system, liver, brain, lung, and reproductive organs. They not only accumulate but persist in these tissues, increasing the chances of severe toxicity (Ferdous & Nemmar, 2020; Gosens et al., 2015; Seiffert et al., 2016). Additionally, *in vitro* studies reported that the destructive effect of AgNPs on DNA could potentiate cancer by inducing the expression of genes associated with cell cycle progression (Ferdous & Nemmar, 2020; Kaiser et al., 2013). Several conditions linked to exposure to AgNPs in the workplace have been reported, such as the irreversible pigmentation of the skin (argyria) or of the eyes (argyrosis) (Drake & Hazelwood, 2005; Van de Voorde et al., 2005). Drake & Hazelwood (2005) also reported other indications of toxicity such as upper (nose and throat) and lower (chest) respiratory tract irritation and reduced glutathione levels. The most common impact of prolonged silver exposure at the workplace is argyria. It is caused by the accumulation of Ag compounds in the human body, marked by a turning of the skin colour to blue or blue-grey. In 1935, sixteen workers of a silver-nitrate factory reportedly experienced generalized or local argyria (Harker & Hunter, 1935). A later study further proved that workplace exposure led to argyria, argyrosis and the intravenous accumulation of silver (Rosenman et al., 1979). Silver-related fatalities were reported by Barrie & Harding (1947), where autopsies on three individuals showed that each suffered from argyro-siderosis of the lungs due to years of workplace exposure to inhaled iron-oxide and silver dust. However, a study conducted by Pifer et al. (1989) had also demonstrated that the increased presence of silver in blood, feces, and hair of reclamation workers did not come with significant health effects.

Regardless, the potential of occupational health hazards posed by nanomaterials on humans and the environment calls for enhanced risk-mitigating physicochemical measures to pre-empt their short and long-term toxic effects (Azoulay et al., 2013; Karim et al., 2017; Kim & Yu, 2016; Yokel & MacPhail, 2011). The National Institute for Occupational Safety and Health (NIOSH US) recommended an Immediately Dangerous to Life or Health (IDHL) exposure dosage of 10 mg/m^3 and the Recommended Exposure Limit (REL) was set to 0.01 mg/m^3 for metal dust such as silver on an 8-hour time-weighted average (TWA) concentration basis (National Institute for Occupational Safety and Health, 2016). Various risk assessment and control banding tools have been developed, including GoodNanoGuide (GNG), Stoffenmanager Nano, CB Nanotool 2.0, NanoSafer, ANSES Control Banding, and Queensland control banding worksheet (Winski, 2017). Unfortunately, as both their particulate and molecular identities are responsible for their biological effects, the consequence of exposure to nanomaterials cannot be accurately predicted from the current understanding of their bulk properties.

Furthermore, the conventional approach to data collection is not robust enough to keep up with the high speed of nanomaterial diversification in the industries. As a result, incomplete nanomaterials data hinders proper occupational health assessment of the workplace. To resolve this issue, the BN model previously published in Marvin et al. (2017) was redeveloped. Subsequently, the newly-derived model was applied towards the prediction of the potential health hazards caused by excessive and prolonged AgNP exposure in the workplace. The integration of risk assessment with BN was proposed through this work due to the displayed ability of our BN model as a machine learning tool towards the prediction of potential health hazards despite incomplete nanomaterial data. Outcomes from simulations additionally suggest that the model would capably capture the interaction and impact of physicochemical property changes within the nanomaterial network itself. In conclusion, the BN model produced in this work could strengthen the case for improving occupational health practices in the nanosilver industry.

2.0 METHOD

The new BN model was developed through a process depicted by the flow chart in Fig. 1.

2.1 Data Collection

The major nanomaterials used in the industries were identified based on published statistics involving ten paint and coating products available in the market and three prominent nanomaterials (i.e., titanium dioxide (TiO_2), silicon dioxide (SiO_2), and silver (Ag)) (*StatNano : Nano Science, Technology and Industry Information*, n.d.). Data for learning and validation were collected from independent results of published studies by Marvin et al. (2017), who had compiled reliable information on the characteristics of nanomaterials from several resources, including physical-chemical property databases and safety data sheets. Crucial parameters were determined that would allow the model to characterise the relationship between the physicochemical properties of nanoparticles and their biological effects on the human body. The data and state were then classified with reference to scientific publications verified by expert elicitation in Marvin et al. (2017), as shown in Tables 1 and 2. Overall, 237 and 48 sets of data were incorporated for learning and validation, respectively.

Table 2 lists the tested endpoints related to the biological effects of a nanomaterial, classified into None, Low, Medium, and High. Tested endpoints must demonstrate significant differences from the control (as reported by the article) to be classified as having a biological effect (Table 3). Notably, this scale reported only the probability of the nanomaterials exerting an effect (strength of the evidence) but not its level of severity. An overall effect node was included to depict the potential that a nanomaterial may exert a biological effect, as calculated from Equation 1.

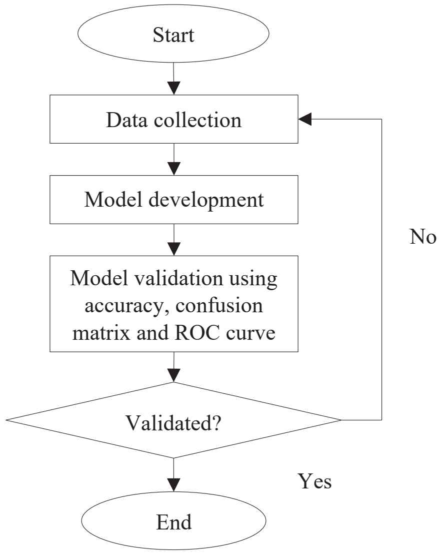


Figure 1 BN Model Development

Table 1 Classification of Data for Model Development

Administration Route	**Study Type**	**Physicochemical Properties**	**Potential Biological Effect**
Inhalation	*In vivo*	Shape	Cytotoxicity
Oral	*In vitro*	Nanoparticle	Neurological effects
Dermal		Surface area	Pulmonary effects
Intravenous		Surface charge	Fibrosis
		Surface coatings	RCNS effects
		Aggregation	Genotoxicity
		Particle size	Inflammation

Table 2 Classification of States for Model Development

Shape	Amorph, Irregular, Sphere
Nanoparticle	Ag, SiO_2, TiO_2
Surface Area	0–15, 15–51, 51–101.25, 101.25–189, 189–2025
Surface Charge	-50–-25, -25–0, 0–-25
Surface Coatings	AHPP, Carbon, Carboxyl, Citrate, Hydroxyl, None, PVP, Silane-Aluminium
Aggregation	High, Low, Medium
Particle Size	0–10, 10–50, 50–100, > 100
Cytotoxicity	High, Low, Medium, None
Neurological Effects	High, Low, Medium, None
Pulmonary Effects	High, Low, Medium, None
Fibrosis	High, Low, Medium, None
RCNS Effects	High, Low, Medium, None

Genotoxicity	High, Low, Medium, None
Inflammation	High, Low, Medium, None

$$HR_i = \sum_{k=1}^{7} BE_{ik} \tag{1}$$

where HR_i is the nanomaterial hazard score of case i and BE_{ik} is the biological effect level score of case i and biological effect k.

Table 3 Criteria for the Classification of Biological Effects (Marvin et al., 2017)

Classification	**Criteria**				BE_{ik}
None	Endpoint(s) falling under the defined effects were tested	No significant difference in the tested endpoint compared to control			0
Low	Endpoint(s) falling under the defined effects were tested	A significant difference in the tested endpoint compared to control			1
Medium	Endpoint(s) falling under the defined effects were tested	A significant difference in the tested endpoint compared to control	Dose-response relationship	• Positive indication of an effect in a few tests or in a few animals • < 75% decrease in cell viability	2
High	Endpoint(s) falling under the defined effects were tested	A significant difference in the tested endpoint compared to control	Dose-response relationship	• Positive indication of an effect in several tests or in several animals • > 75% decrease in cell viability	3

2.2 Model Development

Marvin et al. (2017) predictive nanomaterial risk model was redeveloped using GeNie from BayesFusion LLC. Its network of nodes was manually constructed according to the classifications given in Tables 1 and 2. The directions of its arc were drawn based on the input from expert-verified published data. Parameter learning was then executed using the data collected. Once completed, the model was ready for the validation process. Different analyses can be performed to understand the model, such as the strength of influence and sensitivity analysis.

2.3 Model Validation

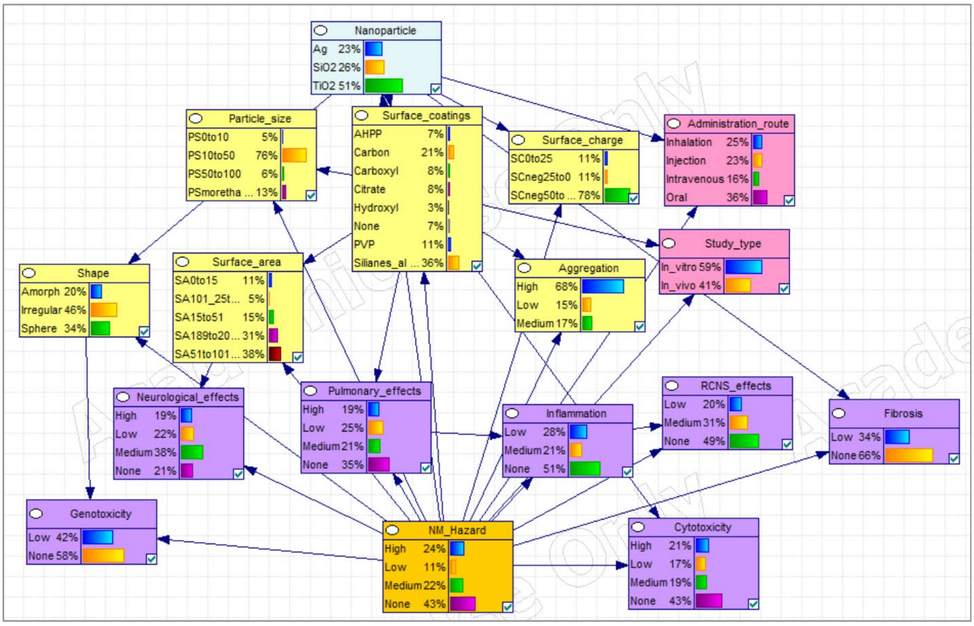
For validation purposes, 48 sets of data were selected randomly from the total data collected on Ag, SiO2, TiO2. These were matched with the developed model before the type of evaluation was selected. The three types of evaluation conducted by GeNIE are test only, leave-one-out cross-validation, and K-fold cross-validation. In this work, a K-fold cross-validation strategy was applied, with K = 10 and class nodes = NM_Hazard. The evaluation process first required the data set to be divided into K parts of equal size. The network was then trained in K-1 parts before a final test was conducted at the end of the last K. The process was repeated K times by selecting different parts of the data for testing. With GeNIe, model usability is evaluated by keeping its core structure fixed, even as parameters are relearned during each fold (BayesFusion LLC, 2020). Three outcomes, namely accuracy, confusion matrix, and receiver operating characteristic (ROC) curve from the validation exercise, would indicate the validity of the model.

3.0 RESULTS

The BN model developed in this work is shown in Fig. 2.

3.1 Accuracy

The ‘Accuracy’ tab showed that the model achieved a 75% accuracy rate by predicting the correct NM_Hazard in 36 out of 48 data sets (Fig. 3). GeNIe had assigned the most probable class node state for each data set in this process. The tab also denoted the model sensitivity and specificity (BayesFusion LLC, 2020). Its sensitivity towards None and Low was similar, with a prediction accuracy of 85.71% (n = 18/21) and 83.33% (n =5/6) for each. The model was less sensitive in predicting the NM_Hazard of High (66.67%, n = 6/9) and Medium (58.33%, n = 7/12) nodes.



Indicator	Definition
	Type of nanoparticles
	Physicochemical properties
	Exposure routes & study types
	Potential biological effects
	NM hazards

Figure 2 BN Model for Nanomaterial Hazard of Titanium, Silicon Dioxide, and Silver

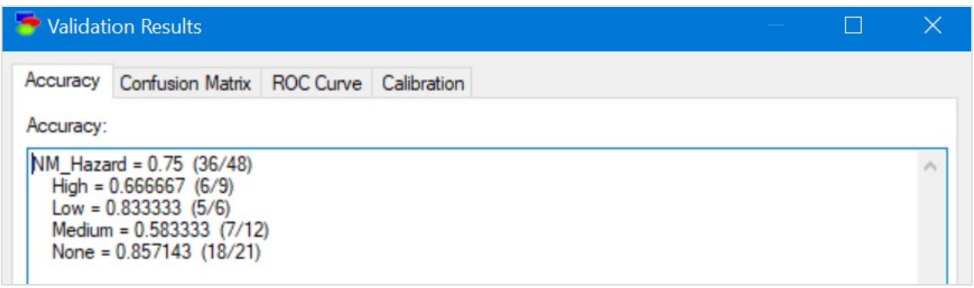
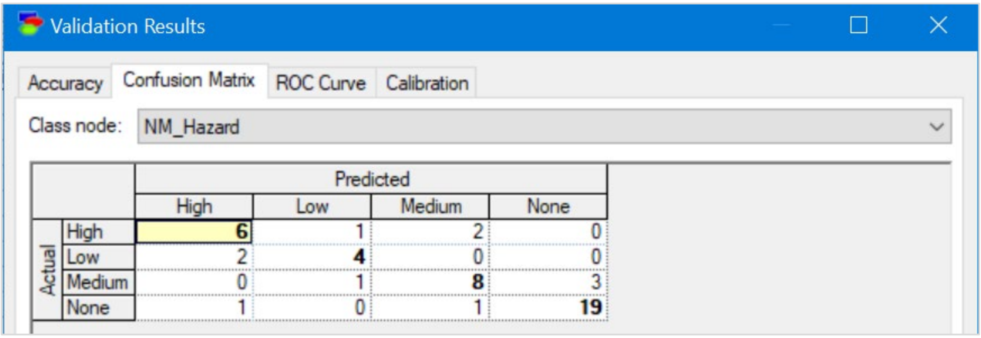


Figure 3 Accuracy of the BN Model for Titanium, Silicon Dioxide, and Silver

3.2 Confusion Matrix

The 'Confusion Matrix' table in Fig. 4 compared prediction directly against the true state of affairs. The columns represent the guesses produced by the model, while rows show how the data sets were actually classified. Here, it is clearly shown that the new BN model was largely successful in correctly assigning the data sets into their appropriate NM_Hazard classes. Bolded numbers were correctly identified instances for each class. However, all off-diagonal cells showed incorrectly identified classes (BayesFusion LLC, 2020).

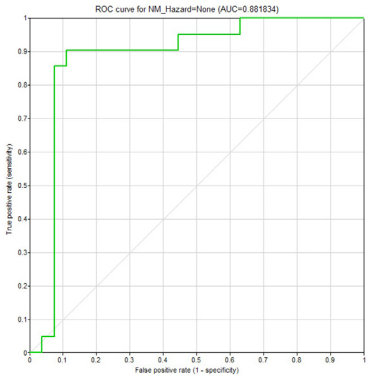


		Predicted			
		High	Low	Medium	None
Actual	High	**6**	1	2	0
	Low	2	**4**	0	0
	Medium	0	1	**8**	3
	None	1	0	1	**19**

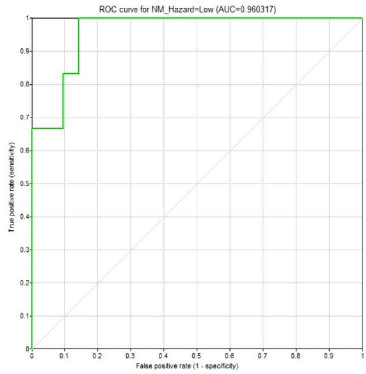
Figure 4 Confusion Matrix of the BN Model for Titanium, Silicon Dioxide, and Silver

3.3 ROC Curve

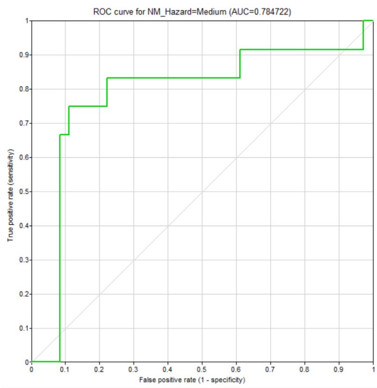
The 'ROC Curve' tab contained the ROC curves for individual data sets of each class variable, expressing the quality of a model-independent classification decision. A curve shows the possible accuracy ranges of the model, limited to a singular point on the curve as per the decision criterion applied by GeNIe. Choosing a different point will affect sensitivity and specificity and thus overall accuracy. The indistinct diagonal line represents a baseline ROC curve of a hypothetical classifier that is insignificant. A functional classifier would produce a curve above this diagonal line. The area under the ROC curve (AUC) is displayed above it. AUC is a simple but imperfect way of expressing the quality of the model using one number (BayesFusion LLC, 2020). Nonetheless, as each classifier (High, Medium, Low, and None) obtained a ROC curve above the diagonal line, it can be concluded that their use for NM_Hazard classification is suitable (Fig. 5).



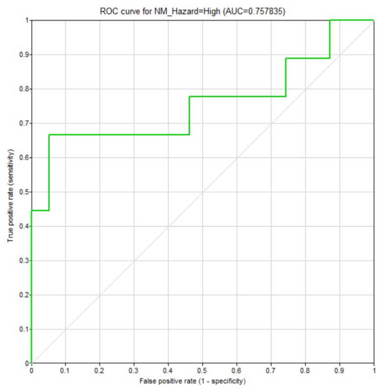
a) ROC curve for NM Hazard = None



b) ROC curve for NM Hazard = Low



c) ROC curve for NM Hazard = Medium



d) ROC curve for NM Hazard = High

Figure 5 ROC Curve of the BN Model for Titanium, Silicon Dioxide, and Silver

4.0 DISCUSSION

In this section, three AgNPs with different physicochemical properties were incorporated as evidence into the BN model for testing and validation purposes. The data are presented in Table 4. These AgNPs are referred to as A, B, and C. Observations of their biological effects were based on pulmonary effects, inflammation, and genotoxicity. These are summarised in Table 5.

In the experimental work conducted by Gosens et al. (2015), three animals per group were exposed to A via intratracheal instillation with doses ranging from 0 to 128 μg/mouse. Their results indicated that although AgNP agglomeration could be observed inside lavaged macrophages, there were neither signs of acute cell damage nor inflammation in the mice. Additionally, no pulmonary effects were reported due to exposure to nanosilver via injection. In a validation exercise, the physicochemical properties of A (particle size, study type, and administration route) were introduced as evidence into the redeveloped BN model produced in this work. Convincingly, the outcomes predicted by the model were "None" for pulmonary effects and inflammation, in line with the published experimental report.

In work conducted by Seiffert et al. (2016), four biological effects (assayed silver levels, distribution of silver particles in the lungs, surfactant composition, and lung function changes) were examined after the exposure of Brown-Norway and Sprague-Dawley rats to B-type AgNP aerosols. The physicochemical properties of B are shown in Table 4. The researchers concluded that exposure to B would cause acute pulmonary neutrophilic inflammation due to the production of proinflammatory and pro-neutrophilic cytokines. Brown-Norway rats were more adversely affected as additional eosinophilic inflammation and deterioration of lung function could be observed. The redeveloped BN model was retested, albeit with the properties of B as newly-introduced evidence. Its functionality was proven once more as the model successfully showed that, in comparison to A, B would impose a greater risk of pulmonary effects and inflammation ("Low" and "Medium"). These predicted changes could have been discerned from the type of evidence provided. The nanoparticles shape and curvature and their administration route are thought to influence cell-binding efficacy and dissolution (Buchman et al., 2019). Findings presented by Helmlinger et al. (2016) suggested that the shape of an AgNP particle greatly dictates dissolution rates and, therefore, its cytotoxicity and antibacterial effects.

Dissolution indicates biodurability and is directly correlated to an entity's potential to influence the long-term toxicity and pathogenicity of the particles deposited in the body. In a biological system, known dissolution rates of the following entities from the highest to the lowest are platelets > spheres glucose synthesis > spheres microwave synthesis ≈ rods > cubes (Helmlinger et al., 2016). This correlation explains why AgNPs persist for at least seven days after inhalation, as published data by Seiffert et al. (2016) indicated that a longer time is required to observe the impact of exposure via inhalation compared to direct instillation.

In the *in vitro* experiments conducted by Kaiser et al. (2013), a different set of parameters were monitored, including apoptosis/necrosis, reactive oxygen species, and genotoxicity. The study showed that the dose and duration of exposure highly influenced genotoxicity. For example, exposure to 5 µg/mL of AgNPs for 48h resulted in DNA strand breaks without significant consequences to health, although adverse effects were observed once the concentration was doubled to 10 µg/mL. Similarly, the percentage of cell death could only be observed at higher concentrations of AgNP exposure. Due to the limitation of the present BN model, a comparison to Kaiser et al.'s study was conducted only for genotoxicity. With its physicochemical properties introduced as evidence, the model classified the effect of C as "None", in agreement with experimental data from the *in vitro* studies. This could be perceived as yet another testament to the model's usability. Furthermore, as C is a mixture of spheres and rods, its biodurability is low compared to other shapes, explaining its non-genotoxic nature. Importantly, the accuracy of its prediction displayed the capability of the BN model to infer a suitable conclusion based on a simple attribute of the nanomaterial of concern.

In conclusion, the comparison shown in Table 5 proved that the BN model is robust enough to produce results already verified through real-world experiments. With a 75% accuracy rate, the model was able to produce accurate predictions with the aid of good quality of data obtained and supported by expert elicitation, as reported by Marvin et al. (2017). Nonetheless, although experts had validated the previous BN model's nodes, states, and linkages, there were certainly ways to improve its reliability. In this current work, a redeveloped BN model was constructed to accept and accrue evidence in the form of physicochemical properties from any published study. This could ensure greater prediction accuracy and thus better assist the assessment of occupational health hazards in the nanosilver industry. In the future, the model algorithm could also be further modified to factor in more evidentiary parameters, such as dose and duration of exposure.

5.0 CONCLUSION

A BN model was developed and used to predict the health hazards imposed by AgNP exposure in this paper. Three case studies were demonstrated with resulting predictions compared to published experimental data. These were consistently in line with published data, indicating that the BN model was able to predict potential health hazards in a nanosilver-centric workplace. The strength of the BN model is derived from its data learning feature and its ability to infer and calculate probabilities according to the newly presented evidence. However, as the BN methodology relies heavily on the initial input, the accuracy of its predictions would only be as good as the quality of the initiating data.

Furthermore, predictions are limited to the properties and effects decided at an early stage of model development. Any other factors that may affect the final results would be disregarded unless included during the development stages. This current study had thence redeveloped the previous BN model to consider nanomaterials' physicochemical properties, as it is likely critical for proper occupational health assessment. The outcomes of this work are vital in supporting the development of a precautionary approach in managing nanomaterial risk and improving occupational health practices in the industry.

Table 4 Nanosilver Physicochemical Properties

Type	References	Particle Size (nm)	Shape	Surface Coating	Surface Charge	Administration Route	Study Type
A	Gosens et al. (2015)	< 20	-	Polyoxy-laurate Tween 20	-	Injection	In vivo
B	Seiffert et al. (2016)	13–16	Nanosphere	Uncoated AgNPs	-	Inhalation	In vivo
C	Kaiser et al. (2013)	25 80–90	Spherical Rods	-	-25	-	In vitro

Table 5 Comparison between Published Experimental Data and Prediction using the BN Model

Type	References	Pulmonary Effect		Inflammation		Genotoxicity Effect		
		Published Experimental Data	Predicted using BN Model	Published Experimental Data	Predicted using BN Model	Published Data	Experimental	Predicted using BN Model
A	Gosens et al. (2015)	No noticeable effects	None	No noticeable effects	None		-	-
B	Seiffert et al. (2016)	Acute pulmonary neutrophilic inflammation	Low	Acute pulmonary neutrophilic inflammation	Medium		-	-
C	Kaiser et al. (2013)	-	-	-	-	• 5 µg/mL for 48 h: more DNA strand breaks, an insignificant effect • 10 µg/mL for 48 h genotoxicity: a significant effect		None

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Original Article

Chemical Health Risk Assessment of Cleaning Activities in an Office Building

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ABSTRACT : *The use of chemicals is a necessity in the workplace. Chemicals are used in office buildings, restaurants, schools, laboratories, manufacturing factories, jewelry shops, and many more places. Chemicals are one of the hazards in a workplace. In Malaysia, it is observed that poor chemical handling has led to tragedies and chemical incidents. Under the Occupational Safety and Health Act (OSHA) 1994, it is one of the main responsibilities of the employer to protect and safeguard employees from the adverse effects of chemicals at the workplace. This study aims to assess the types and hazards of chemical handling and storage chemicals for cleaning activities in an office building. The method used in this study is by conducting Chemical Health Risk Assessment (CHRA) according to the Manual of Recommended Practice Assessment of the Health Risks Arising from the Use of Chemicals Hazardous to Health at Workplace Third Edition First Reprint 2018 published by the Department Occupational Safety and Health (DOSH) Malaysia towards chemical handling and storage of chemical activities in a building. The interactions between office cleaners and eleven (11) types of chemicals are involved in this study. Among the challenges faced were the incomplete chemical Safety Data Sheet provided by the suppliers and the chemical storage room which is not readily provided in the building. To overcome the obstacles, the Safety Data Sheet is directly requested from the chemical suppliers, and a chemical storage area is designated in the building. From the assessment conducted, the current control measures are inadequate and improvements in terms of ventilation, storage, and Personal Protective Equipment are needed. It is expected that this study will later demonstrate the risk assessment of hazardous chemicals in the building that are significant to human health and current control measures that can be further improved to provide a safe and healthy working environment for the office cleaners.*

Keywords - *Chemicals, CHRA, Cleaning, Handling, Storage*

1.0 INTRODUCTION

The use of chemicals is necessary for a workplace, such as office buildings, restaurants, schools, laboratories, manufacturing factories, jewellery shops, and other locations. For example, cleaning services requires hundreds and thousands of liters of chemicals. It is estimated that an average cleaning worker uses approximately 110 kg of hazardous chemicals annually. (Barron *et al.*, 1999). According to the Occupational Safety and Health (Use and Standards of Exposure of Chemicals Hazardous to Health) Regulations 2000, chemicals are defined as chemical elements or compounds or mixtures, whether natural or synthetic, but do not include micro-organisms. Chemicals are widely used as cleaning products, catalysts, polishers, perfumes, fertilizers, and others. When this chemical is used in our daily lives, many workers are exposed to the adverse effects of chemicals. Aliyu *et al.* (2006) defined occupational hazards as any condition of a job that can result in illness or injury, endangerment, jeopardy, peril, risk, a source of danger, and a possibility of income loss or misfortune which includes all forms of departure from health among workers caused by their working conditions.

Chemicals are indeed a silent killer to human health. Wolkoff *et al*. (1998) state a complex pattern of exposure to cleaning agents, which results in health problems, such as allergies and asthma, reported among cleaners. Blatter and Zielhuis (2016) conducted a recent study and are convinced that multiple chemical agents are suspected of causing menstrual disorders among hairdressers who are exposed to the chemical agents. Generally, workers involved in cleaning have the highest rate of contact dermatitis (Caroe *et al.*, 2014). In addition, they also have an increased risk of asthma and rhinitis. (Folleti *et al.*, 2013). Building cleaners are among the prominent group of workers who experience diverse occupational hazards resulting in health problems. A previous study was conducted by Charles *et al.* (2019) to identify the health outcomes and associated hazards in the cleaners' work environment\. The results were astonishing as respiratory diseases(n=17) and dermatologic diseases (n=9) were the most common and significantly associated with exposure to cleaning agents. In a previous study conducted by Zock *et al.* (2001), the asthma risk of home cleaners was mainly associated with kitchen cleaning and furniture polishing, using sprays. The use of cleaning products results in exposure to various chemicals, including Volatile Organic Compounds (VOCs), and causes more than 10% of all cases of adult-onset asthma (Quirce and Barranco, 2010). Unintentional chemical poisoning also occurs, which has been commonly reported to occur among children who were found to be exposed to household chemical products. (Adnan *et al.*, 2013).

In occupational health, prevention is better than cure. It is really important to identify the root causes of near misses or incidents. In Malaysia, it is observed that poor chemical handling has led to tragedies and chemical incidents. The recent incident in Malaysia was the explosion that happened in an integrated waste management center at Negeri Sembilan, Malaysia. According to The Star (2015), the fire was seen razing from the chemical store, which involves flammable liquids and combustible materials. Another chemical-related incident that happened was a building lockdown at Taman Tampoi Indah 2, Johor Bharu. The incident happened following a chemical spill in the laboratory at 4.20 pm, 21st March 2019. Based on a report by the Malay Mail (2019), a chemical spill in the laboratory involving sulphuric acid led to a building lockdown. Concentrated sulphuric acid is extremely corrosive and causes burns when not handled properly. According to Adane *et al.* (2012), accidents involving chemicals have been reported worldwide for several reasons, such as an absence of Personal Protective Equipment (PPE), limited experiences, mishandling of chemicals, and lack of knowledge about the proper actions that needs to be taken during an emergency event. One of the effective methods to prevent accidents in many industries is improving the workplace's safety culture. (Gong, 2018).

The use of a chemical is extremely crucial to ensure a smooth workplace operation. Office cleaners are among the occupations in contact or exposed to the use of cleaning chemicals in their daily routine, whether through inhalation or dermal contact. Chemicals are one of the hazards in a workplace. According to Taheri *et al.* (2018), risk assessment is one of the measures to prevent the hazardous effects of chemicals on human health. The enforcement of Chemical Health Risk Assessment (CHRA) is as stated in the Occupational Safety and Health Act 1994, which emphasise employers must conduct risk assessment to work activities that involve the use of chemicals at the workplace. The assessment is essential to evaluate the potential risks to employees due to exposure to hazardous chemicals. For that reason, CHRA will look into the availability and adequacy of control measures at the workplace. Control measures act as barriers against hazardous chemicals from being in contact with the employees. There are four (4) routes where chemicals can get into contact with the employees and subsequently enter into the body. These are through inhalation, skin contact, ingestion, and rarely inoculation. (Ahmad, 2017). Although this enforcement was introduced in 2000, cases concerning chemical incidents are still reported by the Department of Occupational Safety and Health. Based on the Hierarchy of Control, Standard Operating Procedures (SOP) are one of the control measures under the Administration Control. This SOP is documented, reviewed, updated, and maintained year by year. SOP is the ultimate key or the first barrier to ensuring a safe work method when dealing with chemicals. However, how effective is the current SOP? Does it have any gaps with the current regulations and guidelines? The SOP should be opaque enough and cover the safety aspect from all processes involved when office cleaners handle the chemicals.

The study aims to identify the types and hazards of chemical handling and storage chemicals for cleaning activities in an office building. Then, the chemical hazards will be analyzed through Chemical Health Risk Assessment. The assessment needs to be continuously conducted and the findings reported to create and increase awareness among office cleaners. When awareness is embedded in the culture, it is shown and portrayed among their daily practice. In a study conducted by Miyagawa (2010), the likelihood of unfortunate events can be minimized if chemicals are used and stored properly with strict safety regulations and rules. The safe work practice must be recorded in documented information such as standard operating practice, which must be made available. SOPs act as a guideline in the workplace. This study also aims to propose strategies to resolve the shortcomings by improving the current SOPs of chemical handling and storage for the cleaning activities for the office building.

2.0 METHOD

The chemical health risk assessment is a process that utilizes a systematic approach, namely identifying the hazardous chemical use and management, evaluation of the hazard risk, the adequacy and the effectiveness of current control measures, and identifying the level of risk at the workplace. The assessment is based on the Department of Occupational Safety and Health guideline, Manual of Recommended Practice Assessment of the Health Risks Arising from the Use of Chemicals Hazardous to Health at Workplace Third Edition First Reprint 2018. The assessment involves risk assessments carried out among office cleaners who are directly exposed to the risk of chemicals. In addition, work procedures and SOPs of chemical handling are reviewed. Furthermore, Safety Data Sheets are the main document reviewed to assess the chemical health risk. Based on the guideline, there are a few steps to conduct the assessment. This method is chosen based on the previous studies that had adopted the same methodology for chemical handling and storage. Such studies are the Chemical Health Risk Assessment (CHRA) in a Wet Assay and Fire Assay Laboratory research conducted by Arif Susanto *et al.* (2020). Furthermore, this method provides practical guidance and advice for conducting an assessment of risk to health related to the use of chemicals hazardous to health at the workplace for the compliance to the requirements of the Occupational Safety and Health (Use and Standard of Exposure of Chemicals Hazardous to Health) Regulations 2000.

Conducting a Chemical Health Risk Assessment (CHRA) involves a few parameters observed in the daily routine of office cleaners. A total of 15 office cleaners were monitored during cleaning activities at a 12-storey office building in Putrajaya. The observation includes understanding how the cleaners handle the cleaning chemicals and the type of Personal Protective Equipment worn during the chemical handling. In addition, the observation includes how long the cleaners were exposed to the chemicals during cleaning. The outcome of the observation is recorded and determined by referring to Table 2.1 to Table 2.7. The frequency of chemical exposure to cleaners significantly affects the degree of exposure. For instance, twice the frequency would yield a two-fold increase in exposure. The frequency of potential exposure can be estimated from observing the work activities and feedback from the workers and management. Frequency Rating (FR) is used and is determined from Table 2.1. Another parameter of measurement is the duration of exposure. It has a significant effect on exposure. Twice the duration will result in twice the exposure. Therefore, the average duration is used to determine the duration of exposure. Duration of exposure can be determined from Table 2.2, which is the Duration Rating (DR). From FR and DR, the Frequency-Duration Rating (FDR) can be found as in Table 2.3. All these structured tables are taken from the Department of Occupational Safety and Health, Manual of Recommended Practice Assessment of the Health Risks Arising from the Use of Chemicals Hazardous to Health at Workplace Third Edition First Reprint 2018.

The Magnitude Rating (MR) is determined by the chemical's physicochemical properties and human interface during chemical handling. It is assessed by estimating the degree of chemical released or presence and the degree of chemical inhaled, as shown in Table 2.4. However, MR value can be modified by other factors such as bad work habits, poor personal hygiene, complaints of ill effects, biological monitoring results, or other related diseases or illnesses. In addition, MR value can depend on the conditions of the working area or the way chemicals are being handled. Therefore, it may increase or decrease in terms of the risk involved. Either way, the final MR assigned should not exceed rating of 5 or less than a rating of 1. Based on the Frequency-Duration Rating (FDR) and Magnitude Rating (MR) value, the Exposure Rating (ER) value can be determined from Table 2.5 Exposure Rating (ER).

Table 2.1 Frequency Rating (FR)

Rating	Description	Definition
5	Frequent	Exposure one or more times per shift or per day
4	Probable	Exposure greater than one time per week
3	Occasional	Exposure greater than one time per month
2	Remote	Exposure greater than one time per year
1	Improbable	Exposure one per year or less

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

Table 2.2 Duration Rating (DR)

Rating	Duration of exposure per shift (x)
5	$x \geq 7$ hours
4	$4 \leq x < 7$ hours
3	$2 \leq x < 4$ hours
2	$1 \leq x < 2$ hours
1	$X < 1$ hour

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

Table 2.3 Frequency – Duration Rating (FDR)

		Frequency Rating (FR)				
		1	2	3	4	5
Duration Rating (DR)	1	1	2	2	2	3
	2	2	2	3	3	4
	3	2	3	3	4	4
	4	2	3	4	4	5
	5	3	4	4	5	5

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

Table 2.4 Magnitude Rating (MR)

Degree of Release/ Presence		Degree of Inhaled		
		Low	Moderate	High
	Low	1	2	3
	Moderate	2	3	4
	High	3	4	5

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

Table 2.5 Exposure Rating (ER)

Frequency-Duration Rating (FDR)		Magnitude Rating (MR)				
		1	2	3	4	5
	1	1	2	2	2	3
	2	2	2	3	3	4
	3	2	3	3	4	4
	4	2	3	4	4	5
	5	3	4	4	5	5

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

2.1 Risk Determination

The level of risk is determined by using Risk Rating (RR), which is derived from the Hazard Rating (HR) and Exposure Rating (ER), as shown in Table 2.6. The risk rating is determined by using the following equations:

Risk Rating = Hazard Rating X Exposure Rating

RR=HR x ER

Where:

RR is risk rating (1 to 25) indicates the likelihood of injury or illness;

HR is hazard rating (1 to 5) indicates the severity of adverse effects; and

ER is the exposure rating (1 to 5) indicates the chance of overexposure to the chemicals.

Table 2.6 Level of Risk Determination

		Exposure Rating (ER)				
		1	2	3	4	5
Hazard Rating (HR)	1	RR=1	RR=2	RR=3	RR=4	RR=5
	2	RR=2	RR=4	RR=6	RR=8	RR=10
	3	RR=3	RR=6	RR=9	RR=12	RR=15
	4	RR=4	RR=8	RR=12	RR=16	RR=20
	5	RR=5	RR=10	RR=15	RR=20	RR=25

Low Risk	RR=1 to RR=4
Moderate Risk	RR=5 to RR=12
High Risk	RR=15 to RR=25

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

After determining the Exposure Rating (ER), the Action Priority (AP) can be assigned. Action Priority is identified in each action that needs to be taken. The action priority is used to prepare the action plan for implementing identified control measures. The action priority is assigned based on the level of risk and adequacy of control measures, as shown in Table 2.7. There are three (3) levels of action priority that can be concluded from the assessment. Firstly, Action Priority 1 (AP-1) is where the Risk Rating (RR) is at or above 15 (RR. ≥15) and inadequate control measures or where the Hazard Rating (HR) or Exposure Rating (ER) could not be determined. The second level is Action Priority 2 (AP-2), where the RR is less than 15 (RR<15) and inadequate control measures. Thirdly, Action Priority 3 (AP-3) is an adequate control measure irrespective of the Risk Rating (RR).

Table 2.7 Action Priority Determination

Level of Risk	Adequacy of Control	Action Priority (AP)
High	Inadequate	1
HR or ER could not be determined	-	1
Moderate / Low	Inadequate	2
High/Moderate/Low	Adequate	3

(Source: DOSH, A Manual of Recommended Practice on Assessment of Health Risks Associated with the Use of Hazardous Chemicals in the workplace, 3rd Edition, 2018).

Where:

AP – 1 call for immediate action to be taken

AP – 2 remedial actions still need to be taken

AP – 3 Maintain existing control measures

HR – Hazard Rating

ER – Exposure Rating

2.2 Justification of Methodology

This study employs a strategy of a descriptive research design because this research has a clear aim of the topic of the study. Therefore, the researcher is solely interested in describing the situation or case under their research study in a descriptive design. It is a theory-based design method that is created by gathering, analysing, and presenting the collected data. This allows a researcher to provide insights into the why and how of the research. In addition, descriptive design helps others understand the need for the research better. Thus, the output of the study is the improved Standard Operating Procedure that incorporates the control measures from the Chemical Health Risk Assessment conducted. Furthermore, this study uses the qualitative method since this is the first assessment conducted at the building as it is a new building. Thus, this assessment is crucial to analyze the chemical risks and provide the best safe work practice to prevent any incidents in the future.

3.0 RESULTS AND DISCUSSION

From Table 3.1 Technical Control table and the risk assessment conducted, there are 11 types of chemicals used in chemical handling and storage for the cleaning activities in the office building. One (1) chemical poses a health risk to office cleaners through inhalation. In contrast, another ten (10) chemicals pose a risk via dermal contact. The risk level of risk is simplified in the Technical Control Table below.

Table 3.1 Technical Control

Job or Task	Name of Chemical	Route of Entry (ROE)	Current Technical Control	Current Risk	Recommendation on Technical Control	Level of Risk
Housekeeping - Cleaning	Pledge Furniture Polish with Natural Lemon Oil	Inhalation	Blower, N95 Mask	4 (Low)	Install exhaust fan, Change to R95 Mask	1 (Low)
	JIS Scouring Cream	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)
	EQ MP	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)
	EQ PINE Extra	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)

	AF-QUAT E / AF-DRAKYA / AF-GEM FRESH Air Freshener	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)
	Savonn Carpet Shampoo	Dermal	Blower	6 (Moderate)	Install exhaust fan	1 (Low)
	IMEC Metal Polish	Dermal	Blower	6 (Moderate)	Install exhaust fan	1 (Low)
	Floor Degreaser	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)
	EQ Hand Soap - Apple Flower / Floral	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)
	EQ Scenic V Glass Cleaner	Dermal	Blower	6 (Moderate)	Install exhaust fan	1 (Low)
	EQ Cocorex	Dermal	Blower	6 (Moderate)	Install exhaust fan	3 (Low)

Based on Table 3.1 Technical Control, the current control measures are inadequate and there is a need to improve ventilation, storage, and Personal Protective Equipment. These controls are identified as gaps in the current SOPs. The requirements are listed under Guidelines on Storage of Hazardous Chemicals: A Guide for Safe Warehousing of Packaged Hazardous Chemicals, DOSH, 2005. The current PPE used is the N95 mask which is not suitable and should be substituted with the R95 mask. The current ventilation system and administration control, such as awareness training, must be improvised based on the guideline. These improvements shall be implemented and outlined in the current SOP.

3.1 Substitution of Personal Protective Equipment

Personal Protective Equipment, which is commonly referred to as 'PPE', is an equipment worn by workers at any workplace to minimize exposures to hazards that exist in the workplace that may cause severe injuries and illnesses. These injuries or diseases may result from any contact with chemical, radiological, physical, electrical, mechanical, or other workplace hazards. Personal Protective Equipment may include gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, coveralls, vests, and full bodysuits. Current Personal Protective Equipment (PPE) used in the workplace for this study are N95 respirators. N95 respirators are provided to workers to be used in the chemical storage room. The N95 mask can be substituted to enhance protection against workplace hazards, which are hazardous chemicals, with R95 respirators, which are more suitable for chemical handling. N95 respirators are protective inhalation equipment for chemicals or particles not resistant to oil, whereas R95 respirators are used as protective inhalation against organic vapors such as solvents, degreasers, or resins. R95 respirators provide more protection for the workers during the process of chemical handling. Studies have shown that the use of PPE varies from 10 to 82% depending on the accessibility, adequacy, affordability, and fitness to the user and its discomfort. (Tadesse *et al.*, 2016). Training also plays a significant role in increasing knowledge about the PPE and health problems these cleaners are at risk. (Kalu *et al.,* 2013)

3.2 Proper Ventilation

A chemical storage room or area should be well ventilated according to the chemical products stored. Good ventilation is necessary to keep the levels of gases or vapors from reaching the lower flammability limit or concentration hazardous to health. Ventilation may be afforded by natural or mechanical means. Currently, the storage room uses a blower to provide air circulation in the storage room. The blower shall be replaced by installing an exhaust fan to comply with Guidelines on Storage of Hazardous Chemicals: A Guide for Safe Warehousing of Packaged Hazardous Chemicals, DOSH, 2005.

3.3 Training

For administration control it is recommended that cleaners need to be constantly given safety briefings and awareness training. These programmes can enhance their knowledge and skills in chemical safety. For instance, they are provided training on the correct way to wear PPEs, spillage kit training, chemical handling, chemical labeling, and other topics. Apart from that, safety regulations, posters, and signages should be displayed at strategic locations, particularly in the chemical storage room. Chemical exposure is controlled by using preventive measures such as keeping workspaces clean at all times and supplying cleaners with PPE.

3.4 Standard Operating Procedure

A Standard Operating Procedure (SOP) is a step-by-step instruction developed by employers to help workers conduct routine jobs and activities. SOP aims to boost productivity, quality output, and performance consistency while reducing misunderstanding and noncompliance with industry regulations. In addition, SOP outlines safety measures between processes to minimize workplace hazards while doing work activitise. The current SOP shall be reviewed to emphasize the selection of suitable PPE according to findings of the CHRA.

4.0 CONCLUSION

The study found out that current control measures are inadequate and need to be improved in terms of ventilation, storage, and Personal Protective Equipment. These controls are identified as gaps in the current SOP. The requirements are listed under Guidelines on Storage of Hazardous Chemicals: A Guide for Safe Warehousing of Packaged Hazardous Chemicals, DOSH, 2005. The current ventilation system and administration control, such as awareness training, must be improvised based on guidelines. These improvements shall be implemented and outlined in the current SOP. The CHRA conducted concludes that the current practice is Action Priority 2 (AP-2), whereby the assessment finds that the current procedure has moderate or low risk and requires remedial actions to be taken. Among the study's limitations was the incomplete Chemicals Safety Data Sheet provided by the suppliers and the chemical storage room was not readily provided in the building. To overcome the obstacles, Safety Data Sheet is requested directly from the chemical suppliers, and a chemical storage area is designated in the building. Based on the findings, suggestions for improvement must be made to reduce chemical health risks and enhance workplace occupational safety and health performance. This study can be further improved for future works by enhancing data availability for document review and more researchers involved as observers.

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Original Article

Awareness of Occupational Safety and Health Based on Socio-Demography of Workers at UiTM Cawangan Pulau Pinang

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ABSTRACT : *The level of awareness among workers on Occupational Safety and Health (OSH) in the workplace is very important in ensuring safety at a safe level at all times. Awareness activities can be conducted to reinforce positive attitudes, working behaviour, and safety culture among workers. This study aims to examine the level of awareness among workers at Universiti Teknologi MARA Cawangan Pulau Pinang (UiTMCPP), Malaysia in terms of their socio-demographic and safety awareness factors at their workplace. The respondents of the study comprise a total of 193 staff from different faculties and departments at UiTMCPP. A survey method was used as the instrument to obtain data. The data obtained were analyzed descriptively using frequency, percentage, and mean to identify the level of awareness of respondents. The Statistical Package for the Social Sciences (SPSS) version 20 was used for this purpose. The study found that the socio-demographic factors i.e. gender, age, level of education, and length of service of UiTMCPP staff have influenced on OSH awareness at a different level and they were at a very high level. The males were at a higher level than the female respondents with an average mean score of 4.47 and 4.31 respectively. Both the employees and employer must always cooperate and consult each other on OSH matters. On top of that, the employer must provide appropriate information and awareness on OSH programme. The employer should provide good and efficient safety and health management team to ensure that the OSH awareness of the workers is always at a very high level.*

Keywords - *Awareness, Demography, Influence, Occupational Safety and Health, UiTM.*

1.0 INTRODUCTION

Proper safety protection in the workplace will result to efficient and safe environment where the workers feel safe executing their jobs, are more likely to take personal accountability, and be engaged in work. A safe workplace is a continuous process that involves safety awareness, safety culture as well as safety procedures and practices. Dursun (2013) stated that the frame of mind of the workers to determine the perceptions and judgements about personal abilities and responsibilities to avoid risks in the workplace is called safety awareness. According to the Advanced Consulting and Training Ltd. (2021) safety awareness is a constant realization that all workers should have at all times where they are constantly aware of how they work, and are able to recognize the hazards they face. These are absolutely important in reducing safety-related risks.

Awareness is an important element in any effort in the prevention of occupational injuries and illnesses. Awareness activities can be used to reinforce positive attitudes, working behaviour, and safety culture among workers. Awareness of safety practices is an important matter for employers and employees to ensure safety in the workplace as well as reducing the risk of accidents at work (Kadir & Norfadillah, 2020). When employees are aware of safety and health risks in the workplace, they will be able to address safety and health issues and follow safe work practices (Safe Work Australia, 2020).

A fundamental right of workers to work in any organization is to have a healthy and safe environment. All organizations or employers are responsible to ensure their employees work in a safe workplace. Nevertheless, according to a recent report by the International Labour Organization (ILO), each year 2.78 million workers die from occupational accidents and work-related diseases and where 2.4 million mostly are disease-related, while 374 million workers suffer from non-fatal occupational accidents (ILO, 2019). Very low awareness of legal provisions concerning Occupational Safety and Health (OSH) among the workers, the union leaders, and management were attributed to the major cause of such accidents. A similar finding was also identified by Mohd et al. (2014), where high accident rate is greatly influenced by the low level of safety awareness among workers in the workplace and he concluded that safety awareness is an important element that needs to be nurtured in every employee to prevent accidents at work. Occupational accidents still occur even though the working environment has improved considerably during recent decades.

Safety and health issues do not only happen in the commercial industries but also at institutions of higher learning especially those directly and indirectly involved in the handling of machinery and chemicals at risk, such as Universiti Teknologi MARA Cawangan Pulau Pinang (UiTMCPP), Malaysia. The workers of UiTMCPP can be exposed to the risk of accidents at work. Most laboratories, workshops, and plants available at UiTMCPP have the potential to cause injury or accident to its users if it is not handled properly or if users do not follow the rules as prescribed. Therefore, this study was conducted to examine the demographic level of awareness of OSH at the workplace where the safety awareness factors were used in the measurement. To date there is yet any literature review, data nor research available on OSH conducted at UiTMCPP.

2.0 LITERATURE REVIEW

The implementation of Occupational Safety and Health (OSH) is very important and must be rightly incorporated into more workplaces around the world. Generally, OSH can be categorized into two different entities; occupational safety is the potential safety hazards that can possibly cause injury and the risk factor in the workplace and occupational health which is the physical wellbeing and potential health concern including mental health (Safety and Access, 2020). Effective OSH programmes are beneficial for both employers and employees. The purpose of enforcement of the laws, regulations, standards, and programmes related to OSH was to ensure that the workers, customers, co-workers, family members, and other stakeholders have a better and safer workplace. OSH requires cooperation among multiple stakeholders which is the government, employers, and employees who have roles to play in enhancing safety and health outcomes. It is the role of the company to prevent injuries and hazards in all work environments. The risk assessment regarding safety and health at work must be performed by the employers so that the desired state of safe working conditions can be achieved. It has become an essential requirement to adopt the importance of OSH and to create occupational safety awareness among employers and employees. The formation of this awareness is possible only by performing effective training and for the companies to assess their profile (Dizdar, 2008).

The level of OSH awareness in an organization can be measured via an assessment of employee knowledge, understanding and involvement of aspects of occupational safety and health management such as legal compliance, safety and health policy, safety and health committee, safety and security procedures, training, investigation of complaints and accidents, and emergency action preparation (Kadir et al., 2016; Nik et al., 2019). The organization management must inform the workers about current and changing awareness of health and safety hazards, safe work practices, and risk perception that can help to understand where to focus prevention strategies of OSH. The safety measures of workers' awareness of OSH and the working environment are important countermeasures against occupational accidents.

Employee awareness of the importance of maintaining safety and health can help to reduce the likelihood of accidents at the workplace. Safety awareness must be one of the basic concerns that employers emphasize and the employees themselves must prioritise safety aspects in the workplace. The employer must also take appropriate measures to ensure their employees are sensitive to safety issues by increasing employee awareness. The steps which can be taken by the employer in raising the awareness of the employees to always maintain safety by providing guidelines, education, and training to the workers. This is in line with Lai et al. (2011) study which stated that safety training is one of the most effective mediums for reducing accident cases by helping employees identify hazards which are likely to occur while at work.

The guideline on OSH in the service sector published by the Department of Occupational Safety and Hazard (DOSH) (2004) stated that many accidents occur to workers particularly involving the younger ones when using machines or substances, or equipment, or work in hazardous circumstances without proper training. The workers should not use dangerous equipment or substances unless they have been properly trained and are competent. The managers and supervisors must also be competent and attend suitable trainings. Generally, injury rates are significantly higher among young workers than among older and more experienced ones due to their lack of knowledge, experiences, carelessness, and unawareness of OSH at the workplace. There are many risks related to injury and illness factors at the workplace and the socio-demographic of the workers is one of the factors in an attempt to determine their association with occupational injuries and OSH awareness.

Several studies have been conducted based on employee demographic factors. In terms of age factor, the study by Anuar et al. (2009) found that the level of knowledge and awareness of occupational risks among respondents of medical laboratory workers in Klang, Malaysia showed significant differences by age group. Older workers are shown to be more conscious of safety and to have more professional knowledge and experience compared to young workers. In addition, studies have shown that young workers are at a higher risk of accidents compared to the more senior ones (Choudhry & Fang, 2008). In 2015, Nor and Hamirul concluded in their study that the demographic factors such as age, work experience, level of education, and training attendance among forklift drives in the manufacturing sector are influenced on the level of OSH awareness of employees.

Men in all age groups had more access to OSH services than women even though women had higher educational degrees than men and worked less often in manual occupations such as in industry, construction, and manufacturing sectors (Dragano et al., 2018). In 2018, Sujan et al. investigated on the awareness of occupational hazards and associated factors among automobile repair artisans in Kathmandu, Nepal and found that those who obtained primary, secondary or higher level of education were more aware of occupational hazards compared to the illiterate artisans. However, Uzuntarla et al. (2020) in their study found that the safety awareness level of healthcare professionals in a training and research hospital in Ankara Turkey was high with an average mean score of 3.85 and the sociodemographic characteristics of the respondents were not affected by the awareness level. In another study, Ibrahim and Abdullah (2014) investigated on the pre-service teachers in technical and vocational education in Malaysia on their level of safety awareness and reported that the years of study do not affect their awareness level; their levels were moderate with an average mean score of 3.97.

3.0 METHOD

The study conducted involved the staff of UiTM Cawangan Pulau Pinang (UiTMCPP), Malaysia at both Permatang Pauh and Bertam campuses. This is a quantitative study using statistical analysis on the level of awareness of staff working with the risky types of machines or equipment in teaching and learning either in the workshop, kitchen, laboratory, or fieldwork on aspects of safety and health at work based on social demographic characteristics. The respondents were lecturers, assistance lecturers, assistance science officers, assistance engineers, chefs, and assistance chefs. The level of staff awareness on safety and health aspects in the workplace can be assessed based on their perceptions of occupational safety and health policies, safety and health committees, standard operating procedure, commitment and attitude, training, equipment, and environment (Durrisah et al., 2004). The awareness perceptions and the type of questions in the questionnaire form were used in the study are shown in Table 1. Altogether the total number of questions is 43.

Questionnaires were used as data collection instruments and distributed to 193 staff at UiTMCPP. The distribution of the online questionnaire to the targeted staff was sent via UiTMCPP e-mail. Most questions in the questionnaires were adapted from a research study by Durrisah et al. (2004), and they were modified to meet the research objectives. Questionnaires were prepared in a Likert scale format with a measurement scale of one to five for respondents to indicate the degree of agreement with each question posed which is 1 – strongly disagree; 2 – disagree; 3 – unsure; 4 – agree; and 5 – strongly agree.

Table 1 Awareness Perceptions and Type of Questions

No	Awareness perception	Questions
1	Occupational Safety and Health Policy (OSH)	1. Every organization needs to have a safety and health policy. 2. Safety policy needs to be posted in an easy-to-see area. 3. Safety policy needs to be explained to all employees. 4. Safety policy needs to be clear and easy to understand.
2	Standard operating procedure (SOP)	1. I know there are SOPs at my place of duty. 2. I adhere to all SOPs while doing work. 3. Failure to comply with the SOPs may result in injury to me, and other users. 4. SOPs should be clear and easy to understand. 5. SOPs documents need to be placed in a convenient place.
3	Equipment	1. There is personal protective equipment at my place of duty. 2. I will use personal protective equipment while on duty when needed. 3. I found adequate fire extinguishers. 4. Fire extinguishers are conveniently located. 5. Equipment /machines need to be clearly labeled.

		6. Equipment/machines layout is appropriate and safe.
4	Training	1. I have attended activities related to Occupational Safety and Health. 2. I have to follow activity and safety training continuously. 3. Activity and safety training needs to be exposed to all employees. 4. I am aware that first aid training is important.
5	Safety and Health Committee (SHC)	1. I am aware of the SHC at the university level. 2. I like to engage in activities organized by the SHC. 3. SHC regularly conducts occupational safety activities such as talks, fire drills, and first aid. 4. Every occupational accident will be investigated by the SHC. 5. Safety and health talk organized by the SHC enlighten me on the importance of maintaining safety and health wherever I am. 6. Occupational Safety and Health week are held every year by SHC 7. I am aware of the SHC in my faculty/department at my place of duty. 8. The campaign for 'safe work` and `healthy environment' in the workplace is conducted continuously by SHC.
6	Commitment and attitude	1. Negligence in safeguarding safety will endanger me, colleagues and students. 2. I always obey safety regulations at my place of duty. 3. I will check the equipment/machine first before using it. 4. Personal protective equipment worn does not interfere with my work 5. Any equipment/machine damage will be reported immediately. 6. Occupational safety and health must be prioritized. 7. I will tell the importance of Occupational Safety and Health to colleagues and students 8. I always make sure the equipment /machine clean and tidy after use.
7	Environment	1. My working environment is safe. 2. The air circulation system is good and sufficient. 3. The noise level is safe. 4. Work pieces/tools are organized neatly and securely and labeled in respective categories. 5. The exit door provided is sufficient.

6. I always make sure the aisle is not blocked by any obstacles.

7. Solid/liquid waste materials are disposed of in a safe place.

8. I always keep the floors clean of oil, dust, water, and unsafe materials.

Data obtained from the questionnaires were analyzed using Statistical Package for the Social Sciences (SPSS) software version 20. Descriptive data analysis methods namely frequency, percentage, and mean were used to explain the results of the study. Reliability level test on the set of research questionnaires was conducted involving a total of 35 selected respondents and the results showed that the level of reliability of the questionnaire set of this study was at a high level with a Cronbach alpha value of 0.85. If the value of the alpha coefficient is less than 0.6, i.e. poor reliability, therefore it is necessary to improve the items in the research instrument to increase the value of the coefficient (Stephanie, 2020).

The interpretation of the level of awareness possessed by the respondents is used in this study based on the 5 level scale of the mean score which is adopted from Moidunny (2009) is shown in Table 2. These scales are commonly used for the interpretation of the five-point Likert scale in the descriptive analysis.

Table 2 Interpretation of Mean Score Levels

Scale	Mean range	Level	Score range
5	Strongly agree	Very high	4.21 – 5.0
4	Agree	High	3.21 – 4.20
3	Unsure	Moderate	2.61 – 3.20
2	Disagree	Low	1.81 – 2.60
1	Strongly disagree	Very low	1.0 – 1.80

4.0 RESULTS AND DISCUSSION

4.1 Socio-Demographic

The analysis of the data is based on the 193 respondents returning the questionnaire to the study. The data was classified as a personal background of the respondents based on gender, age, category of staff, length of service, and education level. Table 3 shows the detailed analysis of the personal background of the respondents. In this study, most of the respondents were male (54.4%) and the remaining were female (45.6%). Based on the data acquired, the largest age group of the respondents is 31 to 40 years old (58.1%), the second-largest is 41 to 50 years old (32.1%) and none from age below 20 years old. Majority of the respondents (81.9%) is academic staff, while the non-academic staff is18.1%. The largest education group level is Master's degree holder (53.4%) followed by Ph.D holders (23.8%) while only one respondent (0.5%) is a Sijil Tinggi Persekolahan Malaysia (STPM) holder. Most of the respondents has served at Universiti Teknologi MARA between 11 to 15 years (41.1%), 8.9% served less than 5 years and 2.6% served more than 21 years.

Table 3 Socio-Demographic of the Respondents

Characteristics	Category	Frequency	Percentage (%)
Gender	Male	105	54.4
	Female	88	45.6
Age (years)	< 20	0	0
	20 – 30 served	6	3.1
	31 – 40	112	58.1
	41 – 50	62	32.1
	> 51	13	6.7
Staff category	Academic	158	81.9
	Non-academic	35	18.1
Education level	Ph.D	46	23.8
	Master	103	53.4
	Degree	7	3.6
	Diploma	27	14.0
	S.T.P.M	1	0.5
	Certificate	7	3.6
	S.P.M	2	1.0
Length of service (years)[a]	< 5	17	8.9
	6 – 10	56	29.2
	11 – 15	79	41.1
	16 – 20	35	18.2
	> 21	5	2.6

[a]Data was missing for 1 respondent.
Note: S.P.M = Sijil Pelajaran Malaysia; S.T.P.M = Sijil Tinggi Persekolahan Malaysia

4.2 OSH Awareness Level

Table 4 shows the level of awareness of respondents on OSH in the workplace by gender. Data analysis showed that there was a small difference in the mean average score between male and female respondents of 0.16. The highest and lowest level of OSH awareness factors for male respondents was safety policy (4.90) and environment (4.29) respectively. Meanwhile, the female respondents had the highest commitment and attitude (4.62) and lowest in the safety and health committee (3.88). The data showed that male respondents had a higher level of OSH awareness with an average mean score of 4.47 compared to female respondents with a mean score of 4.31 in which both were very high levels of OSH awareness. A similar result was obtained by Firdaus et al. (2013) in their study of polytechnic staff in Kedah where the awareness level of OSH for males is higher than females with an average mean score of 4.27 and 4.21 respectively. The current study by Kadir et al. (2021) also found that the male respondents had a higher level of awareness with an overall mean score of 4.36 compared to female respondents with a mean score of 4.26.

Table 4 Mean Score for Each OSH Factor by Gender

Gender	Safety Policy	Standard Procedure	Equipment	Training	Safety committee	Commitment	Environment	Average
Male	4.90	4.60	4.39	4.53	3.92	4.63	4.29	4.47
Female	4.28	4.58	4.28	4.41	3.88	4.62	4.14	4.31

The level of awareness of respondents on OSH at the workplace by age is shown in Table 5 and it is found that the level of awareness for all age groups is very high. There are no respondents for the age group less than 20 years old. The respondents aged 50 years and above had the highest level of awareness when they recorded an average mean score of 4.49. Meanwhile, respondents aged 20-30 years had the lowest level of awareness when recording an average mean score of 4.27. Data analysis showed that there was a small difference in the mean average score between age 31 to 51 years and above of 0.03 and this group of age is the highest level compared to the age group less than 30 years old. The findings of the study also showed that the level of awareness increased with the age of the respondents.

The findings of this study are consistent with the results of the study by Kadir et al. (2021) through a study of the level of Awareness of OSH Civil Servants on the safety and health aspect at the workplace who found that the age group of more than 50 years is higher level than the age group of 18 – 29 years with an average mean score of 4.49 and 4.19 respectively. The young workers aged less than 30 years in Italy had less access and lower awareness of OSH issues than workers aged more than 31 years. The former were less aware of their personal responsibility for health and safety, emergency procedures, and basic regulatory framework (Dragano et al., 2018).

Table 5 Mean Score for Each OSH Factor by Age

Age	Safety Policy	Standard Procedure	Equipment	Training	Safety committee	Commitment	Environment	Average
< 20	-	-	-	-	-	-	-	-
20-30	4.67	4.40	4.28	4.17	4.17	4.33	3.89	4.27
31-40	4.91	4.64	4.41	4.45	3.93	4.65	4.25	4.46
41-50	4.92	4.54	4.22	4.55	3.78	4.62	4.17	4.40
>50	4.92	4.58	4.29	4.50	4.09	4.63	4.39	4.49

The level of awareness of respondents on OSH at the workplace by education level is shown in Table 6 and found that the level of awareness for all education level groups is very high. Data analysis showed that there was a small difference in the mean average score between the highest and lowest education level which is 0.20. There is only one respondent who is an STPM holder and no average mean score so that the mean score comparison is considered not valid. The respondents with a certificate level of education were found to have the highest level of awareness of OSH in the workplace with an average mean score of 4.60 while the lowest is those with Master's degree which is 4.40. It is also found that degree holder respondents had lower awareness of OSH compared to those with diploma and below with an average mean score of 4.42 and 4.52 respectively. The difference of the average mean score is very small which is at 0.1.

The findings of this study on the social demographic characteristics of this level of education are different from the several findings of the other study. The results of the study conducted by Kadir et al. (2021) were reported that respondents with Doctor of Philosophy (Ph.D.) had higher scores than those with Sijil Tinggi Persekolahan Malaysia (STPM) with an average mean score of 4.53 and 3.66 respectively. Demirer and Öz (2019) investigated on the employees who had different demographic characteristics and work in Burdur province Turkey. They concluded that as the employees' level of education increases, their occupational safety awareness increases too. They also suggested that OSH education should be given face-to-face. In 2012, Zolkufli and Faiz also found that those who have a Master`s level education have a high level of awareness compared to workers with a diploma and below level of education. The workers who have higher level of education and job position have a high score of knowledge of OSH compared to those who have lower education and position level (Anuar et al., 2009).

Table 6 Mean Score for Each OSH Factor by the Education Level

Education level	Safety Policy	Standard Procedure	Equipment	Training	Safety committee	Commitment	Environment	Average
Ph.D	4.96	4.63	4.31	4.47	3.82	4.61	4.22	4.43
Master	4.92	4.56	4.24	4.46	3.84	4.62	4.16	4.40
Degree	4.70	4.71	4.36	4.46	3.82	4.66	4.25	4.42
Diploma	4.86	4.66	4.66	4.55	4.12	4.66	4.43	4.56
STPM*	4.97	4.20	4.67	4.01	3.88	4.25	4.02	4.29
Certificate	4.75	4.54	4.74	4.57	4.37	4.80	4.45	4.60
SPM	4.50	4.51	4.33	4.50	4.37	4.44	4.20	4.41

*Only one respondent – cannot use for the comparison of the average mean score.

Table 7 shows the level of awareness of respondents on OSH at the workplace according to the length of service and found that the level of awareness for all length of service groups is very high. Data analysis showed that there was a small difference in the mean average score between the highest and lowest length of service level which is 0.20. The respondents who served more than 21 years had the highest level of awareness as they recorded an average mean score of 4.56 while the respondents who served 6-10 years had the lowest level of awareness as recorded an average mean score of 4.36. The average mean score of the length of service less than 5 years is higher than those who served 6-10 years perhaps due to the small number of respondents (8.9%). However, the trend of the average mean score for the groups of the length of service shows that as the length of service increases, their OSH awareness increases too.

The results of the study on the demographic social characteristics of the length of service are consistent with the results of the study by several research. The current study by Kadir et al. (2021) found that the workers who served 15 years and above had the highest level of OSH with an average mean score of 4.37 while those who served less than 5 years obtained the lowest level with an average mean score of 4.30. Sujan et al. (2018) reported that the workers with more than 11 years of work experience were six times and those with 6-10 years of experience were two times more aware of occupational hazards than those under 5 years of experience. Moreover, workers who received pre-service training on work were three times more aware than those who did not receive it before. The study by Firdaus et al. (2013) found that the awareness level of OSH for the length of service more than 11 years is higher than those with less than 10 years with the average mean scores of 4.37 and 4.22 respectively, which is a high level. The workers who have worked for a long time have more work experience and have a higher level of awareness of safety and health in the workplace than other workers (Zolkufli & Faiz, 2012).

Table 7 Mean Score for Each OSH Factor by the Length of Service

Length of service	Safety Policy	Standard Procedure	Equipment	Training	Safety committee	Commitment	Environment	Average
< 5	4.84	4.55	4.34	4.48	4.20	4.59	4.15	4.45
6-10	4.91	4.54	4.33	4.37	3.77	4.59	4.19	4.36
11-15	4.91	4.66	4.34	4.46	3.92	4.67	4.26	4.46
16-20	4.90	4.54	4.32	4.66	3.91	4.67	4.22	4.47
>21	5.00	4.72	4.60	4.55	3.97	4.67	4.40	4.56

Malaysian Occupational Safety and Health Act 1994 (2001) stated that employers have a responsibility to ensure, so far as is reasonably practicable, welfare at work, safety and health of their employees, and the safety and health of other people affected by their undertaking. This duty includes preparing safe systems of work, safe machinery, safe and healthy workplace, and together with adequate information, training, instruction, and supervision. The employees also have to take care of their safety and health adequately. The safety of workers in the workplace should always take priority. The employers must ensure a safe work environment so that the workers can stay safe when performing their duties. Ensuring worker safety means creating a safe, efficient, positive workplace where employees can focus on productivity.

5.0 CONCLUSION

This study shows that the socio-demographic factors of gender, age, level of education, and length of service of UiTMCPP staff have influenced OSH awareness at a different level. This study found that the respondents were at a very high level of OSH awareness. The male workers were at a higher level of awareness than the female workers. The senior workers who have more work experience were at a higher level of awareness than the young workers. The factor of the different education levels of the workers can be considered similar due to very small mean score differences where they are at the same level of OSH awareness which is a very high level. The academicians and supporting workers in the universities are considered professionals who can maintain their safety and health by themselves. They must also be given appropriate information about OSH and join awareness programmes to ensure the goal of OSH awareness will be achieved. Employers should undertake the responsibility of informing and training the employees and their representatives on all matters related to OSH. Improving OSH requires consultation, commitment, and cooperation from all stakeholders. Good and efficient safety and health management teams and safety practices are the foundations of the success of any business and organization in OSH. Thus the employers should play an important role to ensure the OSH awareness level of the workers will always be at a very high level.

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Original Article

A Study on the Risk Level of Carpal Tunnel Syndrome (CTS) due to Smartphone Use among Undergraduates in the Faculty of Health Sciences at the National University of Malaysia

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ABSTRACT : *Smartphones are on the rise, especially among youngsters, as they are more dependent on smartphones. Prolonged use of smartphones may result in Carpal Tunnel Syndrome (CTS) due to repetitive movement of hands. This study aims to identify the association between gender and dominance with CTS and determine the relationship between the duration of smartphone use and the risk level of CTS. Boston Carpal Tunnel Questionnaire was randomly distributed to undergraduates of the Faculty of Health Sciences. A total of 310 respondents agreed to participate in this research. The majority of the respondents comprised 92.6 % females and 7.4% males. However, 92.6% of respondents were right-handed, and the rest were left-handed. The CTS symptom severity scale data found that 58.1% of respondents experienced mild symptoms, compared to 40.6% of respondents who did not experience any symptoms. Based on the analysis performed, it was found that there is no association between gender and hand dominance with CTS. Furthermore, there is a weak but significant relationship between the duration of smartphone use and the CTS symptoms. In conclusion, the risk level of CTS due to smartphone use is relatively low.*

Keywords - *Boston Carpal Tunnel Questionnaire, Carpal Tunnel Syndrome, Smartphone, Undergraduates*

1.0 INTRODUCTION

A smartphone is a device that has the power of a computer. This device provides the user with advanced communication and computing ability / than the normal mobile. Smartphones are equipped with internet access, top-quality cameras, and management tools (Boulos et al., 2011). The latest smartphones are viewed as handheld computers instead of the traditional phone due to their powerful computing capability and enormous memory. The potential of running feature-rich applications on smartphones has made smartphones a more powerful device replacing many devices like alarm clocks, calculators, laptops, GPS navigators, and digital cameras (Singh and Samah 2018).

Smartphones have made the young generation so preoccupied with its technology that it has become a trademark of the young generation. This is because the technology-savvy generation is dependent on advanced touch screen technology, where smartphones can be used at any moment with the accessibility of the internet all day long (Skierkowski and Wood 2012). But, unfortunately, smartphones involve an interaction between the thumb, fingers, and smartphones. While these interactions are generally not burdensome, repeated movements for prolonged periods may cause excessive force on the median nerve and tend to compress it over time. Therefore, repetitive hand movement is one of the factors to cause the occurrence of Carpal Tunnel Syndrome (CTS) (Woo et al. 2019).

Carpal Tunnel Syndrome (CTS) is a medical condition defined by a group of symptoms resulting from the local compression of the median nerve at the wrist. The carpal tunnel is a narrow passageway located on the palmar or anterior aspect of the wrist bound by bones and ligaments. Compression of the nerve leads to symptoms that characterize the syndrome, including numbness, pain, and, eventually, hand weakness (Shaffi Ahamed et al., 2015).

Since the use of smartphones is rising tremendously among all age groups, especially during the pandemic, there is a rise in repetitive hand movement, which is said to be one of the causal factors of CTS. Moreover, only a few studies emphasized the occurrence of CTS due to the use of smartphones by using the questionnaire method.

This research was conducted to determine the relationship between smartphone use among undergraduates of the Faculty of Health Sciences in the National University of Malaysia and the risk level of CTS.

2.0 METHOD

2.1 Study Population

This research was conducted among undergraduate students at the Faculty of Health Sciences, National University of Malaysia. Out of 1600 undergraduate students, 310 participants were selected using a simple random sampling technique (Taherdoost 2018). Sample size calculation was calculated using Raosoft Sample Size Calculator with a 5% margin of error and 95% confidence level. There were several exclusion criteria set for this research. Respondents with a history of wrist surgery and fractures, CTS and other peripheral nerve disorders were excluded from this research. In addition, this study did not select respondents with CTD prone factors, such as diabetes mellitus, rheumatoid arthritis, hypothyroidism, pregnancy or obesity.

2.2 Procedure

A standardized questionnaire used to determine the risk level of Carpal Tunnel Syndrome, the Boston Carpal Tunnel Questionnaire, was distributed to the respondents via Whatsapp and email. In addition, the questionnaire has been converted to Google Form's format for easy answering of questions and data collection. Respondents were required to answer questions about their sociodemographic status, including gender, age, course of study, health issues, frequency, years of smartphone use, dominant hand and CTS diagnosis.

2.3 Boston Carpal Tunnel Questionnaire (BCTQ)

BCTQ is a standardized questionnaire developed by Levine et al. 1993 to determine the risk level of CTS. This questionnaire consists of two sections: Symptoms Severity Scale (SSS) and the Functional Status Scale (FSS). The SSS includes questions about the most common symptoms of CTS, such as wrist pain, tingling sensation, numbness, weakness, and difficulty grasping objects. Each symptom was rated for severity and frequency. Meanwhile, the FSS section focused on the difficulties experienced by respondents in performing daily activities, which involve using the hands, such as writing, buttoning clothes, holding a book while reading, gripping the handle of the telephone, opening jars, household chores, carrying grocery bags, bathing, and dressing.

2.4 Statistical Analysis

Data collected from 310 respondents were analysed by using the IBM Statistical Package for the Social Sciences version 25. Chi-square contingency test analysis was used to identify the association between gender and the prevalence of hand dominance with symptom severity and respondent's functional status score. In contrast, the relationship between the frequency of smartphone use among undergraduates and the risk level of CTS was determined using correlation analysis.

3.0 RESULTS

3.1 Sociodemographic Status

A total of 310 respondents agreed to participate in this research. The majority of the respondents are females with 92.6%, and only 23 are male respondents with a lower percentage of 7.4%. A total of 92.6% of respondents were in the lowest age group, which is 19 to 23 years, 6.8% and 0.6% respondents in 24 to 28 year and 29 to 33 year age group, respectively. The distribution of respondents between courses was not equally the same, because respondents were selected at random. Most of the respondents were from the course of Biomedical Sciences, with a total of 73 respondents. On the contrary, the second-highest respondents were from the Environmental Health and Industrial Safety course with a total of 63 respondents and 39 respondents were from the course of Optometry and Vision Science. Approximately 93.5% of respondents have no health issues and only 20 of them have health issues such as asthma, G6PD, allergies, back pain and low blood pressure.

The most important part of this research is to determine the frequency and years of smartphone use among the respondents. Almost half of the respondents, 48.7%, use a smartphone for more than seven hours a day, while 40.6% use a smartphone for five to six hours a day. Also, 45.8% of respondents have been using a smartphone for more than seven years, 35.2% for five to seven years, and 19% in less than four years. In addition, information about the dominant hand of the respondents was also requested for this research. As expected, there were more respondents with the dominant right hand, 287 respondents, equivalent to 92.6%, and 23 respondents, with the left dominant hand, equivalent to 7.4%. Finally, none of the respondents were diagnosed with CTS and received no treatment.

3.2 Symptom Severity Scale (SSS)

Scores obtained from each respondent were aggregated to obtain a total score for each symptom. Table 1 shows the range of scores assigned to symptom severity, asymptomatic, mild, moderate, severe, and very severe.

Table 1 SSS Scores and Severity

Scores	Severity
0 to 11	Asymptomatic
12 to 22	Mild
23 to 33	Moderate
34 to 44	Severe
45 to 55	Very Severe

Table 2 shows the total scores obtained for the categories assigned. The scores were grouped based on the symptom severity levels. Based on Table 2, the highest percentage of 58.1% of respondents have mild symptoms of CTS, whereas 40.6% of respondents have no symptoms at all.

Table 2 SSS Scores

Severity	Total Score	Percentage (%)
Asymptomatic	126	40.6
Mild	180	58.1
Moderate	2	0.6
Severe	2	0.6
Very Severe	0	0.0

3.3 Functional Severity Scale (FSS)

The scores obtained from each respondent were summed to obtain a total score for each symptom. Table 3 shows the score range assigned as asymptomatic, mild, moderate, severe and very severe according to symptom severity level.

Table 3 FSS Scores and Severity

Scores	Severity
0 to 8	Asymptomatic
9 to 16	Mild
17 to 24	Moderate
25 to 32	Severe
33 to 40	Very Severe

Table 4 shows the total scores obtained for the assigned categories. Scores are grouped according to symptom severity levels. Based on Table 4, 73.5% of the respondents are asymptomatic, they can perform their daily activities without any difficulty. On the other hand, 24.5% of the respondents have mild difficulty in performing their daily activities.

Table 4 FSS Scores

Severity	Total Score	Percentage (%)
Asymptomatic	228	73.5
Mild	76	24.5
Moderate	4	1.3
Severe	0	0.0
Very Severe	2	0.6

3.4 Association between Gender and Hand Dominance with Symptoms Severity and Functional Status Score

Chi-squared analysis was used to determine the association between gender, the severity of symptoms, and respondents' functional status scores. The analysis showed no significant association between gender with symptom severity scores and gender with a functional status score, where p values were = 0.878 and 0.306, respectively. The p values obtained were higher than the value of $p < 0.05$, contributing to a non-significant association.

Chi-square analysis was also used to identify whether the dominant hand is associated with respondents' symptom severity and functional status. The test indicated no association between hand dominance and symptom severity score obtained, where p = 0.140, $p < 0.05$. Similarly, there was no significant association between hand dominance and a functional status score of respondents as the value of p was 0.967.

3.5 Relationship between Frequency of Smartphone Use and the Risk Level of Carpal Tunnel Syndrome (CTS)

Table 5 Correlation between Frequency of Smartphone Use and Total Score of SSS and FSS

			Frequency of Smartphone Use	**Symptoms Severity Scale (SSS)**	**Functional Status Scale (FSS)**
Kendall's tau-b	**Frequency of Smartphone Use**	Correlation Coefficient		0.109	0.027
		Sig. (2 tailed)		0.045	0.614
	Total SSS Score	Correlation Coefficient	0.109		0.348
		Sig. (2 tailed)	0.045		0.000
	Total FSS Score	Correlation Coefficient	0.027	0.348	
		Sig. (2 tailed)	0.614	0.000	

According to Table 5, Kendall's tau-b indicated that the relationship between frequency of smartphone use and the total score of SSS is a weak positive correlation, □ = 0.109, p = 0.045. Meanwhile, the relationship between frequency of smartphone use and total FSS scores is a negligible correlation as the tau value is, □ = 0.027, p = 0.614.

4.0 DISCUSSION

4.1 Association between Gender, Symptoms Severity Score and Functional Status Score

Based on the results obtained, it is clear that the gender, symptom severity, and functional status scores are not significant, that is the variables do not influence each other. In other words, the gender of respondents does not influence Carpal Tunnel Syndrome (CTS), as the majority of those surveyed reported mild to moderate symptoms that could be corrected in a short time. Moreover, these symptoms do not cause any difficulty in performing daily routine activities. However, several studies indicate that gender is one of the CTS prone factors. For example, Atroshi et al. Noted that women possess two to three times greater risk of developing CTS compared to men. This may be due to natural occurrences of women's bodies such as menopause, hypothyroidism, and pregnancy. Besides that, a study conducted by Sassi and Giddins 2016 noted that there is a significant mean difference in the cross-sectional area of the carpal tunnel in women than men because women have smaller hands. Therefore, smaller hands mean smaller cross-sectional areas, this explains why women are more prone to CTS.

4.2 Association between Dominant Hand, Symptoms Severity Score and Functional Status Score

Tests performed to analyze the association between dominant hand and symptom severity scores and functional status scores showed that there was no significance between the hand dominance and scores obtained. According to this study, this means hand dominance does not impact the risk level of Carpal Tunnel Syndrome (CTS) because most of the respondents reported only asymptomatic and mild symptoms and no difficulty performing some of their daily activities listed in the questionnaire. Moreover, the symptoms experienced could be relieved in a short time. Nevertheless, evidence indicated that CTS is more prone to happen in the dominant hand as it involves more repetitive movement of the wrist and fingers (Zambelis et al., 2010). In a research conducted by Woo et al. 2017, the researcher stated that there is a significant difference in the cross-sectional area in both hands and the flattening ratio of median nerve and thickness of transverse carpal ligament. However, since most of the participants did not report any severe symptoms in their dominant hand, this research proves otherwise. 4.3 Relationship between Frequency of Smartphone Use and Risk Level of Carpal Tunnel Syndrome. Statistical tests performed indicated a weak correlation, which means there is only a little association between the frequency of smartphone use and the risk of developing CTS. This is parallel with research conducted by Gustafsson et al. 2018, where he stated that smartphone operation only requires smaller thumb movement and muscle activity. Hence, it is acceptable when the respondents reported that they only experience mild to moderate CTS symptoms. In addition, most of them do not face any difficulties in carrying out their daily activities.

However, in a study conducted by Shim 2012, there is a significant relationship between smartphone use and changes in the carpal tunnel of the respondents involved in the study. This might be due to the ultrasonography method used throughout the study to obtain data from the respondents, where ultrasonography is a clinical diagnosis method of identifying CTS. The carpal tunnel of the respondents was measured using ultrasonography before and after smartphone use for 30 minutes. According to the researcher, there was a significant difference in the median nerve circumference length, area of the median nerve area, the distance between the highest point of the median nerve to the lunate, and distance between the bottom point of the median nerve the lunate. Hence, it can be seen that a clinical diagnosis provides accurate data compared to diagnosis through the questionnaire.

5.0 CONCLUSION

Overall, the risk level of CTS due to a smartphone is low. Even though there is only a weak relationship between smartphone use among students and the risk level of CTS, mild symptoms of CTS were present among the students. These symptoms might develop as the students become more dependent on smartphones due to online studies and the rising use of social media. The limitation of this study is the method of study. The use of the questionnaire to obtain data may not be accurate as some of the symptoms experienced by respondents may not be entirely due to smartphone use. Therefore, a more reliable diagnosis like ultrasonography may have provided a more accurate date on the risk level of CTS due to smartphone use.

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Article Review

Process Safety Management as A Sustainable Safety Process in Managing Chemical Accidents in Malaysia: A Systematic Literature Review

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ABSTRACT : *The level of chemical accidents in Malaysia's Chemical Process Industry (CPI) is very worrying as the accidents occur every year. Thus, a sustainable safety process is necessary to minimize such unwanted events. However, studies regarding the safety process practice review in CPI are insufficient. Therefore, a well-conducted Systematic Literature Review (SLR) is considered a practical solution for keeping the practitioners on a row of the current safety process. Hence, this article reviewed the effectiveness of the process safety management (PSM) system based on PSM elements in CPI in Malaysia. Guided by the PRISMA Statement (Preferred Reporting Items for Systematic reviews and Meta-Analyses) review method, the SLR from the Science Direct, Web of Science, and Scopus databases identified six related studies in Malaysia. As a result, several authors highly implemented the Process Safety Information (PSI) element. Meanwhile, Process Safety Information Management System (PSI4MS) was a popular tool to drive the PSM system. Perhaps, this review article is a guideline to manage safety chemical accidents in Malaysia.*

Keywords - *Chemical Accidents, Safety Process, Systematic Literature Review*

1.0 INTRODUCTION

Malaysia has evolved rapidly from a commodities-based economy into a technology and engineering hub. As a result, various job hazards will be formed, especially those working in chemical processing industries, and the risks associated with chemical accidents will also increase. A chemical accident is an uncontrolled event where fire, explosion, uncontrolled release of toxic chemicals lead to death and injury to many people in a disaster area or cause great damage to property and the environment. These incidents can be sudden and acute or of slow-onset if a 'silent' release of toxic chemicals in a plant can range from small to large-scale emergencies. One of the most catastrophic chemical release accidents since 1991 was the May 7 fire disaster, which occurred at a fireworks factory called Bright Sparklers in Sungai Buloh, Selangor. The accident killed 26 lives, wounded

103 victims, and left an indelible mark on family members and residents (Ying & Ying, 2020). This tragedy is still fresh in mind for some residents, even though it was three decades ago. The accident warrants the parties involved and stakeholders to take more stringent safety efforts. The safety process is one of the safety measures in preventing chemical incidents and accidents. During this millennium, the number of accidents related to the release of chemicals has been steadily increasing, although safety and health awareness and education have been upgraded and exposure to industries has increased. Based on the Annual Report presented by Social Security Organization (SOCSO), 1415 cases of industrial accidents were reported in 2018 (2018 Annual Report, 2018). Hazardous chemical accidents include explosive and non-explosive materials, radiation, flying fragments, and other unclassified materials and substances. In addition, 190 cases were exposed to or in contact with harmful substances, while 127 cases were causing disease from chemical agents.

A safety management system related to the mitigation measure is the Process Safety Management (PSM), which can restrain process loss through appropriate controls of hazard of the process. PSM is considered a guideline to enhance the effectiveness of technical solutions and contribute to the mitigation measures of chemical accidents. According to Aziz & Shariff (2017), the PSM programme as stipulated by the US Occupational Safety and Health Administration (OSHA), Code of Federal Regulations (CFR) Chapter 29, Section 1910.119 in 1992. There are 14 elements in PSM, including Employee Participation (EP), Process Safety Information (PSI), Process Hazard Analysis (PHA), Operating Procedures (OP), training, involvement of contractor, Pre-Startup Safety Review (PSSR), Mechanical Integrity (MI), Hot Work Permit (HWP), Management of Change (MOC), Incident Investigation (II), Emergency Planning and Response (EPR), Compliance Audits (CA), and Trade Secret (TS). All the elements were predicted to prevent some deaths and serious injuries reports five years later, and twice that by subsequent years within five years. Implementing the PSM system to prevent major industrial accidents resulted in various positive effects. For example, in Korea, the number of major industrial accidents, including fatalities, has decreased, and productivity has been increased, and product quality after seven years of PSM implementation since 1996 (Kwon, 2006). This research was also supported by Shanmugam & Razak, (2021) and claimed that the PSM programme was practical and suitable to be implemented under the PSM mitigation measures in Malaysia.

In particular, inadequate and improper enforcement of PSM elements such as PHA, training, and EPR has been identified as the top three PSM elements contributing to most of China's accidents (Zhao, Suikkanen, & Wood, 2014). Another study also supports the above statement. Failure Knowledge Database (FKD-Japan), and Accident Reporting Information Analysis (ARIA), the most common accident contributors to process failure have been identified as failure of PHA (19 %), OP (17 %), employee participation (12 %), training (11 %), MOC (9 %), and MI (9 %) (Bakar et al., 2017). In parallel, some researchers have critically raised these PSM issues and the importance of implementing proper PSM elements in industries. A study of dust explosion incidents in Malaysia for powder manufacturing industries by Ahmad, Ismail, & Othman (2017) recommended that PSM elements such as PHA, training, and EPR should be seriously enforced by the government and local authorities. The company needs to improve its understanding of risk mitigation and control in its work process. Local authorities should review their stakeholders' operating procedures and discuss how to upgrade and implement the PSM elements. In addition, a study of oil & gas and chemical manufacturing industries in the United States by Behie et al. (2020) issued the level of effectiveness on PSM implementation as the number of accidents in this industry was still high. They argued the factors that caused current major incidents and measures that could have an impact on improving the effectiveness of process safety programs. They proved that PSM was the main factor that caused current major incidents such as lack of process safety training, knowledge and practices among workers, and ineffective emergency response plans. This indicates a more holistic approach to implementing effective PSM programs. All these examples show the importance and influence of the PSM system in managing chemical accidents.

The research journey on chemical accident mitigation measures is still far from reaching the finish line. Therefore, this study aims to review the effectiveness of the PSM system based on PSM elements in CPI in Malaysia. PSM contributes to CPI in eliminating or reducing hazards in managing chemical accidents in Malaysia. The Malaysian CPI is of particular interest as the industry contributes to the accident rate in Malaysia. Therefore, the implementation of a PSM system will effectively eliminate and reduce the hazards that contribute to the risk of chemical accidents.

2.0 METHOD

Four stages are involved in the Systematic Literature Review (SLR) process, including identification, screening, eligibility and inclusion. In addition, the inclusion and exclusion criteria steps are also included in the screening process. The reference management software Endnote X7 (Thomson Reuters, New York) was used to sort the records. Finally, the reviewers used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) adopted from Page *et al.* (2021).

2.1 Databases Search Strategy and Identification

Processes were carried out in early August 2021 for the databases search strategy. Based on previous studies and articles, PSM-related keywords were used. Articles were collected through selected search strings from the Science Direct, Web of Science, and Scopus databases. The keywords are such as: "process safety management" OR "safety management system" AND "chemical process industry" OR "chemical industry" AND "chemical accident" OR "chemical disaster". At this stage, only journal articles written in English and published until the year 2020 were selected. According to the specified keywords and search strings, a total of 863 research article records were identified. Our databases search found that Science Direct yielded 738 records, Web of Science yielded 113 records, and Scopus yielded 12 records. During the identification stage, 49 duplicate article records were removed. Thus, 814 records passed to the second stage.

2.2 Screening

The second stage was screening. At this stage, 263 title records and 530 abstract records were removed. In addition, titles and abstracts that did not meet the criteria, such as not related to the PSM elements or the chemical accidents in CPI, reviewed the study and clearly described the case studies other than Malaysia are excluded. Finally, 21 records were moved to the third stage.

2.3 Eligibility and Exclusion Criteria

The third stage was eligible. From 21 records, 15 records were removed according to the inclusion and exclusion criteria. Only articles with empirical studies that related to the implementation and application of PSM elements and explained the PSM performance in managing chemical accidents case studies in Malaysia were selected. According to McLeod, Payne, & Evert (2016), empirical papers should be classified as qualitative, quantitative, and mixed methods. One out of 15 records were found without full text although the request was sent through ResearchGate social networking site request and email to the authors. Six records were discovered from the case studies done other than Malaysia such as Japan, Pakistan, BP Texas City, Bhopal, Japanese FKD, and the US, one record indicated where the case study was not in CPI, two records were related to Inherently Safer Design, two records were from the review papers, two records were not mentioned the PSM elements, and one record not performing any case study. Finally, six records of full articles were extracted and analyzed. All these steps were mentioned in the PRISMA flow diagram in Fig. 1.

2.4 Included

At this stage, only articles with titles, abstracts, and full texts after the inclusion and exclusion process and meeting the criteria were included and reviewed. Then, the quality assessment continued by reviewing the entire text of screened studies. The table was developed from the included articles by mentioning the authors' names, year of publication, type of PSM elements, a field of case studies, measures, and outcome measures. Those data will finally define PSM performance in managing chemical accident cases in Malaysia as a lesson from the past event.

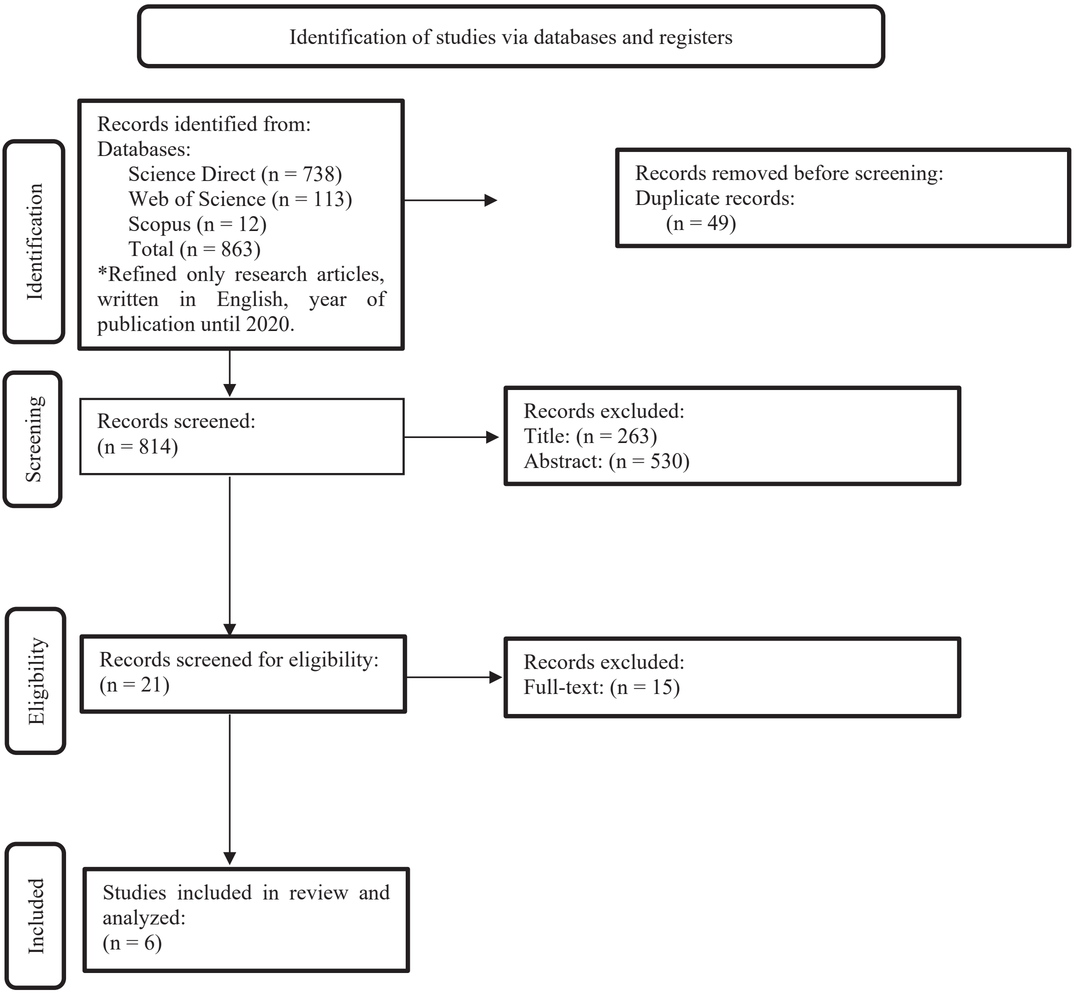

Figure 1 The Flow Diagram of the Study Adapted from Page *et al.*, (2021)

3.0 RESULTS

3.1 Results of the Search

Based on the keywords stated in the methodology, all six selected articles were published in 2003, 2009, 2014, 2015, and 2016. Field of case studies involved Chemical Process Industries (CPI) was from Carbon Dioxide (CO_2) hydrocarbon absorption system pilot plant, LPG treating unit (LPGU) of oil and gas refinery, and High Gravitational Natural Gas Pilot Plant (HGNGPP). Meanwhile, type of PSM elements involved was Incident Investigation (II) (Shaluf, Ahmadun, & Said, 2003), Process Hazard Analysis (PHA) (Shariff & Leong, 2009), Process Safety Information (PSI) (Aziz, Shariff, & Rusli, 2014), and (Aziz, Shariff, Rusli, & Yew, 2014), involvement of contractor (Majid, Shariff, & Rusli, 2015), and Emergency Planning & Response (EPR) (Majid, Shariff, & Loqman, 2016).

Based on the readings, all the authors aim to establish, develop, and construct some specific tools or techniques to improve safety performance in workplaces using the elements from process safety management (PSM). The authors began their articles in the methodology sections by illustrating and explaining the development of safety performance frameworks or flowcharts based on PSM requirements and compliance. Frameworks or flowcharts are specifically shown to guide chemical industry practitioners in establishing a practical working process to improve the effectiveness of the PSM system. The development of these frameworks or flowcharts was eventually being tested in case studies to evaluate the safety performance in real and actual situations in CPI in Malaysia. Based on six selected articles, some of the authors came out with several specific tools such as developing a Process Safety Information Management System (PSI4MS) (Aziz, Shariff, & Rusli, 2014), and (Aziz, Shariff, Rusli, & Yew, 2014), and Emergency Planning & Response (EPR) prototype model (Majid, Shariff, & Loqman, 2016), and a Contractor Management System (CoMS) (Majid, Shariff, & Rusli, 2015), All findings were summarized in Table 1.

3.2 PSM Elements

There are 14 elements in the PSM system stipulated by the US Occupational Safety and Health Administration (OSHA), Code of Federal Regulations (CFR) Chapter 29, Section 1910.119 in 1992, which are Employee Participation (EP), Process Safety Information (PSI), Process Hazard Analysis (PHA), Operating Procedures (OP), training, involvement of contractor, Pre-Start Up Safety Review (PSSR), Mechanical Integrity (MI), Hot Work Permit (HWP), Management of Change (MOC), Incident Investigation (II), Emergency Planning and Response (EPR), Compliance Audits (CA), and Trade Secret (TS). However, only five elements were found in the literature in this review study, which was Incident Investigation (II), Process Hazard Analysis (PHA), Process Safety Information (PSI), involvement of contractor, and Emergency Planning & Response (EPR).

The literature found that the Incident Investigation (II) element was important to define the causes of the accident in the Chemical Process Industry (CPI). A case study by Shaluf, Ahmadun, & Said (2003) at the refinery in West Malaysia reported that hazardous gas named hydrocarbons escaped to the atmosphere and caused a fire due to a failure of the existing system. The conditions exceeded the existing design conditions. Pressure and temperature have exceeded the design limits of the system. The system could not cope with the resultant forces, and the flange joints downstream of the relief valves were suddenly opened. The management called for an investigation into the causes of the incident, a summary of the errors that led to the accident. Three errors were identified that caused the incident to occur. The main cause of the incident was technical and operational errors. Indeed, modification on project specification has supported the incident. A thorough investigation into this tragedy has been concluded a lack of knowledge of the project management and lack of follow-up by the management contributed to technical and operational errors. Thus, the II element in the chemical industry could efficiently guide the management to encounter the incidents from happening again.

Table 1 Descriptive Analysis of Included Articles for the Systematic Literature Review on the Implementation of the PSM Elements Based on Case Studies in Malaysia

No	Authors (Year)	Type of PSM elements	Field of case studies	Measures	Outcome Measures
1.	Shaluf, Ahmadun, & Said, (2003)	Incident investigation (II)	Refinery	Errors of incident	Identify the causes of incidents
2.	Shariff & Leong, (2009)	Process hazard analysis (PHA)	Hydrocarbon fractionation plant	Risk of an Inherently safer design	Identify the potential risk of unwanted events
3.	Aziz, Shariff, & Rusli, (2014)	Process safety information (PSI)	LPG treating unit (LPGU) of oil and gas refinery	Hazard and risk	Manage and control hazards
4.	Aziz, Shariff, Rusli, & Yew, (2014)	Process safety information (PSI)	Carbon dioxide (CO_2) hydrocarbon absorption system pilot plant	Manage process chemicals, technology, and equipment	Organize strategies to manage documentation, communicate information, and written program
5.	Majid, Shariff, & Rusli, (2015)	Involvement of contractor	High Gravitational Natural Gas Pilot Plant (HGNGPP)	Contractors' management system	Minimize and prevent accidents involving contractors
6.	Majid, Shariff, & Loqman, (2016)	Emergency planning & response (EPR)	Oil and gas refinery	Plan and implement ERP	Track and manage better EPR

A study by Shariff & Leong (2009) explained that the inherent risk of all streams of a hydrocarbon fractionation plant causing an explosion was assessed and evaluated using Inherent Risk Assessment (IRA) and integrated with a simulator process design. To estimate the risk, consequences and probability models developed in MS Excel were used. This spreadsheet-based tool is integrated with a process design simulator for process data to quickly and efficiently estimate risk. This assessment shows the implementation of the process hazard analysis (PHA) element in the PSM system. In the reported case study, a catastrophic rupture of a 300 millimeters diameter pipe resulted in a leakage of hazardous gas known as a hydrocarbon. Five out of 27 streams were analyzed based on the inherent properties of the chemicals used and the process conditions of the design. This assessment would influence the probability, the consequence (overpressure) of the explosion incident and the calculation of the overall frequency (F) of the event, as well as the capability of predicting the number of fatalities. According to the assessment, all the calculated risks are below the intolerable region set by Malaysian and thus, confirmed that stream design meets the Malaysian limits.

Process Safety Information (PSI) was most popular and identified in the literature by Aziz, Shariff, & Rusli (2014) and Aziz, Shariff, Rusli, & Yew (2014). It provides organized strategies for document management, conveys information and written programs for maintaining, revising, and updating related information. They developed a technique capable of systematically transforming information into a computer database prototype known as the Process Safety Information Management System (PSI4MS). A case study was conducted using real data from the LPG treating unit (LPGU) of oil and gas refinery Plant X in Malaysia, involving hazardous chemicals such as hydrogen sulfide using the Piping and Instrumentation Diagram (P&ID) (Aziz, Shariff, & Rusli, 2014). All the requirements are managed and monitored by PSI4MS using data captured through digital forms that can be stored in a centralized database involving process chemicals, technology, and equipment that must fulfill the compliance status.

Furthermore, authorized personnel can always be alerted to sufficient process information, covering the processes that need to be compiled to ensure the hazard control and risk reduction program is accomplished. Meanwhile, a case study by Aziz, Shariff, Rusli, & Yew (2014) was conducted at the CO2-Hydrocarbon Absorption System (CHAS) pilot plant under the Research Centre of CO2 Capture (RCCO2C), Universiti Teknologi Petronas, involving the absorption performance of the hazardous chemical named amine solvent in removing flammable gas of Carbon Dioxide (CO2) from the natural-gas stream for pressure of up to 80 bars. By having the PSI4MS, authorized personnel can upload information, update it and make the necessary follow-up. The frequency with which the data is updated depends on the required changes that need to be made at the pilot plant. In addition, other PSM elements such as PHA, Management of Change (MOC), and Pre Start-Up Safety Review (PSSR) could also be updated, thus making safety management easier in the plant process.

Another PSM element, called the contractor's involvement, was also included in this review. Previously, it was determined that some aspects, especially related to the way contractors work do not comply with the regulations and thus encouraging undesirable outcomes. According to a study revealed by Majid, Shariff, & Rusli (2015), shortcomings in the PSM contractors' management program will be organized through the implementation of this element. A Contractor Management System (CoMS) model was developed using the piping and instrumentation diagram (P&ID), and its implementation was tested at the High Gravitational Natural Gas Pilot Plant (HGNGPP) Universiti Teknologi Petronas. The pilot plant was used to study the performance of an in-line rotary separator to remove water vapor from the natural-gas stream for pressure of up to 80 bars. This pilot plant was handling flammable gas at a higher temperature. Here, a contractor played a role in replacing a corroded section of the separation columns that contain absorbents. Begin with the framework and provide a foundation for developing a CoMS prototype model to track and manage the contractor documentation and information for effective implementation in industries. The CoMS was adapted from the computer database model and was developed in the Microsoft Access environment. Interfaces were Managing Contractors, Application, Pre-Contract Screening, Site Safety Plan Checklist, Work Monitoring and Evaluation, and Accident/ Incident Report. Each interface is based on respective objectives and provides information for any company to conduct a gap analysis to determine how close the system complies with PSM requirements. The establishment of the system will assist regulatory compliance and ease the auditing process.

Another PSM element called emergency planning & response (EPR) was also defined in this review. The ERP is an important aspect of the PSM elements, which explains the minimum emergency response elements and procedures for handling emergencies or small releases. According to a study revealed by Majid, Shariff, & Loqman (2016), they aimed to present a structured and easy technique to plan and implement EPR as stipulated in the PSM system. Begin with the framework, and it provides a foundation for developing an EPR prototype model to track and manage EPR documents and information for effective implementation across industries. A model was created using Microsoft Access as the data management tool. Referring to a case study conducted using real data from a utility area of a local oil and gas refinery. Plant X in Malaysia, a model using the piping and instrumentation diagram (P&ID) was developed based on this technique and its application was tested. Plant X complies with local regulations set by the Malaysian Department of Environment (DOE) regarding the spills of hydrochloric acid (HCl). The P&ID was divided into several activity nodes according to its design as a utility area. The scenario was the release of HCl to the surrounding area and how the situation was handled and mitigated. According to the case study, Plant X did not comply with decontamination procedures and the training content of its responders and trainers. The results reflected the feasibility of this model as it helped users track and manage documents efficiently. The findings defined that this concept and structured technique was feasible and could be implemented in the CPI.

4.0 DISCUSSION

This systematic literature review aimed to reveal the effectiveness of the process safety management (PSM) system involving PSM elements in Malaysia's Chemical Process Industries (CPI). A rigorous review from three databases resulted in six articles on the implementation of the PSM system based on case studies in the country introduced by many researchers and practitioners in Malaysia.

According to previous research, contributors to accidents include technical, design, and operating errors of major types of process equipment and piping, of which 85% of accidents are caused by design and operation errors (Kidam & Hurme, 2013). The failure of the technical, design, and operation will eventually be introduced as an explosion and fire accident. To overcome this issue, Majid & Shariff (2019) demonstrated a structured and easy technique for conducting and implementing incident investigations and complying with the PSM system. It helps prompt users on the necessary actions to close the identified gaps that cause the accidents.

Adopting an upgraded PSM system has been shown to reduce the risk of chemical accidents for today's industries. Among 14 elements in the PSM system, the Process Safety Information (PSI) element is highly selected in this review. PSI is chemical, physical and toxicological information related to chemical processes and equipment. It is used to record the configuration of a process, its characteristics, its limitations, and data for process hazard analyses. PSI takes into consideration on hazards of the regulated materials typically found in safety documentation such as Safety Data Sheet (SDS). In the Malaysian situation, Aziz, Shariff, & Rusli and Aziz, Shariff, Rusli, & Yew (2014), has developed a technique based on the PSI element for document management, communication, a written programme to maintain, revise and update hazardous chemicals, equipment and technology information. Process and Instrumentation Diagram (P&ID) was used as a foundation for data management and converted into a computer database prototype known as Process Safety Information Management System (PSI4MS) to demonstrate the concept.

Meanwhile, to present a structured and easy technique for planning and implementing emergency planning & response required by PSM, the development of an EPR prototype helps to track and better EPR management. Majid, Shariff, & Loqman, (2016), aim to present a structured and easy technique for EPR planning and implementation as stipulated in the PSM system in oil and gas refinery Plant X in Malaysia. This study is supported by previous research done by Shamim et al. (2019), which introduced the EPR elemental-based Delphi technique for safer chemical processes using a mathematical model, safety performance index (SPI), based on the principle of relative ranking. It has been developed to evaluate the developed leading and lagging metrics. The established methodology was successfully applied to the case study of a major process accident, which occurred in an industrial process for the production of inorganic chemicals such as soda ash (Na2CO3) in Pakistan. As a result, fifteen performance metrics have been developed for the EPR element of the Process Safety Management (PSM) standard. The results provided insights into plant safety.

As we can see here, most of the implemented PSM elements found in this review used the computer database systems such as Microsoft Access and Microsoft Excel as a tool to create and manage the related safety data. This technology can help safety practitioners to collect and keep information safe and easy access compared to manual searching. In addition, the software is an ideal tool for more advanced data tracking. This statement has been supported by Early (2006). This statement was supported by Early (2006). He described the recent implementation of a database management system (DBMS) at a chemical plant and chronicles the improvements accomplished by introducing a customized system. The examples of DBMS in the chemical company such as management of change (MOC) initiation and tracking, including signoffs and email notifications, process hazard analysis (PHA) recommendation tracking with notifications and approvals, pre-startup safety review (PSSR) close-out item tracking, PSM audit corrective actions tracking, safety incident reporting and corrective action tracking, environmental incident reporting and corrective action tracking, including on-line reporting, spill release, and Community Awareness and Emergency Response (CAER) notifications, customer complaint/quality assurance actions tracking, and generic actions tracking. A current study by Lee, Cameron, & Hassall (2019), recommended today's technology deployment towards Industry 4.0 with a focus on advanced automation, robotics and enhanced human-machine connectivity. Industry 4.0 offers the opportunity to integrate and leverage current technologies and modeling approaches to improve process safety. This modeling approach systematically identifies risks that are within the tolerance criteria and if additional barrier or design changes are required, identifying independent layers of protection include critical equipment management processes and access their effectiveness to minimize consequences, generate alarm signatures that can be useful in unusual situations, identify critical operator interventions, improving procedural risk assessment and reducing the time and risk of error in the traditional risk assessment process. Thus, database systems are more useful and user-friendly tools for developing customized, configurable to fit workflows in management settings.

Therefore, effective action by industries is important to prevent recurrence and reduce the number of accidents in the workplace. Many industries have recently implemented PSM systems to reduce the severity of human and material losses caused by disasters. There are several limitations in this study. First, articles were identified using search strings from the Science Direct, Web of Science, and Scopus databases through 2020 publication. Another limitation of the review is that it was restricted to the effectiveness of the PSM in the Malaysian context. Future studies on new ideas, research and inventions from local researchers and authors are needed to improve and upgrade the framework and implementation of the PSM system in CPI in Malaysia. The invention of safety management software on the PSM system is suggested to enhance operational processes, improve risk management effectiveness, evaluate existing and available frameworks, predict accidents and consequences in the future, offer a variety of solutions and prevent undesired events. The application of safety management software is more flexible and practical to be implemented in this modern era of digitalization and automation. This software controls safety and manages risk with real-time performance monitoring to demonstrate a completely proactive and anticipative approach to operations. Improving and upgrading the PSM system framework will enhance Occupational Safety and Health (OSH) management in every work prospect. Strengthening the self-regulation practice in the workplace, promoting OSH education and research, and enhancing OSH management through technology, digitalization, and automation are eligible in improving the framework of the PSM system.

5.0 CONCLUSION

The development of this review thus demonstrated the PSM system as a mitigation measure in the elimination and reduction of hazards causing risk in the occurrence of hazardous chemical accidents in Malaysia. As a result, several authors have applied the literature of Process Safety Information (PSI) element. Meanwhile, the Process Safety Information Management System (PSI4MS) was a popular tool to implement the PSM system. PSM has achieved excellent performance in risk management, as proven over the years by current researchers. The introduction and implementation of the PSM system for CPI are necessary to reduce the risk of chemical accidents. Therefore, a systematic literature review on PSM implementation effectively manages chemical accidents in Malaysia.

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Book Review

Book Review: Decades of Occupational Safety and Health in Malaysia by Harminder Singh

Article history

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1.0 INTRODUCTION

Decades of Occupational Safety and Health in Malaysia delivers a historical perspective on the development of the Factories and Machinery Department (FMD) in precise and Occupational Safety and Health (OSH) in general. This book is an excellent resource for students, researchers, OSH practitioners, and others to improve OSH in Malaysia. The principal criteria as part of the review includes the content, organization, and reference sources.

2.0 THE AUTHOR

The author of this book is Harminder Singh. He has had a successful career in the Factories and Machinery Department of Malaysia which is now known as the Department of Occupational Safety and Health (DOSH). He worked his way from a fresh engineering graduate all the way up to the position of Director-General of the Department. In addition to that, he was also instrumental in establishing the National Institute of Occupational Safety and Health (NIOSH), Malaysia, which was launched by the then Minister of Human Resources on 1st December 1992. His educational accomplishments include a Professional Mechanical Engineering degree and he is also a Fellow of the Institute of Engineers, Malaysia. He also holds an Honours Degree in Law from the University of London.

3.0 CONTENT

The book has been divided into five chapters. The last three chapters are based on the author's account as a staff of the FMD, Malaysia. It allows readers to easily follow the evolution of OSH from the late 19th century until the early 1990s. It presents a comprehensive analysis on the history of OSH in Malaysia focusing on the development of the DOSH. It offers an objective view of the DOSH's developments and illustrates the interaction between the need of the country and the initiatives taken by the department.

The first chapter of the book opens with an early history of machineries introduced in Malaysia and the law governing them during the pre-independence era of the late 19th century. The earliest discovery of tin mining was in Larut and Kinta in the state of Perak in 1848 and 1880, respectively. The chain pump was the machinery used for mining until the introduction of steam engine and centrifugal pump in 1877 by the Europeans. Dredge was introduced in 1912 to enlarge the scale of mining operations. Legislation pertaining to machineries first appeared in 1892 in Selangor and later the Boiler Enactment was passed in 1898 and this was followed by the Machinery Enactment in 1913 to cover all types of machineries. The Machinery Ordinance was subsequently passed in 1953 to cover the entire Federation of Malaya. The Ordinance was an instrument in establishing the Machinery Department.

The book progresses through the post-independence period of 1957 to 1965. It is during this period, that the first batch of six local machinery inspectors joint the Machinery Department, which was earlier dominated by expatriates. The author also shares his personal experiences of working with expatriate inspectors. He was under the impression that the expatriate bosses were not very happy with qualified Malaysians filling the vacancies in the department. The expatriates would treat them like children although they were given the responsibility to be in-charge of regional offices.

During the period from 1966 until 1978, the first Malaysian Chief Inspector and Deputy Chief Inspector were appointed in 1966 to replace the expatriate officers. The first task of the Chief Inspector was to uplift the morale of the officers and staff of the department. Secondly, they were tasked to improve the image of the Machinery Department which was run by a drunkard expatriate and dishonest chief clerk. During this period the Factories and Machinery Act 1967 was drafted and enforced in February 1970 in West Malaysia. The Act repealed the Machinery Ordinance 1953. With the gazettement of the new Act, the Machinery Department changed its name to the Factories and Machinery Department. The new addition in the scope of the Act was the compulsory reporting of industrial diseases. Eventually, industrial health activities and the Industrial Health Unit was established within the FMD. Senior medical officers from the Ministry of Health were seconded to the department. The Pollution Control Unit was also formed in 1969 to monitor the pollution from chimneys and effluent discharge into the drains and rivers. Eventually, the government established the Department of Environment in 1972 and the Environmental Quality Act was enacted in 1974. With the closure of the Industrial Pollution Unit, the FMD switched its focus to industrial hygiene activities beyond the initial focus on machinery hazards.

Several significant achievements were further explored during the 1978-1989 period. The FMD realized the need for more regular dialogue between employers, employees and professionals on issues of safety and health at workplaces. Based on suggestions by the FMD, the Ministry of Labour agreed to establish the National Advisory Council on Occupational Safety and Health in 1984. A draft of the proposed Act based on Lord Roben's philosophy was developed and discussed by the Council in 1984. However, due to some initial objections from several government departments, the lack of support from officials of the Ministry of Human Resources and constant pressure from some organizations, the implementation of the Act was delayed. In 1985, the FMD also tabled a paper on the need to establish an Institute of Occupational Safety and Health similar to what Germany, United States and Finland had. Extensive discussions were held by the Council. The International Labor Organization also agreed to send an expert to conduct a feasibility study. Finally, the government approved the establishment of the National Institute of Occupational Safety and Health in the early 1990s based on the proposal by the FMD.

The final chapter of the book focuses on the 1990-1992 period. It was a short period in which the author was appointed as the Director General of the FMD. The Department was responsible in the establishment of NIOSH, which focuses on training, research, consultation, and dissemination of information. During this period, the FMD continued to work on establishing the Occupational Safety and Health Act (OSHA). In 1993, the new Occupational Safety and Health Act was tabled in Parliament. With the enactment of the Occupational Safety and Health Act (OSHA), the FMD once again changed its name to the Department of Occupational Safety and Health. In this chapter, the author also provides a glimpse of OSH in the 21st century and beyond.

4.0 STRENGTH AND WEAKNESS

The book provides a clear progression of machineries, technologies, and activities that created different hazards and risks in various industries in Malaysia. Thus, readers are taken on a journey through the eyes of an Occupational Safety and Health enforcement officer and will receive first-hand accounts of the activities involved in trying to make the workplace safe and healthy. The bibliography provides some sources for obtaining more historical information on industrial developments in Malaysia. The appendices conclude with photos and newspaper cuttings of the activities involving the author. The tone of the book reflects the author's passion and love for his job.

Unfortunately, the contents of the book only covers the period of up to 1992 due to the author's retirement from the department in that year. It is impossible to explore all topics thoroughly.

5.0 CONCLUSION

Decades of Occupational Safety and Health is a collection of significant events in OSH, emphasized by the people who made it happened and it correlates with the needs of the industries. The book's use of chronological time frames helps to make the advancements of OSH come to life. The author's enthusiasm on the topic is evident throughout the book. Overall, the book covered the historical developments of OSH in Malaysia in a readable and entertaining style. Therefore, it is suitable for those wanting to know about how OSH developed in Malaysia from the perspective of an enforcement department.

AUTHOR: FADZIL OSMAN

GUIDELINES FOR CONTRIBUTORS (JOURNAL OF OCCUPATIONAL SAFETY AND HEALTH)

The Journal of Occupational Safety and Health (JOSH) is covers with areas of current information in Occupational Safety and Health (OSH) issues in Malaysia and throughout the world. This includes Occupational Safety, Occupational Health, Ergonomics, Industrial Hygiene, Chemical Safety, OSH Management System and other related research title in OSH.

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Kindly refer to Appendix A (Author’s Checklist) and Appendix B (Template of the Paper) for more details/further information.

TYPE OF ARTICLE:

Original Article: Original Article is report on findings from original unpublished research. The article follows the format provided in the guide to authors. The content includes Abstract, Introduction, Materials and Methods, Results and Discussion, and Conclusion.

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Smith, A.B., Adams, K.D., & Jones, L.J. (1992). The hazards of living in a volcano. Journal of Safety Research, 23(1),81-94.

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)

Government Publication:

Ministry of Health Malaysia & Academy of Medicine Malaysia (2003). Clinical Practise Guidelines on Management of Obesity 2003.

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