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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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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

In this edition, a recent research paper investigated the implementation and effectiveness of the Occupational Safety and Health (OSH) risk management system and related regulations. The study focused on the reduction of workplace accidents and injuries in small and medium-sized enterprises (SMEs) in Malaysia.

The paper highlights that SMEs have exhibited a notable inclination towards adopting OSH risk management systems in reducing workplace accident and incidents. Nevertheless, a significant observation is that these systems often rely on manual procedures, lacking the integration of electronic software solutions for a more comprehensive risk monitoring approach. These findings outlined necessity of optimizing the risk monitoring process by incorporating technological solutions, thereby augmenting overall effectiveness.

When evaluating the current adequacy of the existing OSH implementation, the research pinpoints specific areas in need of enhancement. Key aspects encompass reinforcing supervision, nurturing employee discipline, and fortifying practitioner commitment to upholding OSH principles. This research substantially contributes to the comprehension of OSH risk management in the context of Malaysia's SME sector, a significant contributor to the nation's economy.

This paper has provided invaluable insights for OSH regulators, furnishing readers with the necessary guidance to refine regulations and bolster compliance mechanisms. While the findings were subject to certain limitations due to a restricted survey sample and limited response during the COVID-19 pandemic, it is worth noting that the study maintained comprehensive coverage for SMEs across all states in Malaysia.

I eagerly anticipate more similar research studies as a more diverse array of perspectives contributed by individuals at all levels across various industries will ultimately further enhance the improvement of OSH risk management practices and foster safer and compliant work environments. Therefore, we should all remain resolute in preserving the spirit of exploration, diligently monitoring changes in circumstances, and embracing adaptation for continuous improvement.

Haji Ayop Salleh
Chief Executive Editor

Original Article

Impact of Occupational Safety and Health on Performance Improvement in Water Service Projects

Mohamad Mahathir Mohamed Younos,[a,*] Mohamad Syazli Fathi[a]

[a] *Razak Faculty of Technology and Informatics, Universiti Teknologi Malaysia, Jalan Sultan Yahya Petra, 54100, Kuala Lumpur, Malaysia.*

Corresponding author: mohamad.mahathir@gmail.com

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ABSTRACT: *Occupational Safety and Health (OSH) has long been a crucial element in all industries, and especially in water services projects. Water services projects are high-risk industries dealing with complex engineering construction, chemical use, water supply, and people. The increasing number of accidents and fatalities, including those derived from risk-injury and work-related diseases, requires organisations to improve performance from an OSH perspective. This study reviews the impact of OSH on the improvement of the performance of water services projects in Klang Valley through comprehensive questionnaires and descriptive statistics. The findings show how far the water services projects, or the water industry, complies with the OSH requirements and how they persevere to be fully committed to the performance improvement requirements stipulated in the Occupational Safety and Health Act, 1994. This study concludes by examining how OSH can further improve work performance, particularly in water services projects, and the impact on future work and technologies.*

Keywords: *Enactment, Health & Safety, Occupational Safety, Projects, Water Services*

1.0 INTRODUCTION

Water services play a significant role in any country's economic development by establishing the necessary infrastructure for socioeconomic development, while being a major contributor to overall economic growth (Drewer, 1980). However, it is one of the most hazardous industries (Chua and Goh, 2004) owing to the number of accidents and fatalities. According to the Social Security Organisation Malaysia (PERKESO), there was a slight increase in the number of industrial accidents reported in Malaysia between 2012 and 2016, from 35,296 to 35,304 cases. Therefore, there is a need to consider new methods to improve its image. One key to success in business is cost minimisation. Providing a safe and healthy workplace is one of the most effective strategies for reducing the cost of conducting a utility business. Accident frequency and property loss have a significant impact on utility companies. They cause delays in operations, and directly and indirectly incur costs. Therefore, utility companies must provide safe working environments for their employees and subcontractors.

On 25th February 1994, the Occupational Safety and Health Act 1994 (OSHA 1994) was enacted, protecting safety and health for work activities in all economic sectors, especially the utility sector. Rules and regulations regarding work at high elevations are provided by OSHA. The Department of Occupational Safety and Health (DOSH) and other government agencies have regulations that lay down the legal requirements to ensure the safety and health of the workers at the place of work, and the public as well.

This guideline applies to all places of work in building operations and engineering construction activities in Malaysia, covered by the OSHA 1994 (Act 514), the Factories and Machinery Act 1967 (FMA 1967) (Act 139), and all regulations made thereunder. It is designed to serve as a handy reference and can be read together with the abovementioned legislation and other industry codes of practice. Every employer involved in the construction industry is required to comply with all safety and health regulations at the workplace, as stipulated by OSHA 1994 and FMA 1967.

Nevertheless, Hinze (1997) asserted that overseeing security includes four levels: the organisation arrangement, venture administration, site administration, and individual levels. Disappointment at each level was the purpose of a mishap. Disappointment at the main level builds the likelihood of disappointment at the second level, and so on. Uncalled for Occupational Safety and Health (OSH) administration prompts poor security records. It is extremely difficult to accomplish the target of 'zero mishaps' because of the harsh and intense nature of the business. In general, OSHMS, for the most part, depends on the consistent observation of markers of the execution of pertinent procedures and nonstop changes in these procedures. In industrialised countries, mishaps cause a larger number of deaths than infections and any single ailment, aside from those caused by coronary illness (Biggs et al., 2005). Security is a noteworthy concern in any industry. In the utility business, the requirement for such a concern may be more noteworthy than in most other enterprises. This is because of the large number of modern wounds brought about by utility specialists.

2.0 METHOD

Questionnaires were issued to 110 carefully selected personnel within the company's 11 water services projects in Klang Valley to collect information and data. The 110 respondents were all key persons directly involved in the projects. Quantitative data from survey questionnaires were used in this study.

To calculate the sample size, a Z-score of 1.96 with a confidence level of 95% was selected. The confidence interval was 0.05 and the standard deviation was 0.9225. A small standard deviation indicated that the data were clustered near the mean.

Confidence Level	Z-Score
80%	1.28
85%	1.44
90%	1.65
95%	1.96
99%	2.58

$$\text{Sample Size} = \frac{(\text{Z-score})^2 \times \text{Std Dev} \times (1 - \text{Std Dev})}{(\text{confidence interval})^2}$$

$$= \frac{(1.96)^2 \times 0.9225 \times (1-0.9225)}{(0.05)^2}$$

$$= \frac{3.8416 \times 0.9225 \times (0.0775)}{0.0025}$$

$$= 0.2747 / 0.0025$$

$$= 109.88 \text{ (rounded up to 110 persons)}$$

The validity of the questions in this survey was determined by pre-testing, which is crucial to determine any problems with the survey form before sending it to the actual respondents. Unnecessary questions, technical glitches, and potential sources of bias can be eliminated early in the pre-test, so that they do not affect the final data.

In the pre-test, 10 people from the target group were asked to attempt the questions. The testers completed the survey individually just as they would in the actual project, but in the presence of an observer. They were required to complete the survey while thinking out loud, and the observer monitored whatever crossed their minds. For instance, they needed to express if they could not understand the questions, if the questions were too lengthy, inappropriate, or unnecessary, if they got lost in searching for the next section, if the option they wanted was not available, or if the question made them feel uncomfortable. They were allowed to scribble on the questionnaire, highlight or underline unclear sentences, circle irrelevant questions, and add suggestions and comments.

In addition, the testers were observed on how they completed the survey. It was crucial to see if they hesitated or made the same mistake on a particular question, because this could indicate that the survey questions and layout were not clear enough and needed to be improved.

As a result of the pre-test, several questions in the questionnaire were modified, the questions were made more comprehensive, and the number of questions was reduced to cater to the level of understanding and accuracy of responses. Nevertheless, as can be seen in Section C – OSH Management Framework, question number 3 in the actual survey, the answers to this question were all significantly shorter than the other open-ended questions. This indicated that the respondents did not understand the need for the question or were unclear about what they were supposed to answer. However, because the question is crucial, the question stays and all responses were carefully interpreted.

2.1 Survey

The responses were multiple-choice and participants had three options to choose from in the form of a Likert scale. Among the questions asked in the questionnaire were the qualifications of the respondents, the number of years of work experience of the respondents, the type of water services project they were involved in, the occupation of the respondents, and whether they were consultants, safety and health officers (SHO), project managers, site managers, skill operatives, or clients; regarding the problems they faced in the projects they were involved in, the following questions were asked: whether there was a limitation in the Health Safety and Environment (HSE) laws and regulations, whether was corruption, whether there was poor HSE culture, and whether there was a high level of insecurity. In addition, the factors that affected the implementation of HSE were also assessed: whether there was a cost overrun involved, whether there were frequent changes in the design of the project as a whole, a question regarding poor labour productivity, and whether there was any entity or operator involved.

Next, the processing and extraction of these data were analysed according to the collection and recording of the data from the questionnaires using SPSS Version 17.0, including quantitative analysis, mean, and relative importance index method (RII). In the final step, the results obtained and recommendations on how OSH can improve work performance, particularly in water services projects, and the impact on future work and technologies, were published.

In addition to these questionnaires, data from organisational sources were obtained. These included the company's HSE objectives and targets, HSE yearly key performance index, HSE annual report, HSE monthly report, HSE daily report, HIRARC checklist, HSE legal compliance checklist, HSE communication report, accident report, HSE monitoring, and risk governance report. Other outsourced data were obtained from the DOSH Malaysia and Social Security Organisation (SOCSO).

Table 1 shows the number of respondents who participated in the data collection and their respective projects. Table 2 presents the occupations of the respondents. Table 3 shows the qualifications of the respondents, and Table 4 shows the number of years of work experience of the respondents.

Table 1 Number of Respondents

No.	Water Service Projects	Number of Respondents
1	Pipe Replacement Project (1200 mm–200 mm)	10
2	Rehabilitation Elevated Pump House Project	10
3	New Development Project	10
4	Flowmeter Measurement Project	10
5	Meter Replacement Project	10
6	Valve Replacement Project	10
7	Burst Pipe Project	10
8	Leak Pipe Project	10
9	Tank Cleaning and Storage Tank Project (Confined Space)	10
10	Slope Repair Work Project	10
11	Concrete Work Project	10
	TOTAL	**110**

Table 2 Occupation of Respondents

No.	Occupation	Number of Respondents (%)
1	Consultant	15 (13.64%)
2	Safety and Health Officer (SHO)	8 (7.27%)
3	Project Manager	33 (30%)
4	Site Manager	21 (19.09%)
5	Skill Operatives	11 (10%)
6	Clients	22 (20%)
	TOTAL	**110 (100%)**

Table 3: Qualification of Respondents

No.	Qualification	Number of Respondents (%)
1	*Sijil Pelajaran Malaysia* (SPM)	0 (0%)
2	Diploma	5 (4.55%)
3	Bachelor’s degree	82 (74.55%)
4	Master’s degree	16 (14.55%)
5	PhD	7 (6.36%)
	TOTAL	**110 (100%)**

Table 4: Work Experience of Respondents

No.	Number of Years of Work Experience	Total Respondents (%)
1	Less than five years	11 (10%)
2	Between five to 10 years	14 (12.73%)
3	Between 10 to 15 years	67 (60.91%)
4	More than 15 years	18 (16.36%)
	TOTAL	**110 (100%)**

3.0 RESULTS AND ANALYSIS

Regarding sociodemographic characteristics, there were 110 carefully selected respondents throughout the water services company directly involved in the water services projects participating in this study. Among these, 15 of them were consultants, eight were safety and health officers, 33 were project managers, 21 were site managers, 11 were skill operatives, and 22 were clients.

With respect to qualification, Table 3 shows that none of the respondents had only studied until *Sijil Pelajaran Malaysia* (SPM), with at least a small number of five respondents studying up to diploma level. Undoubtedly, most had a bachelor's degree (n = 82). Another 16 respondents had master's degrees, and the remaining seven had PhDs. This shows that most respondents working on the projects had the required qualifications to understand and perform the task well. Respondents with higher qualification levels either worked on projects long enough to obtain the required experience to pursue their studies or decided to do so to climb the career ladder and fulfil their ambition and achieve satisfaction.

Table 4 presents the respondents' work experiences. Eleven of the respondents, 11% said that they had less than five years of work experience in water services projects, and 12.73% admitted to having between five and 10 years of work experience. This was followed by respondents with between 10–15 years of work experience (60.91 %), which was the largest portion in the category. However, 16.36% of them had more than 15 years of work experience. This tallied with the occupation of respondents, which showed that most of them worked as safety and health officers and site managers in the projects and were mostly in the third category with between 10–15 years of work experience.

In another section of the questionnaire, we asked questions about the impact of OSH on the improvement of water services projects' performance in Klang Valley. The response scores averaged between 3 to 5; the problem of 'poor HSE culture' had the highest mean at 4.48. This shows that poor HSE culture results in low OSH compliance in a project. This is a very terrible impression, as in any project and especially in water services, there must always be a high HSE culture among workers for the working environment to be safe. The next highest mean in the list was the lack of skilled staff at 4.28, followed by the severity of penalties, with a mean of 4.23. A penalty of RM 50,000 and two years of imprisonment imposed by the government does not help ensure high OSH compliance in a project if there is no awareness from the workers in the first place. Finally, inadequate facilities and equipment on the side and inadequate coordination and integration with means of 3.80 and 3.67, respectively, gives the impression that the facilities, equipment, coordination, and integration do exist in a water services projects, but are most probably not up to standard at times, thus leading to low OSH compliance.

Table 5 shows the problems affecting the implementation of HSE legislation in water services projects.

Table 5 Problems Affecting the Implementation of HSE Legislation

No.	Problems	Mean	Rank
1	Poor HSE Culture Among Stakeholders	4.48	1
2	Lack of Skilled Staff	4.28	2
3	Severity of Penalties to Offenders	4.23	3
4	Inadequate Funding Facilities and Equipment	3.80	4
5	Inadequate Coordination and Integration	3.67	5
6	Corruption and Bribery	3.62	6
7	High Level of Insecurity	3.62	7
8	Political Influence	3.44	8
9	Limitations in the Present HSE Laws	3.44	9
10	Outdated HSE Laws	3.32	10
11	Inadequate Government Commitment	3.21	11
12	Weak Judiciary System and Structure	3.03	12

Using the Relative Importance Index (RII) method, the grades of the effect of the HSE legislation on the performance improvement that remained were graded by scores of five, where one represents the least crucial and five represents the most crucial. The RII was calculated following Cheung et al.

$$RII = (\sum W) / (A \times N), \quad (1)$$

where W is the weight assigned to each factor by the respondent, ranging from one to five; A is the highest weight = five; and N is the total number of respondents.

Table 6 Relative Importance Index of Each Factor Affecting Performance Improvement

No.	Factors	Consultants R11	Rank	Contractors RII	Rank	Clients RII	Rank
1	Cost overruns	0.773	1	0.822	3	0.863	1
2	Frequent changes in design	0.701	4	0.666	4	0.707	5
3	Poor labour productivity	0.60.1	5	0.888	1	0.800	2
4	Quality non-conformance	0.734	2=	0.745	5	0.734	3=
5	Time loss during project execution	0.734	2=	0.877	2	0.734	3=

The consultant and client graded cost overruns first, with a relative index of 0.773 and 0.863, respectively, revealing the impact of poor HSE culture among stakeholders in cost overruns on water services projects. The findings also indicated that accident frequencies and property losses have a significant impact, leading to overrun costs in water services projects. Different from its contractors' rank, labour productivity is very poor at 0.888 due to the ignorance of workers and management and non-adherence to HSE compliance, including client requirements.

4.0 DISCUSSION

4.1 HSE Policy

A health and safety policy is a written statement by an employer describing the company's commitment to protect the health and safety of employees and the public. Management endorses a commitment to employees regarding their health and safety. A health and safety programme contains the health and safety elements of organisational objectives, which makes it possible for the company to achieve its goal of protecting its workers in the workplace.

The Occupational Health and Safety Regulations specify the minimum requirements for a health and safety programme. Some of the requirements specified in these regulations may not apply to every workplace. However, each employer should conduct their own health and safety risk assessment in consultation with the occupational health and safety committee to determine the hazards present in the workplace. Once hazards have been identified, controls for exposure should be detailed in the health and safety programme.

There are several reasons why workplaces need health and safety policies or programmes, including demonstrating management's full commitment to their employees' health and safety. The reasons are enumerated as follows: first is to show employees that safety performance and business performance are compatible; second, to clearly state the company's safety beliefs, principles, objectives, strategies, and processes to build buy-in through all levels of the company; third, to clearly outline employer and employee accountability and responsibility for workplace health and safety; fourth, to comply with OSHA; and finally, to establish safe work practices and procedures to be followed to prevent workplace injuries and illnesses (Neis & Lippel, 2019).

4.2 HIRARC (Risk Assessment)

The HIRARC is a compound word comprising three consecutive activities. These activities include hazard identification, risk assessment, and risk control. Hazard identification refers to the ability to recognise objects that may cause injury or harm to a person (Purohit et. al., 2018).

Risk assessments are very crucial as they form an integral part of an occupational health and safety management plan. They help to create awareness of hazards and risks, identify who may be at risk (e.g., employees, cleaners, visitors, contractors, the public, etc.), determine whether a control programme is required for a particular hazard, determine if existing control measures are adequate or if more should be done, prevent injuries or illnesses, especially when done at the design or planning stage, prioritise hazards and control measures, and meet legal requirements where applicable.

4.3 Legal and Other Requirements

Under the OSHA 1994, Section 15, it is stated that there are general duties of employers and self-employed persons that need to be adhered to for the safety of their employees, and that these duties also extend to the employees (Ismail and Othman, 2021).

Act 514 of OSHA 1994 under the Laws of Malaysia, Section 15 has been quoted below.

15. General duties of employers and self-employed persons to their employees.

(1) It shall be the duty of every employer and every self-employed person to ensure, so far as is practicable, the safety, health and welfare at work of all his employees.

(2) Without prejudice to the generality of subsection (1), the matters to which the duty extends include in particular-

(a) the provision and maintenance of plant and systems of work that are, so far as is practicable, safe and without risks to health;

(b) the making of arrangements for ensuring, so far as is practicable, safety and absence of risks to health in connection with the use or operation, handling, storage and transport of plant and substances;

(c) the provision of such information, instruction training and supervision as is necessary to ensure, so far as is practicable, the safety and health at work of his employees;

(d) so far as is practicable, as regards any place of work under the control of the employer or self-employed person, the maintenance of it in a condition that is safe and without risks to health and the provision and maintenance of the means of access to and egress from it that are safe and without such risks;

(e) the provision and maintenance of a working environment for his employees that is, so far as is practicable, safe, without health risks, and adequate as regards facilities for their welfare at work.

(3) For the purposes of subsections (1) and (2)-

(a) "employee" includes an independent contractor engaged by an employer or a self-employed person and any employee of the independent contractor; and

(b) the duties of an employer or a self-employed person under subsections (1) and (2) extend to such an independent contractor and the independent contractor's employees in relation to matters over which the employer or self-employed person-

(i) has control; or

(ii) would have had control but for any agreement between the employer or self-employed person and the independent contractor to the contrary.

The amendment of the Construction Industry Development Board Act 520 (CIDB ACT 520) under the Safety of Buildings and Construction Works also states employer responsibility.

The amendment also makes it the contractor's duty to ensure the safety of the building and construction work, whether during or after the construction work. This amendment is applicable to all contractors, whether registered in the CIDB or not. Similarly, any person with the right and power to manage or control a construction site must ensure that the construction site and the means of entering and leaving the site are safe and not harmful to health.

The amendment provides that in the event of a breach of safety, the CIDB is empowered to immediately stop the construction work, conduct an inspection at the site at the contractor's cost, order the execution of specified construction works, and demolish the defective building or any defective parts of the building. Contractors who fail to adhere to the directives issued by the CIDB shall be guilty of an offense and, on conviction, be liable to a fine not exceeding RM500,000, with respect to a continuing failure to comply, an additional fine of not exceeding RM10,000 for every day or part of a day, which the offense continues after conviction.

Any contractor whose breach of duty results in death shall be guilty of an offense and, on conviction, be liable to a fine not exceeding RM500,000, or imprisonment for a term not exceeding two years, or both.

Apart from that, the CIDB Act 520 Amendment also imposes a higher penalty on contractors who undertake construction works without valid contractor accreditation–from RM10,000 to RM100,000–compared to the maximum penalty of RM10,000 before the amendment. Contractors who do not declare their construction projects can be fined up to RM50,000. Contractors who fail to pay the levy can be fined up to RM50,000 or four times the amount of the levy payable, whichever is higher.

4.4 Consultation and Communication

Consultation is a legal requirement under OSHA 1994. Effective and timely consultations with employees are crucial for maintaining and improving safe and healthy workplaces.

The workplace manager and/or management of OSH nominees must establish consultative arrangements with Health and Safety Representatives (HSR) and employees when making any decision or change in relation to OSH in the workplace. These include the identification and assessment of workplace hazards or risks, decisions made on measures taken to eliminate or control workplace risks, review of workplace risk assessments, decisions made about the adequacy of workplace facilities, changes to procedures for monitoring workplace risks, proposed changes to work premises, systems of work, plants, or substances used at the workplace, decisions about changes in job roles, and decisions about consultation procedures and legislative requirements.

Where the information required to be disclosed is confidential (e.g., medical reports and personal records), the workplace manager and/or management OSH nominee should seek legal assistance before deciding to disclose the information. The department will consult and communicate with internal and external stakeholders on matters affecting state-wide health and safety, as determined by Part 4 of the OSHA 1994 and under the main objectives of the department's Health, Safety, and Welfare Policy.

The workplace manager and/or OSH management nominee must communicate the following information to employees: existing OSH practices and systems, changes to current OSH practices and systems, and workplace inspection outcomes (Liu et al., 2019). This includes communicating specific elements of the OSHMS, including the workplace risk profile (OSH Risk Register), the department's health, safety, and welfare policy, completed risk assessments and safe work procedures, safety data sheets for chemicals, and emergency processes, such as evacuation plans and incident controller details.

4.5 Contractor Management

Contractor management is a system of controls that ensures contracted service support for safe facility operations and the company's process safety and personal safety performance goals. This element addresses the selection, acquisition, use, and monitoring of such contracted services. Contractor management does not address the procurement of goods and supplies or offsite equipment fabrication functions covered by the asset integrity quality assurance function. Meanwhile, the most significant contractor safety challenges typically involve workers assigned closest to process hazards or those involved in high-risk occupations, such as construction work, and the safety needs of contractors provide simpler and more routine tasks. In this case, water services projects are not excluded.

Companies are increasingly leveraging internal resources by contracting a diverse range of services, including design and construction, maintenance, inspection and testing, and staff augmentation (Coreynen, Matthyssens, & Bockhaven, 2017). By doing so, a company can achieve goals such as: (1) accessing specialised expertise that is not required continuously or routinely, (2) supplementing limited company resources during periods of unusual demand, and (3) providing staff augmentation without the overhead costs of direct-hiring of employees. However, the use of contractors involves an outside organisation within the company's risk control activities. Contractors can place personnel unfamiliar with the facility's hazards and protective systems in locations where they can be affected by process hazards. Conversely, contractors may expose facility personnel to new hazards such as unique chemical hazards or X-ray sources because of their work activities. In addition, on-site activities may unintentionally defeat or bypass facility safety controls. Thus, companies must recognise and address the new challenges associated with the use of contractors.

5.0 CONCLUSION

This study demonstrates a significant relationship between the level of OSH compliance in water services projects and the impact of OSH on the performance improvement of water services projects. Poor HSE culture, lack of skilled staff, severity of penalties, inadequate facilities and equipment, and inadequate coordination and integration contribute to a low level of OSH compliance. Noncompliance with existing HSE legislation leads to accidents that cause cost overruns, which affect water services project performance.

It is crucial that water services projects take the initiative to examine the demographic criteria of persons before hiring them. This ensures that only qualified personnel are hired. In addition, a good-quality HSE policy, HIRARC (risk assessment), legal and other requirements, consultation and communication, and contractor management are equally crucial in observing the impact of OSH on the improvement of water services projects' performance.

Finally, compliance with safety regulations will be even more challenging in the future with the advancement of technologies (Revolution 4.0) and outside influences. Therefore, water services projects need to get their fundamentals right, thus enabling them to continue to be pioneers in the OSH field.

REFERENCES

Biggs, H.C., Sheahan, V.L. dan Dingsdag, D.P. (2005). A Study of Construction Site Safety Culture and Implications for Safe and Responsive Workplaces. *The Australian Journal of Rehabilitation Counselling,* Vol. 11, No. 1, pp. 1-8.

CIDB. The Amendment CIDB Act 520. Retrived from http://www.cidb.gov.my/index.php/en/akta-520.

Chua, D.K.H., & Goh, Y.M. (2004). Incident Causation Model for Improving Feedback of Safety Knowledge. *Journal of Construction Engineering and Management,* Vol. 130, No. 4, pp. 542-551.

Coreynen, W., Matthyssens P., Bockhaven W.V. (2017) Boosting Servitization Through Digitization: Pathways and Dynamic Resource Configurations for Manufacturers. Industrial Marketing Management, Volume 60, pp. 42-53.

Drewer. S, 1980. Construction & Development: A New Perspective. *Habitat International*, Vol. 5, No. (3/4), pp. 395-428.

Hinze, J. W. (1997). Construction Safety. Columbus, Ohio: Prentice Hall, pp. 1-6.

Ismail, K.A.K., Othman, I. (2021). Causes of Construction Accidents and the Provisions of Safety Regulations in Construction Industry in Malaysia. ICCOEE 2021: ICCOEE2020, pp. 602–607.

Laws of Malaysia. Act 514 Occupational Safety and Health Act 1994. Section 15.

Liu, K.H., Tessler J., Murphy L.A, Chang C.C, Dennerlein J.T. (2019) The Gap Between Tools and Best Practice: An Analysis of Safety Prequalification Surveys in the Construction Industry. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, Vol. 28, No. 4, pp. 683-703.

Neis, B. and Lippel, K. (2019) Occupational Health and Safety and the Mobile Workforce: Insights from a Canadian Research Program. *NEW SOLUTIONS: A Journal of Environmental and Occupational Health Policy*, Vol. 29, No. 3, pp. 297-316.

PERKESO. Number of Industrial Accidents Reported 2012-2016. Retrived from https://www.perkeso.gov.my/index.php/en/laporan/number-of-accidents on 26 August 2018.

Purohit, D.P., Siddiqui, N.A., Nandan, A., Yadav, B.P. (2018). Hazard Identification and Risk Assessment in Construction Industry. *International Journal of Applied Engineering Research*, Vol. 13, No. 10, pp. 7639-7667.

Original Article

Construction Professionals' Perception of Construction Workers' Safety Attitudes and Behaviors on Construction Sites

Chan Yuan Eng,[a,]* Ryan Ong Soong Keat[a]

[a] *Lee Kong Chian Faculty of Engineering and Science, Universiti Tunku Abdul Rahman (UTAR), Sungai Long Campus, Selangor, Malaysia.*

*Corresponding author: dr.yechan@gmail.com

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ABSTRACT: *The safety attitudes and behaviors of the construction workers play an important role in the occurrence of construction accidents on construction sites; however, the problem is that there is relatively limited research conducted locally regarding the perceptions of construction professionals regarding the safety attitudes and behaviors of construction workers on a construction site. This study aims to determine the perceptions of construction professionals regarding the critical safety attitudes and behaviors of construction workers on construction sites for the prevention of construction accidents as perceived by construction professionals. This study was conducted using a pilot survey and a self-administered questionnaire consisting of 97 respondents from consulting firms and construction sites located in Penang, Malaysia. Data analysis in this study was carried out using the Microsoft Excel Auto-filter Statistical Software (MEASAT) and the Relative Importance Index method. The findings of this study on the safety attitudes and behaviors of construction workers on construction sites revealed that positive communication must be two-way; that is, there must be elements of sending and receiving. Effective communication with the construction workers is essential. For example, they should help each other when they are working at height on a building or structure.*

Keywords: *Construction Professionals, Construction Safety, Construction Sites, Construction Workers, Safety Attitudes, Safety Behaviors*

1.0 INTRODUCTION

Construction is one of the most complex and dangerous activities in the world. Construction site work includes the construction of landed estates, low-rise and high-rise buildings, infrastructure, landscaping works, commercial buildings, repair work, oil and gas, refurbishment, and maintenance work. These studies include many hazardous tasks and conditions such as dust, excavation, noise, working at height, power tools, and equipment. In the construction industry, the risk of death is five times higher than in manufacturing, while the risk of serious injury is two and a half times higher (Sawacha, 1999). The most common accidents are falling from heights, falling objects, exposure to dangerous substances, and dust inhalation.

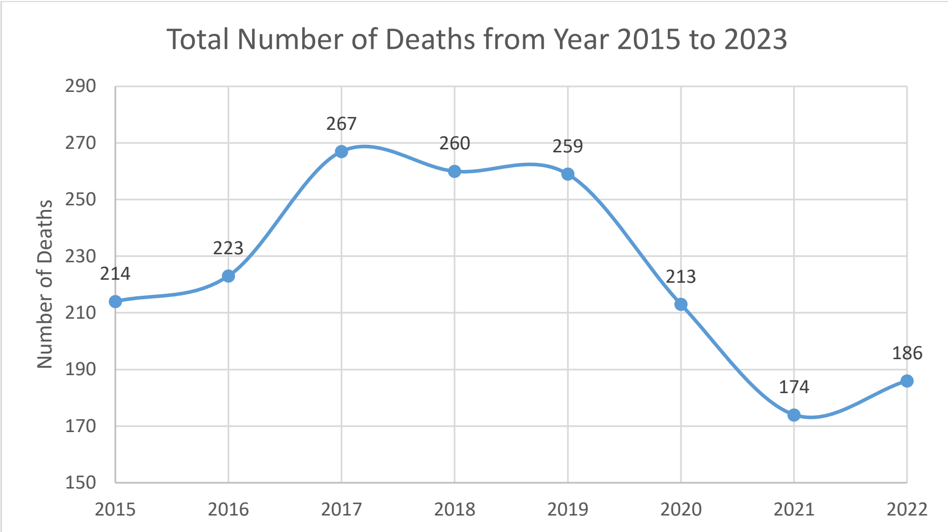

Figure 1 Total Number of Deaths from Year 2015 to Year 2022

Sources: Department of Occupational Safety and Health (DOSH)

As shown in Figure 1, the results change dramatically between 2015 and 2022. Starting in 2015, the number of deaths reached 214 and increased slightly to 223 in 2016. In 2017, the number of deaths increased continuously to 267, before falling slightly to 260 in 2018 and 259 in 2019. After one year, the number of deaths fell to 213 and continued to fall to 174 in 2021. In 2022, however, the number of deaths re-increased to 186.

Workplace accidents are a major public safety issue in many countries, usually involving situations beyond the control of other construction workers on site, especially the main contractors and subcontractors who are still not fully aware of safety rules and regulations. Combined with long working hours to speed up completion, accidents are common. Accidents slow down productivity and cause distress to workers and their families. Studies suggest that by assessing a department's safety attitudes and behaviors, it should be possible to predict the likely accident rates within the department and take proactive remedial action. It is also important for construction workers to be aware of how their safety attitudes and behaviors affect their safety performance on construction sites. Construction workers need to be aware of the rules and regulations enforced by the relevant authorities, and researchers need to focus on studying the possible insecurity factors and problems to better understand the safety situation of construction workers on construction sites. The research gap that this study aims to fill is to determine the perceptions of construction professionals on the critical attitudes and behaviors of construction workers at construction sites to prevent construction-related accidents in Malaysia.

Most researchers have studied the safety issues on construction sites but have not focused on the perceptions of construction professionals regarding the safety attitudes and behaviors of construction workers at construction sites. For example, Daniel Ndakuta Kolo (2019) studied the safety issues involving workers at building construction sites in Nigeria and focused on working conditions and unsafe work activities, but did not focus on the attitudes and behaviors of workers. Hassan and Rahim (2019) examined the relationship between supervisor safety, safety management practices, and safety compliance behaviors among employees in a medical laboratory. Nadhim et al. (2016) studied falls from height in the construction industry.

Yeong and Wahab (2016) investigated the mediating effect of safety culture on safety communication and human factor accidents in the workplace in Malaysia. A study conducted by Kaskutas et al. (2013) focused on fall prevention and safety communication training for foremen, which is a report on a piling project to improve residential construction safety.

In addition, Zin and Ismail (2012) studied the behavioral safety compliance factors of employers toward improving occupational safety and health in the construction industry. Loosemore and Malouf (2019) studied safety training and the formation of positive safety attitudes in the Australian construction industry.

Man et al. (2017) conducted a thematic study on the risk-taking behaviors of construction workers in Hong Kong. Goh et al. (2016) studied accident prevention practices on high-rise building construction sites. Guo et al. (2015) developed and tested an integrative model to predict safety behaviors in the construction industry. Seo et al. (2015) used structural equation modeling to analyze the safety behaviors of temporary construction workers. Thuan et al. (2015) examined the health and safety management practices of contractors in Vietnam. As can be seen from the above review of a sample of researchers who have conducted studies on various safety issues, most researchers have not considered the perceptions of construction professionals regarding the safety attitudes and behaviors of construction workers at construction sites. Therefore, this study was conducted to fill this gap in the existing literature. This is the rationale and justification for conducting this research, and the findings are presented in Section 5. The research questions and objectives were as follows:

Research Questions

1. What are the critical attitudes of construction workers on construction sites toward accident prevention as perceived by construction professionals?

2. What are the critical behaviors of construction workers on construction sites to avoid accidents as perceived by construction professionals?

Research Objectives

1. To determine the critical attitudes of construction workers on construction sites to avoid accidents as perceived by construction professionals.

2. To determine the critical behaviors of construction workers on a construction site to avoid accidents as perceived by construction professionals.

Why was Penang chosen as the research area? The purpose and rationale for conducting research on the perceptions of construction professionals of the safety attitudes and behaviors of construction workers at construction sites in Penang, Malaysia are as follows:

1. The construction industry in Penang contributes significantly to the economic growth and reputation of the region. Research into safety attitudes and behaviors can help to improve the reputation and competitiveness of an industry. By promoting a strong safety culture and demonstrating a commitment to worker welfare, construction professionals in Penang can attract investment, clients, and skilled workers. This study provides evidence-based recommendations to improve safety practices and position Penang's construction industry as a leader in safety excellence.

2. Conducting research in Penang could contribute to ongoing efforts to improve occupational safety in the construction industry. By understanding the perceptions of construction professionals such as project managers, engineers, and supervisors, researchers can identify specific areas of concern and explore strategies to improve safety attitudes and behaviors. This study can inform the development of targeted training programs, policies, and interventions to address the unique challenges faced by construction professionals in Penang. Accidents that occur on construction sites are caused either by the negligence of construction companies or by the workers themselves, which affects construction operations. The death of a construction worker who fell from a height in Penang in 2016 was caused by the failure of his company to provide safe working conditions and an adequate supply of personal protective equipment (PPE) to workers (Wahab, 2017).

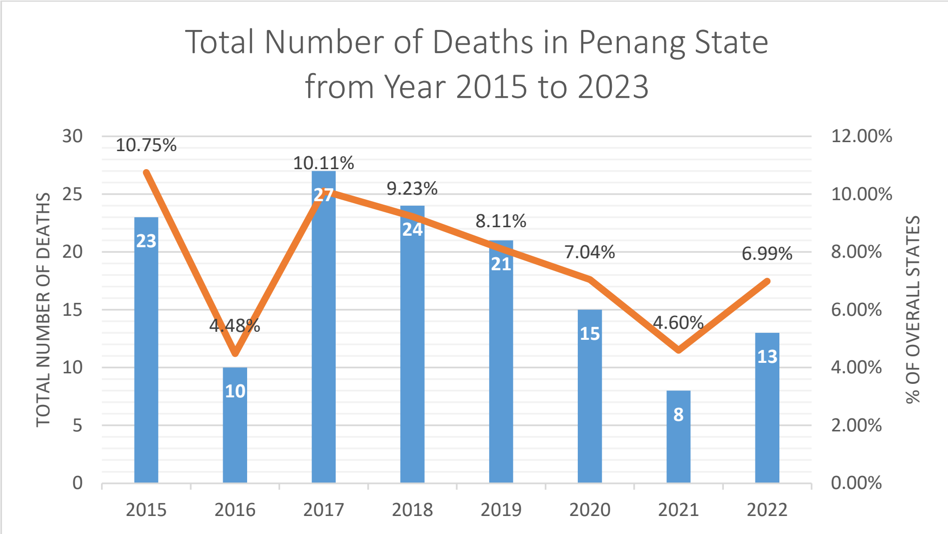

Figure 2 Total Number of Deaths in Penang State from Year 2015 to Year 2022

Sources: Department of Occupational Safety and Health (DOSH)

Referring to Figure 2, the number of deaths in Penang State in 2015 was 23, which was 10.75% of the number of deaths in Malaysia. In the year 2016, this number dropped to 10, and the percentage dropped to 4.48%. However, in 2017, this number increased again to 27, which is 10.11% of that in Malaysia. From 2017 to 2021, the number of deaths and the overall percentage dropped continuously. In 2018, 2019, and 2020, the numbers were 24, 21, and 15, respectively. These values are 9.23%, 8.11%, and 7.04%, respectively. In 2021, the number of deaths was the lowest (8), corresponding to approximately 4.60% of the deaths in the countries. However, in 2022, the number of deaths increased again to 13, representing 6.99% of the country as a whole.

In summary, conducting research on the perceptions of construction professionals on safety attitudes and behaviors in Penang, Malaysia can support the improvement of occupational safety, enhance regulatory compliance, improve the reputation and competitiveness of the industry, foster collaboration among stakeholders, and promote knowledge transfer and best practices.

2.0 LITERATURE REVIEW

A construction site accident can be defined as a risk in the construction industry. It is an undesirable, unplanned, and unexpected event. Hinze (1997) mentions that an accident may not injure the worker on the site, but it may cause damage to equipment, plant, and machinery, as well as to the persons who caused the accidents. Every possible cause of an accident must be considered. Attitudes can generally be defined as the regular feelings, perceptions, thoughts, and tendencies of an individual to perform or act on certain aspects of the environment (Secord and Backman, 1969). Attitude is a psychological attribute that starts in the mind.

Therefore, safety attitudes in the construction industry can be explained by the tendency of construction workers or the workforce to think, feel, or act with certain stated goals toward their safety performance. To recognize the importance of safety attitudes in improving safety performance in the workplace, Lingard and Rowlinson (2005) explained attitude as the intention to respond positively or negatively to objects and people in the environment. Furthermore, a construction workforce's safety attitude should not be determined as if they are safe in the workplace, but should comply with appropriate safety standards, laws, rules, and instructions when required, as attitudes and behaviors are interrelated.

If an individual's attitudes are psychological, then behaviors must be physical. Lingard and Rowlinson (1997) described safety behavior as a behavioral element of a "basic safety infrastructure." Krause (1997), similar to Chen and Fu (2006), recommends that attitude determines behavior. This means that if a construction worker had good safety attitudes, this will lead to good safety behaviors. As a result, their safety performance will improve. Krause (1997) also explained that behavior has a "counter effect" on attitude. For example, improving safety behaviors on a construction site can improve the positive attitudes of the persons involved. In the construction industry, professionals and experts contribute to safety performance. Improvements in safety performance on construction sites can be achieved if all those involved in the construction industry have a positive attitude toward safety.

2.1 Theory of Safety Attitudes

Attitudes can generally be defined as the regular feelings, perceptions, thoughts, and tendencies of an individual to perform or act on certain aspects of the environment (Secord and Backman, 1969). In theory, attitude is a psychological attribute in which everything about a person's behavior comes from the mind. Therefore, safety attitudes in the construction industry can be explained as the tendency of construction workers or the workforce to think, feel, or act in relation to certain stated goals for their safety performance. To recognize the importance of safety attitudes in improving safety performance in the workplace, Lingard and Rowlinson (2005) explained attitude as the tendency to react positively or negatively to objects and people in the environment. Safety attitudes of construction workers can be identified from multiple perspectives.

Siu et al. (2003) used the Safety Attitudes Questionnaire (SAQ) which was proposed by Donald and Canter (1993) to examine the relationships between age, attitude, and safety performance. It was found that older construction workers were more likely to have positive attitudes than younger construction workers. Curtis Breslin et al. (2007) found that young construction workers are employed in various occupations, including construction, that are perceived as potential safety hazards due to the lack of control over the ability to improve or change working conditions. Although work to establish safe attitudes is essential, it remains inadequate. Sound theoretical explanations and effective training to change attitudes need to be given widespread attention.

The concept of safety attitudes is an important aspect of creating a safe working environment. According to Triandis (1980) and Eagly and Chaiken (1993), in order to improve safety attitudes through training, it is essential to understand the three main components of this concept: emotions, cognition, and behavior. The main purpose of identifying the elements of critical attitudes of construction workers is to understand their attitudes toward safety, thereby helping the government and employers review their safety regulations, laws, and investments in safety solutions. The safety attitudes of construction workers consist of general feelings or emotions, safety awareness, the way they communicate, their thinking about contingencies, and their ability to observe their working environment.

2.2 Critical Attitudes of Construction Workers to Avoid Accidents

The purpose of identifying the elements of construction workers' critical attitudes is to understand their attitudes toward safety, thereby providing employers with information to check their construction workers' compliance with safety laws and regulations. The safety attitudes of construction workers consist of general feelings or emotions, safety awareness, ways of communicating, thinking about unforeseen circumstances, and the ability to observe the work environment.

2.2.1 Perform Tasks Carefully and Cautiously

Nadhim et al. (2016) emphasized that the carelessness of construction workers is one of the reasons why they fall from heights, causing permanent disability or even death. Therefore, construction workers must always be careful in the workplace to ensure that there are no accidents on construction sites. Lubega et al. (2000) noted that accidents on construction sites are due to worker negligence and carelessness.

2.2.2 Think of the Consequences and Avoid Taking Risks

Bellamy et al. (2008) mentioned that conducting a study on risk-taking considers the possibility of reducing or managing the consequences of an unsafe act that may compromise safety through ongoing exposure to the surrounding environment. Most participants agreed that risks have the potential to cause injury or death, and some participants responded that some examples of risks include working at height or working in a place that is unsafe or dangerous.

Risk-taking attitudes are hazardous at construction sites and there is a high probability of injury leading to death. Fang et al. (2006) found that older and married construction workers did not take risks while working on construction sites, but were safer. Iacuone (2005) described how construction workers' views on Occupational Safety and Health (OSH) are influenced by different hegemonic masculinities in the construction industry.

2.2.3 Maintaining Positive Emotions and Thinking

Feelings and thoughts are often associated with one or more specific events and are strong enough to disrupt thought processes. Emotions, however, are general feelings or states that are often not identifiable by specific stimuli and are not strong enough to interrupt the ongoing thought process. Allowing negative emotions and thinking to affect one's overall attitude or work mood can have many negative consequences. Therefore, high emotional quotients (EQ) and good emotional management are important characteristics of organizational life. It is essential to create publicly visible and ideal emotional displays as part of the job.

2.2.4 Positive Communication

In the construction industry, construction work requires a high level of communication between all construction and management personnel. Communication is a way for people to express ideas and feelings, and to transfer knowledge and information between individuals (Cigularov et al., 2010). Good communication is important for improving teamwork and better ways of working methods. Poor communication can lead to misunderstandings between colleagues and delays in construction projects. Yeong and Wahab (2016) noted that safety communication is the main factor that has a significant impact on accidents at construction sites. The extent to which communication can influence the safety behavior of construction workers in the workplace has been studied by several researchers. Kaskutas et al. (2013) found that safety communication is a factor that predicts the safety behavior of construction workers in the workplace. Geller (2005) stated that an organization's safety attitude is affected by how safety is discussed and communicated. A positive attitude toward effective communication can influence the safety behavior of employees working on construction sites (Michael et al., 2006).

2.2.5 Keeping a Low Profile

Individual factors play an important role in the occurrence of construction accidents. The main cause of construction accidents is attitude. Therefore, the cause of accidents on site is the construction worker himself, which includes demographics, personal experience, mentality, physical health, and well-being, especially personal assurance, confidence, and reaction. One solution to preventing accidents on construction sites is to keep a low profile while working on the site. Self-assurance, also known as overconfidence, can be described as a belief in one's ability to succeed. Achieving a healthy balance of confidence is challenging. Although confidence is seen as a positive attribute, overconfidence can lead to arrogance and cause more harm to individuals. Kolo (2015) found that overconfidence was the second most common cause of accidents among construction workers.

2.3 Theory of Safety Behaviors

Attitudes and behaviors are linked. If an individual's attitudes are psychological, then behaviors must be physical. Lingard and Rowlinson (1997) described safety behavior as a behavioral element of the "basic safety infrastructure." An individual's attitude determines their behavior. This means that, in theory, a construction worker with a good safety attitude is more likely to exhibit good safety behaviors. As a result, their safety performance will improve. Krause (1997) also explained that behaviors have a "counter effect" on attitude. For example, improving safety behaviors on a construction site can improve the positive attitudes of the workers involved. Ajzen (1994) postulated a theory of planned behavior that illustrates how human behavior is normally influenced by norms and beliefs, control beliefs, and self-efficacy in perceived behavioral control and action. Glendon and Mckenna (1995) emphasized that attitude formation is very important, especially for the construction worker who is performing a construction task. Lingard and Yesilyurt (2003) found that first aid training changed construction workers' safety attitudes and behaviors in the construction workplace by making them more concerned about the implications of safety in their behavior when injuries occur. In the construction industry, where construction professionals and experts contribute to safety performance, improvements in safety performance can be achieved if all parties have positive attitudes toward and promote safety.

2.4 Critical Behaviors of Construction Workers to Avoid Accidents

Vijayakumar (2007) defined behavior as a psychological action that can be observed and measured. According to Daniels (2005), Krause described safety behavior as a methodology applied to behavior analysis to achieve continuous improvement in safety performance. Safety behaviors explain the behavior of construction workers in relation to safety practices and activities, such as safety compliance and safety training courses, which explain the core activities performed by construction workers in accordance with occupational safety and health requirements and good practices to prevent workplace accidents (Mahmood, 2010). Glendon and Litherland (2001) conducted a study that used observational sampling of key behavioral inventories to measure safety performance. Safety behavior was randomly sampled to appraise the proportion of unsafe work practices, in particular non-compliance with Safety Operating Procedures (SOPs) and PPE practices. Johnson (2007) mentioned that safety behavior is the most important element in reducing workplace injuries and indirectly influences the consequences of an accident before it occurs.

2.4.1 Following the Correct Working Procedure and Method

Construction site accidents are caused by several factors. Incorrect working procedures or methods are often used on construction sites, which can lead to undesirable events. It is therefore essential that a method statement is submitted to the Superintending Officer and that the approved safety method is followed. A method statement is a step-by-step statement or method that describes a particular activity or operation. The method of presentation may be in the form of a flowchart or written step-by-step instructions. The presentation of the method statement covers all aspects of the activity, including its scope, responsibilities, prerequisites, methods of performing work or activities, testing or verification, and reference documents, especially safety and health requirements or risk-based assessments. There are many variations of the term method statement, including work procedures, work instructions, work method statements, routines, standard operating procedures, method statements, safety declarations, and safe work practices. However, the main purpose of the method statement is to detail the complete process of the activity in a simple, step-by-step manner that the new engineer or construction worker can easily understand and perform. In some industries, the term "safe method statement" is also used. Although it is now an integral part of every method statement, it is still used to consider and focus on health and safety requirements.

2.4.2 Wearing of PPE

The approval of PPE is one of the needs and requirements of the Factories and Machinery Act 1967, the Occupational Health and Safety Act 1994, and the regulations thereunder. This legislation may be referred to as Legislation on PPE. The Regulations prescribe seven types of PPE which must be approved by the Chief Inspector of Factories and Machinery and the Director General of the Department of Occupational Safety and Health:

a. Head protection
b. Foot protection
c. Hearing protection
d. Eye protection (chemical hazard)
e. Hands protection (chemical hazard)
f. Body protection (safety harnesses, lifelines, and all devices for lifeline attachment)
g. Body protection (chemical hazard)
h. Respiratory protection (chemical hazard)

This applies to all PPE products used in the workplace, including both imported and locally manufactured PPE products. To be approved, all PPE must have a full-type test report and product certification license from the independent Inspecting/Certification Body appointed by Department of Occupational Safety and Health (DOSH), which is SIRIM QAS International Sdn. Bhd. (DOSH, 2023).

To ensure the best possible protection for construction workers in the workplace, the cooperative efforts of both employers and construction workers will help to implement and maintain a safe and healthy working environment (Rahim, 2008).

2.4.3 Compliance of Construction Workers

Accidents can occur anytime and anywhere in the world. Most construction accidents occur on construction sites, where people are more susceptible to various hazards, in particular, heavy machinery and work at heights (Zakaria, 2010). Human error, carelessness, equipment failure, dangerous behavior, and unsafe working conditions are common causes of workplace injuries and fatalities. However, it is difficult to predict accidents on construction sites. However, it is possible to minimize potential workplace hazards on the construction site. The best approach is to ensure that all construction workers on the site comply with the DOSH safety rules and regulations. Construction site personnel must ensure that construction workers and safety and health representatives are consulted, informed, and well-trained in all aspects of occupational safety and health, including contingency arrangements associated with their work, and ensure their participation.

2.4.4 Proper Housekeeping

Keeping a site clean and tidy can help reduce the risk of injuries and accidents caused by debris and obstacles. This practice is called housekeeping (Lingard and Rowlinson, 1994). In addition, it is essential to prevent accidents and injuries at the scene (Lingard and Rowlinson, 1994). This recognition is reflected by the empirical findings of Haslam et al. (2005). In this study, it was observed that among 100 construction accidents studied in the United Kingdom, workplace factors, especially site layout and space availability, had poor housekeeping practices, accounting for approximately 49% of the accidents. Problems identified included hazards or shapes of objects that could cause slips and trips. Uneven surfaces, debris, and muddy environments were also identified. Haslam et al (2005) noted that these problems occur when the walkway is uneven and poorly maintained, and said: "From the point of view of people familiar with safety in many other industries, the harsh conditions found in buildings seem to indicate a weak safety and risk management culture in the industry."

2.4.5 Accessing Heights and Working Platform in a Correct Way

Working at height on a building or structure under construction is one of the leading causes of death and serious injuries in Malaysia, and comprises approximately one-third of fatal injuries to construction workers. Working at a height is any operation that could cause a person or construction worker to fall from a high position on a building or structure and cause personal injury to the person or construction worker (Goh, 2017). This includes working on ladders or flat roofs, falling from fragile surfaces, or even falling into openings or holes in the floor. Aerial work occurs in various industries, and each work environment has many hazards. However, a common cause of accidents is the failure to take adequate precautions while working at height. This is because workers sometimes fail to plan properly and underestimate the risks involved when working at height. They either did not protect themselves by using PPE or may have used PPE in an inappropriate manner.

In summary, the views of construction professionals on the safety attitudes and behaviors of construction workers significantly impact safety performance on construction sites. Constructive attitudes and adherence to safe behaviors contribute to safer working environments, whereas unfavorable attitudes and risky behaviors increase the likelihood of accidents and injuries. By understanding and addressing the factors influencing safety attitudes and behaviors, construction professionals can implement strategies that promote a safety-conscious culture and improve the overall safety performance of workers.

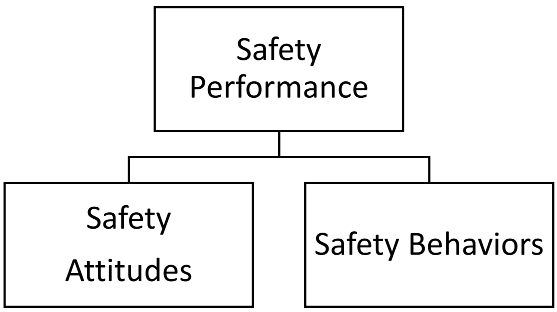

Figure 3 Conceptual Relationship between Safety Attitudes, Safety Behaviors, and Safety Performance

Based on the above safety attitudes and behaviors, construction workers' attitudes play a crucial role in shaping their safety performance on construction sites. Positive safety attitudes, such as performing tasks carefully and cautiously, thinking of the consequences and avoiding taking risks, maintaining positive emotions and thinking, positive communication, and keeping a low profile, will contribute to a safer work environment. When workers have a safety-conscious mindset, they are more likely to take proactive measures to identify and mitigate potential hazards, report unsafe conditions, and adhere to established safety procedures. Conversely, negative attitudes such as complacency, risk-taking behavior, or a lack of belief in the effectiveness of safety measures can lead to unsafe practices and increase the likelihood of accidents and injuries. Therefore, understanding the perceptions of construction professionals regarding worker attitudes is crucial for developing strategies to foster positive safety attitudes and improve safety performance.

The behaviors exhibited by construction workers significantly impact their safety performance. Safe behaviors include consistently following safety guidelines, using PPE correctly, practicing effective communication regarding safety concerns, participating in safety training programs, and promptly reporting incidents or near-miss events. Workers who demonstrate these behaviors create a culture of safety and contribute to reducing accidents and injuries. However, unsafe behaviors such as taking shortcuts, disregarding safety protocols, engaging in distractions, and failing to communicate hazards pose significant risks to worker safety. Identifying behaviors that affect safety performance is essential for implementing targeted interventions and promoting a safety-focused work environment.

The perceptions of construction professionals regarding the safety attitudes and behaviors of construction workers are critical to understanding and improving the safety performance at construction sites. Positive safety attitudes, including the recognition of the importance of safety and commitment to following protocols, foster a safer work environment. Similarly, safe behaviors, such as adhering to safety guidelines, using PPE correctly, and reporting incidents, contribute to reducing accidents and injuries. Conversely, negative attitudes and unsafe behaviors increase the likelihood of accidents and injuries, posing risks to worker safety. To enhance safety performance, it is essential to cultivate positive safety attitudes and promote safe behaviors among construction workers. This can be achieved through targeted interventions, training programs, and the establishment of a strong safety culture within construction organizations.

3.0 METHOD

Quantitative research consists of empirical and statistical studies (Newman and Benz, 1998) in which data collected can be analyzed numerically and interpreted in tabular, graphical, and statistical forms. However, this method is often used to process large amounts of data and is important for obtaining highly reliable results. The data collected in this manner must be valid and reliable for analysis to generate new insights into this research area.

Quantitative research is typically conducted by distributing closed-ended questionnaires to respondents by hand or email. A written survey can clearly illustrate the expected relationship, describe future hypotheses, and explain why it is useful for the research. Researchers deductively use the literature in a particular model as a framework for investigating the need for research or the speculation of research outcomes. The way to determine hypotheses that fulfill the requirements of intelligence research is through the literature. To obtain quantitative data for this study, a set of related questions was carefully prepared and distributed to construction professionals and experts in the Malaysian construction industry, especially in Penang, Malaysia.

Data collection is the key to this research process. Using a survey method to collect data is one strategy for obtaining knowledge of certain aspects of the perceptions of a phenomenon (Taylor et al., 2016). The purpose of the survey was to highlight the safety factors that influence the understanding of certain situations. It operates for three main purposes: descriptive, interpretive, and conceptual. Researchers must pay attention to obtaining accurate data from respondents to achieve their research goals and objectives. After the research questions and objectives have been identified and the study design determined, the data collection process begins (Kothari, 2004). According to Kothari (2004), there are two types of data: primary and auxiliary. For the first time, the primary data were collected directly from the respondents, whereas the secondary data were the data that had been collected, analyzed, and statistically processed in previous studies.

In this study, a quantitative research method was adopted and used as a tool for data collection; therefore, the main element of the primary data was through the distribution of survey questionnaires. The wording of the questionnaire was simplified for clarity. If there are subjective issues, there should be enough space in the questionnaire to prevent respondents from restricting their opinions. The questionnaire should include the intent of the questionnaire, and the definitions of unfamiliar terms should be provided in explanatory notes to avoid respondents misunderstanding the questions. The questionnaire for this study comprises three sections: A, B, and C. Section A is about the respondent's profile, which includes the company, position of respondents, duration of time the respondent has worked in the construction field, the number of projects that the respondent was involved in, and the size of the projects the respondent was involved in. Section B concerns the perception of critical attitudes and behaviors of construction workers to avoid accidents at construction sites. A Likert scale was used in the questionnaire for respondents' critical ratings based on their perceptions. It ranges from "1" for the "least critical" to "5" for the "most critical" attitudes of construction workers toward safety to avoid accidents at the construction site. Section C solicited respondents' perceptions of construction workers' critical behaviors regarding their safety to avoid accidents at construction sites.

This pilot study played an important role in the methodology used in the present study. The trial questionnaire was used for the pilot survey before the full-scale data solicitation from the respondents. The questionnaire was completed before distribution. Chua (2016) stated that a pilot survey is a small-scale preliminary survey to test the possibility of a well-prepared questionnaire before conducting the final survey. Approximately 30 sets of trial questionnaires were distributed and collected for the pilot survey to determine their reliability and validity. The main reason for conducting the pilot survey was to check the wording, terminology, and appropriateness of the questionnaire to ensure that the correct meaning of the questionnaire was communicated to target respondents to avoid any misunderstanding of the questionnaire (Kumar et al., 2012). In addition, the pilot survey can be used to monitor the order of questions and ensure that questions are asked appropriately so that respondents can answer them properly. The pilot survey can also help determine whether other questions need to be listed as proprietary data in the questionnaire. The results of this preliminary study are important and should be considered when formulating a questionnaire for full-scale surveys. Trial questionnaires were printed and distributed to construction professionals and consultants in the selected research area in Penang, Malaysia (Figure 2). Targeted respondents included project architects, project engineers, project quantity surveyors, safety and health officers, site safety supervisors, project managers, project directors, and site supervisors. The respondents were required to complete questionnaires and provide their comments, if any. As previously mentioned, 30 sets of trial questionnaires were printed and distributed to solicit responses from respondents during the pilot survey.

The research area included construction professionals working at consultant companies and construction sites in Penang, Malaysia. The respondents included construction professionals and consultants such as project architects, project engineers, project quantity surveyors, safety and health officers, site safety supervisors, construction project managers, project directors, and site supervisors.

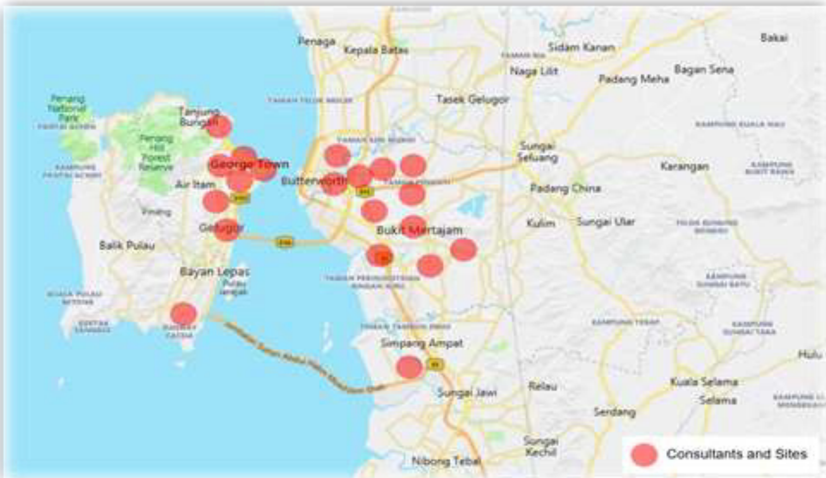

Figure 4 Consultant Companies and Construction Sites in Penang, Malaysia

Statistics from the DOSH show that there were 275 work-related accidents, of which 72 accidents resulted in death, 13 in permanent disability, and 13 in non-permanent disability (DOSH, 2023). In this study, approximately 130 respondents (50%) were taken as the sample size. A total of 130 sets of questionnaires were distributed, with the aim of receiving at least 80% of the distributed questionnaires. To ensure a good collection of the answered questionnaires, the questionnaires were delivered by hand and mail.

Table 1 Results of the Pilot Survey

Construction Professionals	Unsatisfied	Satisfied	Very Satisfied	Commented	Total
Project Architects	-	2	-	-	2
Project Engineers	-	4	2	2	6
Project Quantity Surveyors	-	4	2	2	6
Safety and Health Officers (SHO)	-	1	-	1	1
Site Safety Supervisors (SSS)	-	2	-	-	2
Project Managers	-	2	-	-	2
Project Directors	-	2	-	-	2
Site Supervisors	-	-	3	-	3
Total (Nos.)	0 (0%)	17 (71%)	7 (29%)	5 (21%)	24 (100%)

Table 1 shows the Relative Importance Index (RII), which was adopted to determine the relative importance of relativity toward the safety attitudes and behaviors of construction workers, as perceived by construction professionals (Doloi et al., 2012). The RII formula given by Tam et al. (2006) is as follows:

$$RII = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N}$$

$$(0 \leq \text{RII} \leq 1)$$

where N is the total number of respondents and 5 is the highest weighted score (5,4,3,2,1),

n_1= number of respondents (most critical)

n_2= number of respondents (more critical)

n_3= number of respondents (critical)

n_4= number of respondents (less critical)

n_5= number of respondents (least critical).

4.0 RESULTS AND DISCUSSION

Table 2 Respondents' Profile

Demographic	Frequency (n)	Percentage (%)
Position		
Project Architect	5	5.16%
Project Engineer	13	13.40%
Project Quantity Surveyor	33	34.02%
Safety and Health Officer (SHO)	4	4.12%
Site Safety Supervisor (SSS)	11	11.34%
Project Manager	13	13.40%
Project Director	7	7.22%
Site Supervisor	11	11.34%
Total	97	100%
How long have you been working in the construction field?		
1 – 5 years	13	13.40%
6 – 10 years	27	27.84%
11 – 20 years	24	24.74%
More than 20 years	33	34.02%
Total	97	100%
How many projects have you been involved in so far?		
1 – 5 projects	13	13.40%
6 – 10 projects	29	29.90%
11 – 15 projects	33	34.02%
More than 15 projects	22	22.68%
Total	97	100%
What is the type of project that you are currently involved with?		
Commercial Projects	27	27.84%
Residential Projects	26	26.80%
Mixed Development Projects	9	9.28%
Infrastructure Projects	35	36.08%
Total	97	100%
What is the size of the projects that you are currently involved with?		
Less than 10 million	18	18.56%
10 million – 50 million	28	28.87%
50 million – 100 million	40	41.24%
100 million – 500 million	11	11.34%
500 million – 1 billion	-	-
More than 1 billion	-	-
Total	97	100%
Have you ever heard of the safety attitudes and safety behaviors of construction workers?		
Yes	84	86.60%
No	13	13.40%
Total	97	100%
When you handle projects do you practice safety attitudes and safety behaviors?		
Yes	64	65.98%
No	33	34.02%
Total	97	100%

Table 2 shows the profiles of the respondents who participated in the pilot and final surveys and their experiences and practices in handling construction projects.

Table 3 Ranking of Critical Attitudes of Construction Workers

1 = Least Critical; 2 = Less Critical; 3 = neutral; 4 = More Critical; and 5 = Most Critical.

Critical Attitudes	Level of Criticality					Relative Importance / Comparative Significance	
n_{1-5}	n5	n4	n3	n2	n1		
Likert Scale	1	2	3	4	5		
	Frequency (n)					RII	Rank
Performs Tasks Carefully and Cautiously	2	15	26	33	21	0.72	2
Thinks of Consequences and Does Not Take Risk	4	18	27	34	14	0.67	5
Maintains Positive Emotions and Thinking	2	15	33	30	17	0.69	4
Positive Communication	2	16	22	33	24	0.73	1
Keeps a Low Profile	2	16	27	33	19	0.71	3

Table 4 Critical Attitudes of Construction Workers

Critical Attitudes	Relative Importance Index (RII)	Order of Criticality (Rank)
Positive communication	0.73	1
Performs the tasks carefully and cautiously	0.72	2
Keeps a low profile	0.71	3
Maintains positive emotion and thinking	0.69	4
Thinks of the consequences and avoid taking risks	0.67	5

Table 3 shows the most and least critical attitudes of the construction workers toward site safety. Based on Table 4, this study shows that positive communication (RII 0.7258) between construction workers is the most critical attitude for minimizing the occurrence of accidents on site. Positive communication must be two-way, which means that there must be elements of sending and receiving. SHO and SSS must always be vigilant when on site. If an accident occurs on a construction site, the construction workers must immediately inform the safety personnel. If safety personnel have predicted any actions that could harm construction workers, they must take preventive measures to prevent undesirable events from occurring.

Table 5 Ranking of Critical Behaviors of Construction Workers

1 = Least Critical; 2 = Less Critical; 3 = neutral; 4 = More Critical; and 5 = Most Critical.

Critical Behaviors	Level of Criticality						Relative Importance / Comparative Significance	
	n_{1-5}	n5	n4	n3	n2	n1		
	Likert Scale	1	2	3	4	5		
		Frequency (n)					RII	Rank
Follows Correct Working Procedure and Method		-	11	24	44	18	0.74	3
Wears Personal Protective Equipment (PPE)		2	7	31	45	12	0.72	5
Compliance of Construction Workers		-	11	28	37	21	0.74	4
Proper Housekeeping		-	7	29	33	28	0.77	2
Access to Heights and Working Platforms in a Correct Way		-	6	27	36	28	0.78	1

Table 6 Critical Behaviors of Construction Workers

Critical Behaviors	Relative Importance Index (RII)	Order of Criticality (Rank)
Access to Heights and Working Platforms in a Correct Way	0.78	1
Proper Housekeeping	0.77	2
Following The Correct Working Procedures and Methods	0.74	3
Compliance of Construction Workers with Safety Rules and Regulations	0.74	4
Wearing Personal Protective Equipment (PPE)	0.72	5

4.1 Critical Attitudes of Construction Workers

Based on Table 4, this study shows that positive communication (RII 0.7258) between construction workers is the most critical attitude to minimize the occurrence of accidents on site. Positive communication must be two-way, which means that there must be elements of sending and receiving. SHO and SSS must always be vigilant when on site. If an accident occurs on a construction site, construction workers must immediately inform safety personnel. If safety personnel can predict actions that could harm construction workers, they must take preventive measures to prevent undesirable events from occurring.

4.2 Critical Behaviors of Construction Workers

According to Table 6, correct access to heights and working platforms, with a relative importance index value of 0.7773, is the most critical behavior of construction workers in minimizing and preventing the occurrence of accidents. It is also the most dangerous action compared to other critical safety behaviors, which is why it is considered the most critical behavior of construction workers on construction sites.

4.3 Critical Attitudes that Affect Critical Behaviors

Effective communication with construction workers is therefore essential. For example, if construction workers want to reach the height of a building structure, they should help each other to observe the surroundings and inform each other if one of them sees an action that could be harmful to the other. In addition, construction workers should practice good housekeeping on the construction sites. To minimize the likelihood of injury, workers must be very careful and cautious in performing housekeeping. Being cautious means that construction workers must follow correct working procedures and methods and adhere to good safety practices, norms, laws, and regulations. Construction workers must maintain a positive attitude when performing their tasks and adhere to safety legislation, especially the Occupational Safety and Health Act of 1994 (as amended in 2020) and the safety rules and regulations published and enforced by DOSH.

Good housekeeping makes it easier for the site or project manager to manage safety and minimizes the risk of accidents. However, careful construction workers may be less likely to have accidents than other workers who are careless in their construction activities. The health and safety manager should always remind the construction workers to adhere to safety procedures and provide adequate advice to their workers, and the construction workers should consider the consequences and risks when performing their jobs. No construction worker should ignore the use of PPE. This study provides insights for construction professionals, especially site managers, health and safety representatives, site safety supervisors, and consultants, in planning the safety of construction workers on construction sites. Proper planning of safety measures for construction work will minimize the occurrence of accidents on construction sites.

5.0 CONCLUSION

This study reveals the most and least critical attitudes of construction workers toward safety on site. First, this study shows that communication among construction workers is the most critical attitude toward safety in order to minimize the occurrence of accidents on site. Critically, communication must be two-way, which means that there must be elements of both sending and receiving. In general, one person must provide the correct instructions or orders. Subsequently, another person who is given the instruction or order must receive and acknowledge it to create clear communication. Therefore, safety professionals, such as SHO and SSS, must always be on duty on construction sites and put effort into observation. When accidents occur on site, construction workers must immediately inform safety personnel to prevent and minimize risks and damage. However, safety personnel predict actions that may harm construction workers. Safety personnel must implement preventive measures to prevent unwanted events. Communication is therefore the most critical safety attitude. The study also identified the most and least critical behaviors of the construction workers in terms of safety on site, with "Access to Heights and Working Platforms in Correct Way" being identified as the most critical behavior of construction workers in terms of minimizing and preventing accidents. In terms of the likelihood of accidents occurring, if the construction workers did not follow the correct and appropriate way to access heights, working platforms had the highest likelihood of accidents, as it is the most dangerous behavior compared to other safety behaviors. Hence, it is also the most hazardous action compared to other safety behaviors. This is why it is the most critical behavior of the workers on the site compared to other critical behaviors, as mentioned above. High-frequency communication is therefore essential for teams. For example, if team members are going to access a height, they should help each other observe the surroundings and inform each other if one of them spots a hazard that could be harmful to another. Additionally, construction workers need to do their housekeeping before leaving the construction sites.

To minimize the likelihood of injury, workers must be very careful and cautious when performing housekeeping tasks. Good housekeeping makes it easier for site or project managers to perform their management duties more easily, thereby minimizing the risk of accidents will be minimized. However, construction workers who keep a low profile are less likely to have accidents than other workers who are more likely to show off. To maintain a low profile, construction workers must follow the correct work procedures and methods; that is, they must follow the method statement prepared by the construction project manager or site supervisor. Construction workers must maintain positive emotions while performing their duties by following the safety rules and regulations published by DOSH, particularly the Occupational Safety and Health Act of 1994. In addition to OSHA 1994, safety and health plans should be prepared by the SHO so that construction workers can comply with safety measures. SHO should always remind construction workers of safety precautions and provide adequate counseling to their workers.

This study has some limitations. One limitation is the sample size of the study, which may not have captured the diversity and range of perspectives among construction professionals. Future studies should aim for larger and more diverse samples to ensure the representativeness and generalizability of the findings. Data collected through self-report measures may be subject to biases such as social desirability or recall bias. Future studies could consider incorporating multiple data collection methods, such as direct observation or interviews, to complement self-report measures and provide a more comprehensive understanding of safety attitudes and behaviors. Many studies on the perceptions of construction professionals have relied on cross-sectional designs, which limit their ability to establish causal relationships or capture changes over time. Longitudinal studies or experimental designs could be used in future research to examine the temporal dynamics of safety attitudes and behaviors, and to assess the effectiveness of interventions or training programs. Some studies have focused on specific construction sites or geographical locations, which limits the generalizability of the findings. Future studies should aim to include multiple sites or locations to capture variations in safety attitudes and behaviors across different contexts.

In addition to these limitations, there are some recommendations for future research. Future studies should adopt mixed methods approach, combining quantitative and qualitative methods. This would provide a more comprehensive understanding of the factors influencing safety attitudes and behaviors and allow for a deeper exploration of the underlying reasons for the perceptions of construction professionals. Conducting comparative studies between different regions or countries could provide insights into the influence of cultural, regulatory, and organizational factors on safety attitudes and behaviors. Comparisons can also be made between different types of construction projects (e.g., residential vs. commercial) or different roles within the construction industry (e.g., project managers vs. site supervisors). Future studies should place more emphasis on exploring the organizational factors that shape safety attitudes and behaviors, such as leadership styles, organizational culture, and safety management practices. This would provide valuable insights for the development of interventions and strategies aimed at improving safety at the organizational level. It is essential to investigate the long-term effects of safety interventions and programs on the attitudes and behaviors of construction professionals. Future research should investigate the sustainability and durability of changes in safety attitudes and behaviors over time to assess the long-term impact of interventions. Including multiple stakeholders, including workers, subcontractors, clients, and regulators, in future studies will provide a more complete understanding of the dynamics and interactions that influence safety attitudes and behaviors. This can help identify areas of alignment or potential conflict, and inform strategies for improving safety practices through collaborative efforts. By addressing these limitations and making recommendations for future studies, researchers can improve the rigor, depth, and applicability of findings related to construction professionals' perceptions of the safety attitudes and behaviors of construction workers on construction sites.

REFERENCES

I. Ajzen and M. Fishbein. 1994. The Influence of Attitudes on Behavior. University of Massachusetts – Amherst.

B.J.M. Ale, H. Baksteen, L.J. Bellamy, A. Bloemhof, L. Goossens, A. Hale, M.L. Mud, J.I.H. Oh, I.A. Papazoglou, J. Post, J.Y. Whiston. 2008. Quantifying occupational risk: The development of an occupational risk model. Safety Science 46 (2): 176-185.

K.P. Cigularov, P.Y. Chen, and J. Rosecrance. 2010. The effects of error management climate and safety communication on safety: A multi-level study. Accident; Analysis and Prevention 42 (5): 1498-1506.

F.C. Curtis Breslin, J. Polzer, E. MacEachen, B. Morrongiello, H. Shannon. 2007. Workplace injury or "part of the job"?: Towards a gendered understanding of injuries and complaints among young workers. Social Science and Medicine 64 (4): 782-793.

Danial. 2019. SOCSO data shows increase in construction accidents and deaths in 2018 (Online). A Job Thing. Available at: https://www.ajobthing.com/blog/socso-data-shows-increase-in-construction-accidents-and-deaths-in-2018 (Accessed 11 March 2020).

V. Davis and K. Tomasin. 1990. Construction Site Safety. Internal Publication, Thomas Telford, London.

Department of Safety and Health (DOSH). 2023. Fatal accident cases. Available at: https://www.dosh.gov.my/index.php/component/content/article/352-osh-info/accident-case/955-accident-case.

Department of Safety and Health (DOSH). 2023. Personal protective equipment (PPE). Available at: https://www.dosh.gov.my/index.php/services/enforcement/approval-and-authorisation/personal-protective-equipment-ppe.

I. Donald and D. Canter. 1993. Attitudes to safety: Psychological factors and the accident plateau. Health & Safety Information Bulletin 215: 5-8.

A.H. Eagly and S. Chaiken. 1993. The Psychology of Attitudes. Harcourt Brace Jovanovich, Orlando, FL.

D. Fang, Y. Chen, and L. Wong. 2006. Safety climate in construction industry: A case study in Hong Kong. Journal of Construction Engineering and Management 132 (6): 573-584.

A. Gibb, S. Hide, R. Haslam, D. Gyi, T. Pavitt, S. Atkinson, and R. Duff. 2005. Construction tools and equipment – Their influence on accident causality. Journal of Engineering, Design and Technology 3 (1): 12-23.

A.I. Glendon and D.K. Litherland. 2001. Safety climate factors, group differences and safety behaviour in road construction. Safety Science 39 (3): 157-188.

E. Goh and M. Loosemore. 2017. The impacts of industrialization on construction subcontractors: A resource based view. Construction Management and Economics 35 (5): 288-304.

K.C. Goh, H.H. Goh, M.F. Omar, T.C. Toh, and A.A.M. Mohd Zin. 2016. Accidents preventive practice for high-rise construction. In MATEC Web of Conferences. EDP Sciences 47.

B.H.W. Guo, T.W. Yiu, and V.A. González. 2015. Predicting Safety Behaviour in the Construction Industry: Development and Test of an Integrative Model.

Z. Hassan and R. Rahim. 2019. The relationship between supervisor safety, safety management practices, and safety compliance behaviour among employees. Sains Humanika 11 (2-2): (2-2).

J.W. Hinze. 1997. Construction Safety. Prentice Hall, Inc., NJ.

D. Iacuone. 2005. 'Real Men Are Tough Guys': Hegemonic masculinity and safety in the construction industry. The Journal of Men's Studies 13 (2): 247-266.

S.E. Johnson. 2007. The predictive validity of safety climate. Journal of Safety Research 38 (5): 511-521.

V. Kaskutas, A.M. Dale, H. Lipscomb, and B. Evanoff. 2013. Fall prevention and safety communication training for foremen: Report of a pilot project designed to improve residential construction safety. Journal of Safety Research 44: 111-118.

L. Kolman and P. Rymešová. 2007. Attitudes to Work and Organization as a Part of a Competency Model. Czech University of Life Sciences, Prague, Czech Republic.

D.N. Kolo. 2015. Safety Issues Involving Workers on Building Construction Sites in Nigeria: An Abuja Study. Institute of Graduate Studies and Research.

C.R. Kothari. 2004. Research Methodology: Methods and Techniques. 2nd edition. New Age International Publishers, New Delhi.

T.R. Krause. 1997. The Behavior-Based Safety Process: Managing Involvement for an Injury-Free Culture. Van Nostrand Reinhold, New York.

M. Kumar, S.A. Talib, and T. Ramayah. 2012. Business Research Methods.

H. Lingard and N. Holmes. 2001. Understandings of occupational health and safety risk control in small business construction firms: Barriers to implementing technological controls. Construction Management and Economics 19 (2): 217-226.

H. Lingard and S. Rowlinson. 1997. Behavior-Based Safety Management in Hong Kong's Construction Industry. National Safety Council and Elsevier Science.

H. Lingard and S.M. Rowlinson. 2005. Occupational Health and Safety in Construction Project Management. Taylor & Francis, UK.

H. Lingard and Z. Yesilyurt. 2003. The effect of attitudes on the occupational safety actions of Australian construction workers: The results of a field study. Journal of Construction Research 04 (1): 59-69.

H. Lubega, B.M. Kiggundu, and D. Tindiwensi. 2000. An Investigation into the Causes of Accidents in the Construction Industry in Uganda. Challenges Facing the Construction Industry in Developing Countries.

R. Mahmood, M.F.Mohd. Isa, M. Mustafa, F.S. Abd Aziz, and A. Salleh. 2010. Safety Behaviour: The Role of Safety Commitment. College of Business, UUM.

S.S. Man, A.H.S. Chan, and H.M. Wong. 2017. Risk-taking behaviors of Hong Kong construction workers – A thematic study. Safety Science 98: 25-36.

J.H. Michael, Z.G. Guo, J.K. Wiedenbeck, and C.D. Ray. 2006. Production supervisor impacts on subordinates' safety outcomes: An investigation of leader-member exchange and safety communication. Journal of Safety Research 37 (5): 469-477.

E.A. Nadhim, C. Hon, B. Xia, I. Stewart, and D. Fang. 2016. Falls from height in the construction industry: A critical review of the scientific literature. International Journal of Environmental Research and Public Health 13 (7): 638.

I. Newman and C.R. Benz. 1998. Qualitative-Quantitative Research Methodology: Exploring the Interactive Continuum. University of Illinois Press, Carbondale.

T.T. Nguyen, P. Manu, A.M. Mahamadu, and S. Ash. 2015. Inquiry into the health and safety management practices of contractors in Vietnam: Preliminary findings. In CIB W099 Belfast, pp. 280-289. EEI Publishing.

A. Rahim and A. Hamid. 2008. Causes of accidents at construction sites. Malaysian Journal of Civil Engineering 20 (2): 242-259.

E. Sawacha, S. Naoum, and D. Fong. 1999. Factors affecting safety performance on construction sites. International Journal of Project Management 17 (5): 309-315.

P.F. Secord and C.W. Backman. 1969. Social Psychology. McGraw-Hill, New York.

H.C. Seo, Y.S. Lee, J.J. Kim, and N.Y. Jee. 2015. Analyzing safety behaviors of temporary construction workers using structural equation modeling. Safety Science 77: 160-168.

O.L. Siu, D.R. Phillips, and T.W. Leung. 2003. Age differences in safety attitudes and safety performance in Hong Kong construction workers. Journal of Safety Research 34 (2): 199-205.

The Star. 2019. SOCSO data shows rise in construction accidents and deaths last year (Online). The Star Online. Available at: https://www.thestar.com.my/news/nation/2019/01/21/socso-data-shows-rise-in-contruction-accidents-and-deaths-last-year/ (Accessed 11 March 2020).

S.J. Taylor, R. Bogdan, and M.L. DeVault. 2016. Introduction to Qualitative Research Methods: A Guidebook and Resource. 4th edition.

H.C. Triandis. 1980. Values, attitudes, and interpersonal behavior. In Nebraska Symposium on Motivation. Nebraska Symposium on Motivation 1979 H. E. Howe & M. M. Page (Eds.). University of Nebraska Press, Lincoln 27: (195-259).

T. Vijayakumar. 2007. Achieve Total Safety Culture through Behaviour Based Safety, Proceeding of the 10th Conference and Exhibition of National Institute of Occupational Safety and Health (NIOSH). Malaysia, pp. 303-313.

D.M. Wiegand and E.S. Geller. 2005. Connecting positive psychology and organizational behavior management: Achievement motivation and the power of positive reinforcement. Journal of Organizational Behavior Management 24 (1-2): 3-25.

S.S. Yeong and S.R.A. Wahab. 2016. The mediating effect of safety culture on safety communication and human factor accident at the workplace. Asian Social Science 12 (12): 127-141.

Z. Zakaria, Z.H. Hussin, N. Noordin, and Z. Zakaria. 2010. Accidents at the construction site in northern area: Malaysia experienced. Management Science and Engineering 4 (3): 106-116.

S.M. Zin and F. Ismail. 2012. Employers' behavioural safety compliance factors toward occupational, safety and health improvement in the construction industry. Procedia – Social and Behavioral Sciences 36: 742-751.

Original Article

Capturing Prevention through Design Practices through the Lens of Industry Practitioners' Experiences in Occupational Safety and Health in Construction Industry Management Projects

Che Khairil Izam Che Ibrahim,[a,*] Sheila Belayutham,[a] Mazlina Zaira Mohammad,[a] Shafienaz Ismail[a]

[a] *Faculty of Civil Engineering, Universiti Teknologi MARA, 40450, Shah Alam, Selangor, Malaysia*

[*]Corresponding author: chekhairil449@uitm.edu.my

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ABSTRACT: *Prevention through Design (PtD) is an innovative concept that aims to transform the currently fragmented health and safety practices into a consolidated approach by designing out hazards and risks in the early design phases of a construction project. As PtD has gained attention in the Malaysian construction industry through the recent introduction of the Occupational Safety and Health in Construction Industry (Management) (OSHCIM) guideline in 2017, having in-depth knowledge of PtD practices to fulfill OSHCIM requirements in construction is imperative. This study explores the knowledge and skills involved in practicing PtD through the lenses of practitioners with experience in the pilot OSHCIM projects. Data were collected qualitatively through two series of online focus group sessions conducted with experienced OSHCIM practitioners. The findings indicate that PtD practices could be a game changer for designers, especially in safety and health practices. However, PtD-related tacit and explicit knowledge, as well as PtD-related technical and collaborative skills among designers, need to be enhanced to fulfill designers' duties, as stipulated in the OSHCIM. The findings also indicate that such pilot OSHCIM projects could act as a practical platform of best practices and lessons learned, which can be shared with the wider construction community to close the 'knowledge gap' regarding PtD practices. Subsequently, this study provides insight into the necessary knowledge and skills required for PtD diffusion, mitigating possible concerns among designers regarding OSHCIM implementation, where a new normal of practice is required when OSHCIM is mandated in the future.*

Keywords: *Construction, Prevention through Design (PtD), Safe Design.*

1. INTRODUCTION

Accidents and fatalities are well-recognized in construction worldwide. Similar to other developing countries, Malaysia's construction industry is one of the most dangerous industries, with the highest death rate compared to other industries. In 2019, the Malaysian construction sector recorded 84 fatalities, 15 permanent disabilities, and 227 non-permanent disabilities (Department of Occupational Safety and Health (DOSH), 2020). The rising accident rate in the Malaysian construction industry has led the Ministry of Human Resources, through the DOSH, to introduce a new initiative: integrating the prevention through design (PtD) concept into the existing occupational safety and health (OSH) and risk management. The guidelines on Occupational Safety and Health in the Construction Industry (OSHCIM) were launched in 2017, and they emphasize the need to anticipate and 'design out' risks and hazards (in tools, equipment, processes, materials, and structures) at the early design stages in construction projects.

It is worth highlighting that the OSHCIM was developed based on Construction Design and Management (CDM) in the United Kingdom, and this concept has been widely accepted in other countries under specific legislative frameworks. For instance, PtD has been mandated under the CDM regulations 2015 in the UK, the Model Work Health and Safety Act 2011 in Australia, the Health and Safety at Work Act 2015 in New Zealand, and the Workplace Safety and Health Regulations 2015 in Singapore. By contrast, countries such as the United States and Hong Kong have voluntarily been driving this concept.

Considering that the influence of PtD-related legislation in reducing accident occurrence is significant (Toole and Gambatese, 2008; Gambatese et al., 2017), and considering the influence of OSHCIM in OSH management, an investigation into PtD practices in Malaysia is timely and significant. Efforts to understand the current state of OSHCIM practice cannot be overlooked, as they could assist in providing practical insights that could facilitate the progress of OSHCIM practice among construction organizations. As part of a wider study to understand PtD competencies, this study aims to explore the knowledge and skills involved in practicing PtD through the lens of practitioners with experience in pilot OSHCIM projects. The role of a designer or organization (those who have design responsibilities) in PtD practice is crucial, as they are expected to produce inherently safer designs for the lifecycle of a project and, at the same time, fulfill their ethical duty to the safety and health of human beings (Manu et al., 2019).

2. THE RECENT PTD STUDIES IN THE CONSTRUCTION DOMAIN

A growing number of studies have been conducted in recent years on PtD-related issues during construction. However, the intention here is not to review the broader PtD literature but to concentrate on recent PtD-related research (over the past three years) in construction. The Scopus database was selected as an appropriate search platform because it has the largest database, is comprehensive, and has wider coverage (Yi and Yang, 2014). Scopus has also been used in many construction studies focusing on various areas (e.g., OSH, digital, collaboration, and project management) (Che Ibrahim et al., 2020).

The search was performed in December 2019 and covered articles published from 2018 to 2020. The complete keywords used for this search were "prevention through design," "safety by design," "construction design management," "design for safety," "safety in design," "design risk management," and "construction." The initial search returned 61 papers which was reduced to 41 papers (due to duplications and conference proceedings) screening. To discover the patterns of recent studies, we split the timeframe of the selected articles into three sub-periods (See Table 1) and summarized each study based on year of publication.

Table 1. Snapshots of Recent PtD-Related Studies in Construction Domain

Key features / Year	2018	2019	2020
No. of relevant articles	8	16	17
Main Topic	Application in infrastructure projects, Integration of BIM, Implementation factors	Organizational Capability, BIM, Serious gaming	Digital Tool, Education, Organizational Capability, BIM, KAP, Hazard recognition, Communication
Context of Study	Review, Process, Perception, Project	Review, Simulation, Perception, Conceptual	Review, Automation, Competency, Perception
Terminology	DfS, PtD	PtD, CDM	CDM, PtD, DfS, DfOSH
Methodological Framework	Desk Study, Case study, Survey, Interview	Desk Study, Case Study, Survey, Interview	Desk Study, Case study, Survey, Interview, Observation
Geographical Setting	Ghana, Singapore, China, US, Korea, Italy	UK, US, Nigeria,	UK, US, Malaysia, Palestine, Australia, China

KAP, Knowledge, attitude, and practices; BIM, Building Information Modeling

In 2018, PtD-related literature on construction emerged within the context of establishing a clear application in certain types of projects, such as tunnels and subways. Building Information Modeling (BIM) also gained attention from scholars during this period. Qualitative and quantitative methodological frameworks were used during this period. Studies in this period mainly focused on developed countries, such as the US, China, Korea, Italy, and the UK. In 2019, studies on PtD focused primarily on organizational capability and education. Interest in PtD and BIM activities continued to increase during this period. While studies focused mainly on the UK and the US, PtD studies started to grow to developing countries such as Nigeria. In the year 2020, research expanded to include more focused multidimensional PtD topics such as hazard recognition, communication, and the development of PtD tools. Further, studies adopted more qualitative methodologies. This period also saw an increase in studies conducted in developing countries, such as Malaysia and Palestine.

Overall, despite the continued growth in the PtD literature, studies in developing countries are still limited. In particular, in Malaysia, where PtD practice is still in its infancy owing to the quite recent implementation of OSHCIM, more studies need to be conducted to expand PtD knowledge in the context of construction.

3.0 METHOD

This study adopted a pragmatic methodological approach using a qualitative methodology, particularly online focus group (FG) discussions. Given the coronavirus disease 2019 (COVID-19) pandemic and the enforcement of the Enhanced Movement Control Order during the study, conducting discussions online approach was the best option. Two online FG sessions were conducted (See Table 2) to discuss key PtD competency attributes.

As this study necessitated the need for information-rich participants (i.e., practitioners with experience in PtD-related practice), a purposive sampling strategy was used to select the participants. Thus, participants were selected through recommendations from the DOSH. In particular, those who were involved in OSHCIM pilot projects were invited. As PtD is a relatively new practice in Malaysia, including participants with experience in OSHCIM activities is crucial for enabling more conclusive and genuine feedback on designers' capabilities to engage in PtD practices.

Table 2. PtD Focus Group Session

Meeting	Date	Type of Organization	No. of Participant	Designation	Online Platform
FG Discussion	April 2020	Regulatory Body Technical agency Developer Consultant/Contractor	18	Civil & Structural Mechanical & Electrical Quantity Surveyor Architect Safety & Health Officer	Google Meets
FG Discussion	May 2020	Regulatory Body Developer Consultant Contractor	8	Civil & Structural Mechanical & Electrical Quantity Surveyor Architect Safety & Health Officer	Microsoft Teams

A total of 26 industry professionals (73.1% (19 male) and 26.9% (7 female)) with an average of 15 years of experience in the construction industry participated in the two FG sessions. The participants included nine architects (34.6%), seven safety and health architects (26.9%), four civil, structural, mechanical, and electrical architects (15.4%), and two quantity surveyors (7.7%). The majority of respondents were registered professionals from various professional bodies. The respondents' demographic details are shown in Table 3.

Four researchers facilitated the FG sessions. The FG interviews lasted for an average of two hours. The sessions were conducted mainly in English to ensure that accurate contextual meaning was captured during data collection and to avoid problems with interpretation during the analysis. In addition, all discussions were digitally recorded (with permission from the participants) using the features provided in the videoconferencing applications (i.e., Google Meets and Microsoft Teams).

Table 3. Summary of Respondents' Demographics

Demographic Profile	Respondent characteristics	No. of respondents (N = 26)	%
Disciplines	Civil & Structural	4	15.4
	Architect	9	34.6
	Mechanical & Electrical	4	15.4
	Quantity Surveyor	2	7.7
	Safety & Health	7	26.9
Organization	Government Agencies	10	38.5
	Developer/Owner	9	34.6
	Consultant	4	15.4
	Contractor	3	11.5
Academic Qualification	Degree	11	42.3
	Master	13	50.0
	PhD	1	3.85
	Others	1	3.85
Professional Qualification	Engineer (Ir.)	5	19.2
	Architect (Ar.)	5	19.2
	Technologist (Ts.)	1	3.85
	Certified Safety and Health Officer	7	26.9
Years of Experience	Between 10 and 15	15	57.7
	Between 16 and 20	5	19.2
	More than 20	6	23.1

Practitioners were introduced to the PtD competency attributes identified in the initial work of this project (See Che Ibrahim et al., 2020). Next, these attributes were discussed in detail in relation to participants' experience in OSHCIM projects. The focused discussion also enabled the research team to explore an in-depth understanding of the context of these attributes (e.g., adequacy, practicality, and relevance) of PtD practice. To analyze the qualitative data, initial coding was carried out by considering the descriptive terminologies used by interviewees during the FG discussions. Then, thematic analysis was conducted using a structured coding scheme to relate the attributes of PtD competencies.

4.0 RESULTS AND ANALYSIS

This section presents the data extracted from the FG discussion. The insights reached were synthesized and integrated into a descriptive structure comprising three main competencies attributes: knowledge, skills, and experience. Table 4 presents an example of quotation classification based on the coding scheme.

Table 4 Sample of Comments Based on the Coding Scheme

Quotation	Source	Theme Context	Theme Category
"Designers need to have a full cycle of experience, from design until the maintenance, to have more knowledge on PtD"	Project Manager	Construction Design feature Management concepts Managing contract document Dynamic of the design process & construction practice	Knowledge Experience
"Designers need to have a specific level of experience in handling projects"	Consultant	Design	Experience
"Experience in construction could help designers visualize potential safety risks"	Consultant	Construction practice	Experience
"The use of project delivery influences the way teams work on PtD practice, with a traditional approach, we don't have contractor input at the beginning, we rely on the experience of designers to prepare and do the hazard analysis"	Safety and Health Officer	Project Delivery Experience Hazard recognition Skills	Knowledge, Skills, Experience
"Designers should receive early education as traditionally all OSH activities are done by contractors"	Safety and Health Officer	Early education	Knowledge Experience
"Designers have to understand the relevant guidelines as they needs to ensure compliance with all relevant requirements at the beginning stage of the design"	Consultant	OSH and PtD-related regulations / guidelines	Knowledge
"OSHCIM practice is not one or two weeks' work, it's throughout and after the project. Financial implications should be seriously considered"	Project Manager	Financial / Cost Benefits analysis	Skills
"We normally think about the construction costs, but we believe having some kind of cost-benefit analysis that can be geared toward upfront costs rather than later costs would be extremely useful"	Cost Manager	Financial / Cost Benefits analysis	Skills

The FG discussions also highlighted the importance of being equipped with financial-related skills and knowledge to be able to exercise financial skills such as cost-benefit analysis, life cycle costing, and risk assessment, and therefore guide decision-making in the context of PtD adoption. Although cost is perceived as a major barrier among local practitioners (Che Ibrahim and Belayutham, 2020), evidence from this pilot project indicates that cost control can still be achieved despite the implementation of the PtD. The most important aspect is the ability to provide a quantitative rationale and the ability to provide alternative solutions that can provide cost savings over the life cycle of a project (particularly during maintenance). These skills could also help PtD practitioners track the costs and benefits of PtD interventions over time. This is supported by several studies (e.g., Dharmapalan et al., 2015), where construction activities may have an impact on a wide range of risks, resulting in uncertainty about the associated costs, and the ability to conduct such an analysis (e.g., cost of accident prevention) could facilitate our understanding of the economic impact of PtD.

Upon further observation, greater collaboration (e.g., in terms of co-location during the design phase, spending more time in the design phase, and developing trusting relationships) is also visible during the conduct of pilot projects. Project teams spend more time discussing the design regarding risk and hazard identification compared to traditional design exercises. As such, collaborative skills are crucial, as the integration of different forms of expertise in PtD contexts could create unique solutions that lead to innovation, thus achieving the goals and aims of a project (Gambatese et al., 2017). Overall, technical and collaborative skills are essential for designers who wish to implement PtD. By developing these skills, designers can help create safer, more cost-effective, and more sustainable construction projects.

4.3 Experience

As the pilot OSHCIM projects are the initial exercises by the DOSH to provide practitioners their first actual practical experience of PtD practice in Malaysia, practitioners are expected to have little experience on the conduct of PtD practice (in particular on risk analysis, OSH documentation, etc.) is expected. As highlighted in the FG discussions, design experience is not a significant issue; however, on-site experience is critical for designers to enhance their capabilities. It is worth noting that all the OSHCIM pilots are building-type projects; hence, the participants' experience is limited within this scope. Experience managing different types of projects (including infrastructure) could enhance the dynamism of designers' capabilities for dynamic design processes (e.g., the complexity of a project could lead to extensive design changes) (Larsen and Whyte, 2013).

While pilot projects offer a platform for collaboration and cooperation between designers and builders (to integrate constructability issues), the reality of the local construction industry is the opposite. The lack of collaborative procurement is cited as one of the main barriers for the industry in creating a collaborative environment. Another concern is the lack of advanced contract procurement to incorporate PtD practices. Experience in such an environment could encourage designers to work collaboratively (inter- and intra-organizationally), contributing to the expansion of their competence toward improving construction processes and safety performance (Manu et al., 2019).

The need for PtD experience in tertiary education is another topic that was discussed. As OSHCIM is set to be mandated in the coming years, there is a significant need to establish PtD knowledge during tertiary education. Such educational learning experiences could shape the interpersonal skills and mindsets of future designers toward design thinking and a preventive culture. Appropriately educated designers can ease the need to perform the required duties as stipulated in OSHCIM.

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5. CONCLUSIONS

Drawing from the "experience" of practitioners' involvement in OSHCIM pilot projects, it can be concluded that the need for PtD-related tacit and explicit knowledge, PtD-related technical and collaborative skills among construction stakeholders, and PtD-related experience are crucial to the fulfillment of designers' duties, as set out in OSHCIM. Although this study is only a snapshot of PtD competencies in the local context, the findings fill a 'knowledge gap' that the industry needs to enhance its competencies to facilitate the development of PtD activities.

This study was limited to the views of experienced OSHCIM practitioners regarding the three main attributes of PtD competencies. Consequently, the findings do not represent the views of the entire construction industry. Future efforts could focus more on the practical activities (e.g., design risk reviews, OSH documentation, and financial implications) involved in OSHCIM pilots as part of capturing the lessons learned and best practices to further enhance existing PtD guidance in the local construction industry.

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REFERENCES

Che Ibrahim, C.K.I., Manu, P., Belayutham, S., Mahamadu, A-M., & Antwi-Afari, M.F. (2022). Design for Safety (DfS) practice in construction engineering and management research: A review of current trends and future directions. *Journal of Building Engineering*, 15, 104352.

Che Ibrahim, C.K.I., & Belayutham, S. (2020). A Knowledge, Attitude and Practices (KAP) Study on Prevention through Design: A Dynamic Insight into Civil and Structural Engineers in Malaysia. *Architectural Engineering and Design Management*, *16*(2), 131-149.

Che Ibrahim, C.K.I., Belayutham, S., Manu, P., & Mahamadu, A-M. (2020). Key Attributes of Designers' Competency for Prevention through Design (PtD) Practices in Construction: A Review. *Engineering, Construction and Architectural Management, 28*(4), 908-933.

Dharmapalan, V., Gambatese, J.A., Fradella, J., & Vahed, A.M. (2015). Quantification and Assessment of Safety Risk in the Design of Multi-Storey Buildings. *Journal of Construction Engineering and Management*, *141*(4), 04014090.

Department Occupational Safety and Health (DOSH). (2020). Occupational Accidents Statistics. Available at: https://www.dosh.gov.my/index.php/statistic-v/occupational-accident-statistics (Accessed 8 September 2020).

Gambatese, J.A., Gibb, A.G., Brace, C., & Tymvios, N. (2017). Motivation for Prevention through Design: Experiential Perspectives and Practice, Special Collection on Construction Safety. *Practice Periodical on Structural Design and Construction*, *22*(4), 04017017.

Hardison, D., Hallowell, M., & Littlejohn, R. (2020). Does the Format of Design Information Affect Hazard Recognition Performance in Construction Hazard Prevention through Design Reviews?. *Safety Science*, *121*, 191-200.

Larsen, G.D., & Whyte, J. (2013). Safe Construction through Design: Perspectives from the Site Team. *Construction Management and Economics*, *31*(6), 675-690.

Manu, P., Poghosyan, A., Mahamadu, A., Mahdjoubi, L., Gibb, A., Behm, M., & Akinade, O. (2019). Design for Occupational Safety and Health: Key Attributes for Organisational Capability. *Engineering, Construction and Architectural Management, 26* (11), 2614-2636.

Toole, T. M., & J. Gambatese, J. (2008). The Trajectories of Prevention through Design in Construction. *Journal of Safety Research*, *39*(2), 225-230.

Toole, M. (2017). Adding Prevention through Design to Civil Engineering Educational Programs. *Journal of Professional Engineering Education and Practice*, *143*(4), 02517005.

Original Article

A Survey on the Evaluation of Medical Emergency Response (MER) for Workplace Injuries in Asia-Pacific BASF

Jefferelli SB,[a,*] Surreshan S.,[a] Trauth B.[b]

[a] *Corporate Health Management, EHS Services Asia Pacific, BASF Asia-Pacific Service Centre Sdn. Bhd., Level 25 Menara TM, Jalan Pantai Baharu, 59200 Kuala Lumpur, Malaysia.*
[b] *Corporate Health Management, BASF SE, Carl-Bosch-Strasse 38, 67056 Ludwigshafen am Rhein, Germany.*

Corresponding author: jeff.bahrin@basf.com

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ABSTRACT: *Despite high safety standards, workplace injuries still occur. Thus, it is important to ensure effective Medical Emergency Response (MER) to limit the impact of injury. The evaluation of MER for workplace injuries is crucial in determining whether the on-site response is adequate, and to develop the appropriate remedial action plan. In early 2021, a basic questionnaire was developed, and the staff of the related sites were guided in conducting MER evaluations. Following this, a survey was conducted over six months, between June and December 2021, to determine whether the respected sites had evaluated the MER. The results of the survey showed that there were 99 workplace injuries, of which 14 were Loss Time Injuries (LTI), nine were Restricted Duty Injuries (RDI), and 76 were First Aid Cases (FAC). However, the sites where six of these injuries happened did not respond to whether MER was evaluated within the timeline and was therefore excluded from further analysis. The percentage of workplace injuries (n=93) with MER evaluation were overall (43%), LTI (64%), RDI (44%), and FAC (39%). The results obtained in this study indicated that most MER for workplace injuries have not been evaluated, and the more severe an injury, the more likely for MER to be evaluated.*

Keywords: *Emergency response, Injuries, Medical emergency response, Workplace*

1.0 INTRODUCTION

BASF is a chemical company based in Ludwigshafen, Germany, with companies in 90 countries and nearly 20,000 employees based in the Asia-Pacific region (BASF Report, 2021). The BASF Corporate Health Requirements define the standards to be adhered to by all BASF Group companies. It states that a site emergency response plan should define the relevant resources, procedures, tasks, and responsibilities required to manage medical emergencies, including mass casualty incidents, if applicable. The plan should include detailed procedures for emergency calls, first aid, medical emergency treatment, and transportation to suitable clinics or hospitals. The sites should consistently aim for immediate emergency response and avoid any unnecessary delay. Regarding medical emergency preparedness, the BASF sites were classified into three risk categories, based on the total number of people on site and the health hazards, which, in turn, determine the level of Medical Emergency Preparedness and expected Emergency Response (MEPER). All the sites are expected to conduct at least one medical drill annually (BASF, 2021). The BASF guide on MEPER states that high-quality medical care should be made available to all individuals at BASF sites worldwide during acute illnesses or accidents. Additionally, it states that the following should be ensured: emergency telephone calls and first-aid measures by certified first aiders; prompt high-standard medical emergency treatment provided at the location of the incident; prompt transport to a hospital with the necessary facilities while guaranteeing continuous monitoring and treatment; and implementation of emergency response plans and regular drills to professionally manage acute illnesses, accidents, or incidents of mass casualties (BASF, 2020). Although the BASF requires incidents at the workplace to be investigated (BASF, 2022b), there are no specific company requirements that state the need for the Medical Emergency Response (MER) of workplace injuries to be evaluated. However, the benefits of evaluating or checking programs are well-accepted. A common management method used is the Plan, Do, Check, Act cycle.

Workplace injury is defined by the Department of Occupational Safety and Health (DOSH), Malaysia, as the negative impact on health due to exposure to chemical, biological, physical, work-organizational, or psychosocial factors at the workplace. A workplace is defined as any physical location where work-related activities are performed, and whenever the effects of occupational safety and health on the personnel are involved. This includes traveling or in transit, working at the premises of a client or customer, or working at home (DOSH, 2011).

The BASF defined work-related injuries as sudden bodily injuries of employees caused by work activities that are classified as work-related based on the investigation of the incident. Such incidents are categorized as fatalities (FAT), loss time injuries (LTI), restricted duty injuries (RDI), and first aid cases (FAC). All incidents must be reported in the Global Incident Database (GID) within two (2) business days (BASF, 2022b). The BASF, located in the Asia-Pacific region, uses the Asia-Pacific Accident Incident Management System (AP_AIMS) as its primary data collection tool. Every incident reported in AP_AIMS is transferred to the GID on the following day (BASF Training Material, 2022).

Experts have suggested that when defining the challenges of MER, the location, population, and type of injuries and illnesses must first be identified. Subsequently, legal requirements and industry standards for managing MER must be determined. Following this, appropriate existing and emerging practices for managing these challenges must be established (Ponsonby W et al., 2009). A qualitative study conducted on 114 critical offshore incidents identified seven themes related to MER challenges: communication, decision-making, facility layout, logistics problems, offshore medical response, SOP, protocols, and weather conditions (Huzaini et al., 2020).

One way of improving and standardizing the medical emergency response to major incidents is by creating a database to identify how the descriptive analysis of reports submitted to this database can be used to improve emergency response. Through systematic reporting, relevant data can be obtained and used to improve emergency medical responses to major incidents (Hardy S et al., 2018). Experts have stated that to improve MER, emergency departments and hospital staff should be familiar with the protocols and be trained to evaluate and treat victims of chemical exposure. Requirements and guidelines, such as decontamination procedures, methods of evaluating chemical exposure, identifying substances, recognizing toxidromes, ensuring adherence to appropriate personal protective equipment (PPE), and initiating treatment for life-threatening conditions must be properly identified (Wanner G et al., 2019). To enhance the ability to deal with Sudden Cardiac Arrest (SCA), blunt trauma to the chest, firearm injuries, asthma, head injuries, drug overdose, allergic reactions, and heatstroke, a summary of essential information regarding life-threatening decisions such as SCA, detailed information on cardiopulmonary resuscitation (CPR), and the automated external defibrillator (AED) has been developed (Hazinski M et al., 2004).

A cross-sectional study was conducted in schools in Osaka, Japan, to determine whether there was a well-prepared medical emergency response plan by identifying the type of school, the number of students, staff, AED, place of installation, training of staff on CPR, MERP development and implementation, and the number of SCA cases faced (Nishiuchi T et al., 2018).

Currently, there are no available data or surveys on the evaluation of MER for workplace injuries, which may suggest that such research or information may not have been widely published or may be limited in scope. Hence, a survey was conducted at the BASF in the Asia-Pacific region to determine the percentage of workplace injuries where MER was evaluated, and to determine whether there was a difference in the proportion of injuries evaluated based on the type of injury. The data obtained from this study is important in supporting the assumption that MER in most workplace injuries is not evaluated and that the more severe the injury, the more likely it is to be investigated.

2.0 METHOD

This study was conducted over six months between June 2021 and December 2021. All workplace injuries reported in the AP_AIMS, the BASF Asia-Pacific workplace incident database, were identified and included in the survey. Sites with workplace injuries were contacted and asked whether an evaluation of the MER for workplace injuries was performed. Only sites that evaluated the MER were included in the survey. Cases from sites that responded when contacted (93 in total) were included in the survey, whereas cases from sites that did not respond when contacted (six in total) were excluded. The evaluation of MER using the methods recommended by the BASF (Appendix A) or those of the sites was accepted as fulfilling the criterion of having been evaluated for MER. The responses were analyzed and summarized.

3.0 RESULT

During the study period, there were 99 workplace injuries and no fatalities. Six workplace injuries (6%) were from sites that did not respond within the stipulated timeline to the query of whether the MER was evaluated and were thus excluded from further analysis. These six cases were all FACs.

Table 1. Number of Workplace Injuries and Number and Percentage Evaluated

Category	Number	Number evaluated	Percentage evaluated
LTI	14	9	64%
RDI	9	4	44%
FAC	70	27	39%
Overall	93	40	43%

Of the 14 LTI cases, nine (64%) were evaluated for MER; of the nine RDI cases, four (44%) were evaluated; and of the 70 FAC cases, 27 (39%) were evaluated. Overall, 43% of the reported workplace injuries were evaluated for MER. Of these, 64% were LTI cases, 44% were RDI cases, and 39% were FAC cases (Table 1).

4.0 DISCUSSION

This preliminary study indicated that for most medical injuries, quick responses, appropriate first aid, and prehospital care assist in limiting the impact of an injury. An effective MER plan would facilitate such a response. Medical drills or evaluation of MER post MERs can be used to evaluate and enhance the effectiveness of the MER plan. To facilitate the evaluation of the MER, BASF Asia Pacific developed a basic evaluation questionnaire and guidance. Therefore, a survey was conducted using existing resources to determine the number of sites that evaluate MER in workplace injuries in the organization and whether the decision to evaluate was based on the severity of the injury.

A limitation of this survey, as it was conducted in only one region, industry, and company, was that there might be differences in practices in different regions, industries, or organizations. Furthermore, it was conducted soon after the launch of the new MER assessment tool, which may have increased the staff's awareness and interest in conducting such evaluations. Before the launch of such assessment tools, the percentage of MER evaluations of workplace injuries was likely lower. In addition, this survey did not evaluate the quality or findings of MER evaluations at the sites.

The survey provided basic data on the incidence of workplace injuries; however, MER has not yet been evaluated. If the survey was not conducted soon after the launch of the new regional guidance and questionnaire on MER, the MER evaluation of workplace injuries may have been significantly lower. This is not surprising because, although the company requires an investigation of workplace incidents (BASF, 2022), the focus is on root cause analysis. Hence, from the perspective of MER, there is a missed opportunity to identify and close MER gaps.

Previously, many BASF sites in the Asia-Pacific region were unfamiliar with MER evaluation. Therefore, we developed an MER evaluation form and guide (Appendix A). We believe that this has increased the interest in and practice of evaluating the MER of workplace injuries at our sites in this region. However, there is a need to further promote the evaluation of MER to increase the number and quality of such evaluations.

The results of this survey indicated that the more severe the injury, for example, LTI compared to RDI or FAC, the higher the likelihood of it being investigated. Although this situation is understandable owing to greater attention being given to more severe cases, it is believed that there are also countless learning opportunities to be gained from the MER of less severe injuries.

Given the currently limited information on the evaluation of workplace injury MER and its value, a more comprehensive study is recommended to provide more representative figures on the MER of workplace injuries and determine the quality of evaluations and gaps in MER that can be used to strengthen existing workplace programs.

5.0 CONCLUSION

This study indicated that most MER of workplace injuries were not evaluated (57%). Additionally, it also signified that the severity of an injury (LTI 64%, RDI 44%, and FAC 39%) influences the likelihood of MER being evaluated. This demonstrates a significant loss in knowledge regarding MER, regardless of whether it meets expectations. Such knowledge can be used to determine whether an existing MER system at a site is in order, or to identify specific areas for improvement. These measures are important to ensure adequate MER at these sites in the future. It is highly recommended that all workplace injuries be evaluated and used as opportunities to improve MER. More extensive studies will be conducted in the future, including a pilot study and statistical analysis, to obtain more accurate data and a better understanding of the actual practice.

Appendix A

Medical Emergency Response (MER) Investigation Form

This is an example of a basic assessment form. It is not comprehensive, and some sections may not be applicable. Feel free to amend by deleting, changing column size, etc. as required.

1. Basic information *(Fill in the blanks.)*

Question	Answer
1.1 Date of Incident:	
1.2 Time of Incident:	
1.3 Area Incident Occurred:	
1.4 Company:	
1.5 Site/location:	
1.6 Country:	

2. Type of MER *(Choose one best answer.)*

Question	Answer	
Resulted in patient		Not referred to Hospital
		Referred to Hospital
		Fatal

3. Summary of injury *(Describe the number of persons and type of injury; i.e., cuts, burns, and area affected; i.e., head, chest, in the space below.)*

4. Alarm *(Fill in the empty spaces.)*

Question	Answer
Who was the caller?	
Who received the call?	
Time the call was received	
Content of call:	
-When?	
-Where?	
-What?	
-Who?	
-How many?	
Time medical staff was informed	
Time ambulance was called	
Who decided to call an ambulance?	
Time ambulance arrived at the scene	

5. At the scene

5.1 First Aider (FA) *(Fill in the empty spaces.)*

Question	Answer
Was the FA notified?	
What time did the FA arrive at the scene?	
Did FA wear gloves and other PPEs?	
Does FA have valid FA certification?	

Summary of FA actions *(Describe actions in the space below: ensure safety; assess patient; assure, stabilize, secure patient; transfer; equipment used; treatment given; communicate; record)*

5.2 Medical Staff (MS) *(Fill in the empty spaces.)*

Question	Answer
Who was the most senior MS at the scene?	
What time did the MS arrive at the scene?	
Did the MS wear gloves and other PPE?	
Does MS have valid advanced life support certification?	

Summary of MS actions *(Describe actions in the space below: ensure safety; assess patient; assure, stabilize, secure patient; transfer; equipment used; treatment given; communicate; record)*

6. Transfer to Site Clinic or First Aid Room *(Fill in the empty spaces if relevant.)*

Question	Answer
What time did the patient arrive?	
Was the person on duty informed before transferring the patient?	
What type of vehicle was used?	
Does the vehicle have life support equipment?	
Was the patient secured (i.e., belt)?	
Who monitored the patient during the transfer?	
Was the person monitoring the patient secured?	
When did the patient arrive at the clinic or FA Room?	

Summary of actions at Site Clinic or First Aid Room *(Describe actions in the space below: further assess patient; assure, stabilize, secure patient; transfer; communicate; record)*

7. Transfer to Hospital *(Fill in the empty spaces.)*

Question	Answer
Was the hospital informed before the transfer?	
What type of vehicle was used?	
Does the vehicle have life support equipment?	
Was the patient secured (i.e., belt)?	
Who monitored the patient?	
Was the person monitoring the patient secured?	

8. At the Hospital *(Fill in the empty spaces.)*

Question	Answer
What time did the patient arrive?	
Was the hospital prepared to receive the patient?	
Who handed the patient over to the hospital?	
Which hospital personnel received the patient?	
Was the patient history document provided?	
Was BASF CEMG, MSDS provided?	

9. Strengths Identified from MER *(Describe in the space below.)*

10. Areas for Improvement from MER *(Describe in the space below.)*

Form Completed by:

Signature	
Name	
Designation	
Date completed	

REFERENCES

BASF Report. (2021). Integrated corporate report on economic, environmental, and social performance. https://report.basf.com/2021/en/

BASF. (2021). Corporate Health Management (G-R-OCH-001) https://confluence.basf.net/pages/viewpage.action?pageId=351931526

BASF. (2020). Medical Emergency Preparedness and Emergency Response (G-GD-OCH 040) https://documentcloud.adobe.com/spodintegration/index.html?r=1&locale=en-us

BASF. (2022b). EHS Reporting (G-R-REP-001). https://confluence.basf.net/pages/viewpage.action?pageId=359743076

BASF Training Material (2022). AP_AIMS (Asia Pacific Accident Incident Management System). AP BASF Accident Incident v1.0 - Copy Of UnitClassification

DOSH. (2011). Guidelines on Occupational Safety and Health Management Systems. https://www.dosh.gov.my/index.php/legislation/guidelines/general/597-04-guidelines-on-occupational-safety-and-health-management-systems-oshms/file

Hardy, S., Fattah, S., Wisborg, T., Raatiniemi, L., Staff, T., & Rehn, M. (2018). Systematic reporting to improve the emergency medical response to major incidents: a pilot study. *BMC Emergency Medicine*, *18*(1), 1–7. https://doi.org/10.1186/s12873-018-0153-x

Hazinski, M. F., Markenson, D., Neish, S., Gerardi, M., Hootman, J., Nichol, G., Taras, H., Hickey, R., O'Connor, R., Potts, J., van der Jagt, E., Berger, S., Schexnayder, S., Garson, A., Doherty, A., & Smith, S. (2004). Response to Cardiac Arrest and Selected Life-Threatening Medical Emergencies: The Medical Emergency Response Plan for Schools A Statement for Healthcare Providers, Policymakers, School Administrators, and Community Leaders. *Circulation, 109*(2), 278–291. https://doi.org/10.1161/01.CIR.0000109486.45545.AD

Huzaini, A. S. B., Mohammad, R., Othman, N., & Kadir, Z. A. (2020). Exploring of offshore medical emergency response system challenges in oil and gas environment. *Journal of Environmental Treatment Techniques*, *8*(1), 364–373.

Nishiuchi, T., Kinoshita, R., Kubota, Y., Paul, M., & Hiraide, A. (2018). The Current Status of Development and Implementation of Medical Emergency Response Plan in Schools. *Pediatric Emergency Care*, *34*(3), 189–192. https://doi.org/10.1097/PEC.0000000000000689

Ponsonby, W., Mika, F., & Irons, G. (2009). Offshore industry: Medical emergency response in the offshore oil and gas industry. *Occupational Medicine, 59*(5), 298–303. https://doi.org/10.1093/occmed/kqp075

Wanner, G. K., Atti, S., & Jasper, E. (2019). Chemical Disaster Preparedness for Hospitals and Emergency Departments. *Delaware Journal of Public Health*, *5*(4), 68. https://doi.org/10.32481/djph.2019.10.019

Original Article

Technical Error Measurements, Reliability, and Validity of Customized Anthropometric Grid

*Siti Nur Sarah binti Zubir,[a] Mohd Nur Ikhwan bin Shafiee, Siti Zaharah binti Abd. Rahman, Hazwan Adli bin Hamadan, Nor Shahira binti Mohd Salim, Mohd Esa bin Baruji [a], Evelyn Tan [a], Raemy bin Md Zein [a]

[a] *Consultation Research & Development Department, National Institute of Occupational Safety and Health (NIOSH), Lot 1, Jalan 15/1, Section 15, 43650 Bandar Baru Bangi, Selangor, Malaysia.*

*Corresponding author: sitinursarah@hotmail.com

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ABSTRACT: *The National Institute of Occupational Safety and Health (NIOSH) Malaysia aimed to study anthropometric measurements for the working-age population. However, there is limited literature on the reliability and technical error of measurement (TEM) in anthropometric measurement. This study assessed the properties of stature, eye height, tibial height, bideltoid breadth, elbow span, and waist circumference of 10 volunteers. Four observers measured the mentioned dimensions using a Martin anthropometer and designated anthropometric grid. Findings showed high inter- and intra-observer reliability using 'mean absolute difference' and 'reliability coefficient.' Hence, measurements of the above dimensions using the test instruments may be considered reliable and valid within the limits of their error. We recommend that special attention be given to improving reliability and validity of anthropometric measurements to ensure the accuracy of data for ergonomic design.*

Keywords – *Reliability, Technical Error of Measurement, Validity*

1.0 INTRODUCTION

Anthropometric evaluation of a group of people is critical for developing ergonomic products, tools, and workstations for all populations (Mohd Nur Ikhwan et al., 2021). Anthropometry is the measurement of humans, encompassing any physiological, psychological, or anatomical traits (Ulijaszek & Kerr, 1999). Measurements are essential for the analysis and design of human use and optimizing working and living conditions. These measurements provide data on the engineering and personal protective equipment that should be used or designed. This would ensure a proper match between the assigned work and the individual worker, comfort and ease of equipment use, and effective control of the equipment. Most equipment used in Malaysia are made in other countries and the design is based on the country’s nationals' anthropometric data, which may not be the same as that of Malaysian nationals. All anthropometric measurements require measurement tools. Any equipment or observers are liable to errors that must be considered as they are propagated in subsequent statistical analyses and influence interpretations and conclusions (Arroyo, Freire, Ansotegui, & Rocandio, 2010). Variations in human traits due to biological differences and experimental environments may result in measurement errors owing to fluctuations in biological or mechanical factors. Although obtaining an error-free true value is ideal, it is practically impossible to achieve this with continuous measurements. However, it is crucial to minimize such errors as accurately as possible to detect actual variations and improve performance (Ryan-Stewart, Faulkner, & Jobson, 2022). Measurement errors owing to technical, personal, or measurement factors can be minimized through appropriate equipment calibration and control of observer bias.

Estimating the technical error of measurement (TEM) in anthropometric studies is essential for ensuring accuracy and reproducibility. Studies that do not estimate the TEM are prone to significant errors (Krishan & Kanchan, 2016). Various terms are used to describe anthropometric measurement errors, including coefficient of reliability (R), technical error measurement (TEM), and validity (Ulijaszek & Kerr, 1999). In the anthropometric literature, precision refers to the degree of variability between repeated measurements on a subject by the same observer (intra-observer precision) or by different observers (inter-observer precision) (Arroyo et al., 2010). Reliability is the degree to which within-subject variability is present and is caused by factors other than the variance of measurement error or physiological variation. The second type of measurement error, validity, is the extent to which the 'true' value of a measurement is attained. The technical error of measurement (TEM) is another accuracy index used to express error margins in anthropometry (Jamaiyah et al., 2010). Furthermore, there is a lack of research on the technical error of measurement (TEM) of anthropometric measurements in Malaysia. Considering these research gaps, the purpose of the present study was to describe the standardization process of the inter- and intra-observer reliability of the anthropometric measurements used and the validity of the designated anthropometric grid.

2.0 MATERIAL AND METHOD

Four beginner observers were analyzed using the coefficient of reliability (R) and TEM calculations for their measurement results to interpret the proportion of between-subject variance free from measurement error and to verify the intra- and inter-evaluator variation, respectively. All observers were trained during the study phase to familiarize themselves with the anthropometric techniques. Ideally, duplicate measurements of at least 10 individuals should be performed to calculate the intra- and interobserver TEM and R (Ulijaszek & Kerr, 1999). Many previous studies have used similar methods, such as those of Carsley et al. (2019) and Hardy et al. (2018).

2.1 Anthropometric methods

Anthropometric measurements are non-invasive quantitative assessments of the human body used to analyze various physical characteristics. These measurements are widely recognized as some of the most reliable tools available for evaluating and quantifying human dimensions (Casadei & Kiel, 2023). Anthropometric measurements were performed using a Martin Anthropometer (TTM, Japan) to the nearest 1.0 mm and a designated anthropometric grid designed (Figure 1) from a previous study (Nurani et al., & Hari Krishnan (2015) to the nearest 0.1 cm. All dimensions were measured in centimeters (cm) to the nearest 0.1 cm. To obtain the TEM, R values, and validity, each observer measured ten volunteers on two different days. On the first day, the observers measured the subjects in the morning and evening, whereas on the second day, all subjects were measured only in the evening. The method used in this study was adapted from Perini et al. (2005).

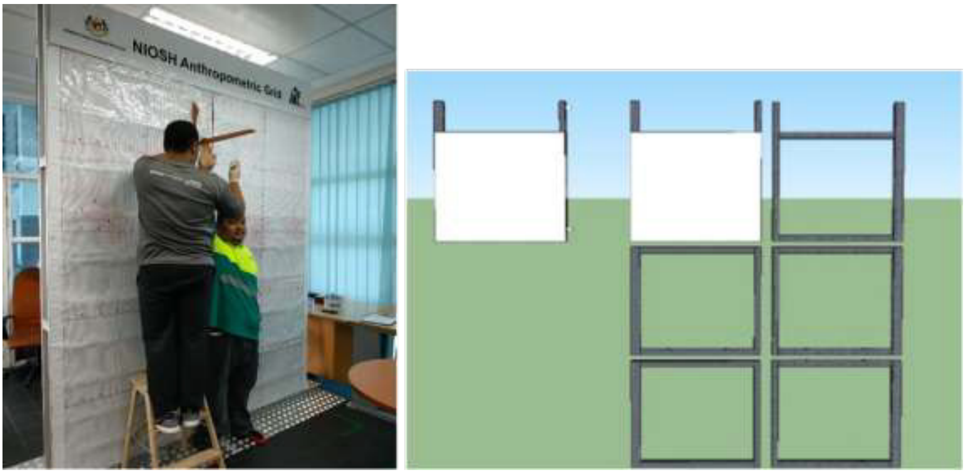

Figure 1: Designated anthropometric grid

2.3 Statistical analysis

For reliability, the findings of the statistical analyses were reported using the mean absolute difference (MAD) and correlation coefficient (R). The absolute mean difference is a crude method to check for differences or agreement between two readings. The correlation coefficient (R) was used to assess the reliability more objectively; the values for the reliability coefficient ranged from 0 to 1. A coefficient of below 0 indicates "no reliability", >0 to <0.2 is slight reliability, 0.2 - <0.4 is fair reliability, 0.4 - <0.6 is moderate, 0.6 - < 0.8 is substantial, and 0.8 – 1.0 is almost perfect reliability (Carsley et al., 2019; Haniff Jamaiyah et al., 2008). TEM is obtained by performing several repeated measurements on the same subject, either by the same observer or by two or more observers, taking the differences and entering them into an appropriate equation. The calculations for intra- and inter-observer errors were broadly the same. For intra-observer analysis, TEM involves two measurements, and inter-observer TEM involves two measurements using Equation (1).

D is the sum of the deviations and N is the number of volunteers measured. When more than two observers are involved, the equation for estimating the inter-observer TEM is more complex using Equation (2).

Where N is the number of participants, K is the number of observers (assuming one determination per observer) for the variable for each participant, and M is the measurement. The units of TEM were the same as those of the anthropometric measurements in this study, centimeters (cm).

The positive association between TEM and the measurement size is problematic because the relative imprecision of different measurements cannot be assessed. To compare the TEM of different variables or populations, Perini et al. (2005) recommended the conversion of absolute TEM to relative TEM (% TEM) using Equation (3).

Despite making a direct comparison of different anthropometric measures possible, % TEM provides no information for the comparison of studies in which more than one observer is used, and in which both intra- and inter-observer TEM are reported. There are two methods to overcome this problem. The first is to square the TEM, turning them into variances, summing them, and then taking the square root to obtain the total TEM. For the two observers and two measurements per observer, where, TEM (intra1) is the intraobserver TEM for the first observer, TEM (intra2) is the intraobserver TEM for the second observer, and TEM (inter) is the interobserver TEM between the two observers. TEM (intra1), TEM (intra2), and TEM (inter) were calculated using Equation (1). A value for TEM (intra) for each observer, calculated using Equation (1), is incorporated in Equation (4). All TEM (intra-observer) values were squared, summed, and divided by the number of observers. Furthermore, with more than two observers, TEM (inter) was calculated using Equation (2):

This value can then be used to compare measurement errors across studies, regardless of the number of observers used. Another approach to obtain comparability of anthropometric measurement errors is to use the coefficient of reliability (R), which ranges from 0 to 1 and can be calculated using the following equation:

SD2 is the total intersubject variance for the study, including measurement error. All analyses were performed using Microsoft Excel. The coefficient of reliability (R) ranges from 0 to 1 and can be calculated using the following equation:

$$R = 1\text{-}\left(\frac{(\text{total TEM})^2}{SD^2}\right)$$

SD^2 is the total intersubject variance for the study, including measurement error. Mueller and Martorell (1988) reported that this coefficient is the most commonly used measure of anthropometric precision in population studies. All analyses were performed using Microsoft Excel.

3.0 RESULT

3.1 Sample characteristics

The anthropometrical measurements were extracted from a sample of 10 NIOSH workers (age: 27.70 ± 2.26; female: 6 and male: 4) who volunteered to participate in the study.

3.2 Reliability

3.2.1 *Intra-observer reliability*

Table 1 Intra-observer reliability

	Mean of First Measurement (cm)	Mean of Second Measurement(cm)	Mean Absolute Difference (cm)	% TEM
Stature				
Observer 1	160.4 ± 8.6	160.4 ± 8.3	0	0.3
Observer 2	160.7 ± 8.6	160.6 ± 8.6	0.10	0.4
Observer 3	157.7 ± 7.7	157.8 ± 7.5	0.05	0.4
Observer 4	159.1 ± 8.1	159.5 ± 7.9	0.46	0.4
Eye height				
Observer 1	150.0 ± 8.6	149.7 ± 8.1	0.23	0.4
Observer 2	149.8 ± 8.1	149.6 ± 8.1	0.20	0.3
Observer 3	148.0 ± 8.1	147.4 ± 8.1	0.60	0.6
Observer 4	148.5 ± 7.9	148.9 ± 7.7	0.38	0.4
Tibial height				
Observer 1	41.7 ± 3.3	41.6 ± 3.2	0.10	0.6
Observer 2	41.3 ± 3.3	41.7 ± 3.0	0.34	1.4
Observer 3	41.4 ± 3.2	41.6 ± 3.2	0.16	0.7
Observer 4	41.6 ± 2.9	41.7 ± 3.1	0.04	0.4
Bideltoid breadth				
Observer 1	41.9 ± 3.9	41.8 ± 3.8	0.10	0.7
Observer 2	41.9 ± 4.2	42.1 ± 4.2	0.20	0.8
Observer 3	42.2 ± 4.2	41.9 ± 3.9	0.3	0.8
Observer 4	41.9 ± 3.7	41.8 ± 3.7	0	0.9
Elbow span				
Observer 1	83.4 ± 4.9	83.0 ± 4.8	0.36	0.5
Observer 2	83.3 ± 4.9	83.2 ± 4.7	0.06	0.5
Observer 3	83.2 ± 4.0	83.3 ± 4.3	0.09	0.5
Observer 4	82.7 ± 4.2	83.1 ± 4.5	0.46	1.0
Waist circumference				
Observer 1	15.4 ± 1.3	15.3 ± 1.5	0.10	2.5
Observer 2	15.3 ± 1.3	15.1 ± 1.4	0.20	1.6
Observer 3	15.2 ± 1.6	15.0 ± 1.2	0.10	2.7
Observer 4	15.2 ± 1.6	15.0 ± 1.2	0.20	2.5

Anthropometric measurements are presented in Table 1. The mean absolute difference (MAD), which measures the average difference between two sets of measurements, ranged from 0 to 0.60. The MAD indicate that the differences between the measurements were minimal. The technical error of measurement (TEM), which measures measurement precision, ranged from 0.3% to 2.7%. This suggests that the measurements were relatively precise with some variability depending on the measurement.

3.2.2 Inter-observer reliability

Table 2 Inter-observer reliability

	Mean (cm)	SD	Total TEM	% Total TEM	R
Stature	159.1	7.8	1.3	0.8	0.972
Eye height	148.9	7.6	1.3	0.9	0.969
Tibial height	41.6	3.0	0.5	1.3	0.968
Bideltoid breadth	42.3	3.7	1.5	3.6	0.832
Elbow span	83.4	4.3	0.7	0.9	0.970
Waist circumference	15.3	1.3	0.4	2.9	0.888

The results of the inter-observer variability in anthropometric measurements are presented in Table 2, which includes the percentage of total technical error of measurement (TEM) and the coefficient of reliability (R) for each measurement. The total TEM values ranged from 0.8 to 3.6, indicating the error observed for each measurement. The coefficients of reliability (R) for all measurements were > 0.8, suggesting good reliability and consistency of the measurements obtained by different observers.

3.3 Validity of Designated Anthropometric Grid

Table 3 Inter-instrument (Validity)

	Mean (cm)	SD	Total TEM	% Total TEM	R
Stature	159.1	7.8	2.5	1.5	0.900
Eye height	149.0	7.9	1.9	1.2	0.940
Tibial height	41.6	3.0	0.5	1.0	0.972
Bideltoid breadth	42.0	3.7	0.6	1.2	0.976
Elbow span	83.3	4.2	1.0	1.1	0.946

Table 3 presents the comparison results between the Martin anthropometer and the designated anthropometric grid. The technical error of measurement (TEM) for all measurements ranged from 1.0 to 2.5, indicating a relatively small margin of error. Moreover, all correlation coefficients (R values) were greater than 0.8, indicating a strong correlation between the Martin anthropometer and the designated anthropometric grid.

4.0 DISCUSSION

This study reports the intra- and interobserver reliabilities of stature, eye height, bideltoid breadth, tibial height, elbow span, and waist circumference using multiple reliability statistics, mean absolute difference, and technical error measurement of the coefficient of reliability (R). Similar analyses were performed for intra-instrument (validity) between the Martin anthropometer and designated anthropometric grid. All mean absolute differences were minimal. Almost all intra- and inter-observer > 1.5 and > 2.0, respectively. According to Table 1, Table 2, and Table 3, some technical measurement errors (TEM) are above the acceptable range. The TEM value may be attributed to all the observers being beginner anthropometrists who were unfamiliar with the body landmarks used in the measurements. However, all R values in this study were greater than 0.8, indicating acceptable reliability. TEM can be considered as an evaluation session for observers to improve anthropometric data quality (Conkle, Ramakrishnan, Flores-Ayala, Suchdev, & Martorell, 2017).

The validity of the designated anthropometric grid as a test instrument compared to the reference instrument, the Martin anthropometer, was also assessed in the present study. The technical error of measurement (TEM) for the designated anthropometric grid was within an acceptable limit, whereas the correlation coefficients (R values) between the two instruments were above 0.9. These results indicated the high accuracy of the designated anthropometric grid as a measurement tool for anthropometric studies. The designated anthropometric grid readings were remarkably close to those obtained using the Martin anthropometer. Therefore, the designated anthropometric grid can be considered as a suitable alternative measurement instrument for anthropometric studies.

5.0 CONCLUSION

In conclusion, our results showed acceptable precision for the evaluated anthropometric dimensions considering that the observers were beginners. Although some TEM values were above the acceptable limit, the R values for all measurements were close to 1.0. Thus, the designated anthropometric grid is relatively reliable and valid for use in anthropometric development. In conclusion, this study aimed to assess the reliability and validity of a designated anthropometric grid as a measurement instrument for anthropometric studies. The study found that the designated anthropometric grid demonstrated high accuracy compared with the Martin anthropometer, with a technical error of measurement (TEM) within the acceptable limit and correlation coefficients (R-values) above 0.9.

Meanwhile, the intra- and inter-observer reliabilities for the measured parameters were acceptable, despite some technical errors of measurement being above the acceptable range. These results suggest that the designated anthropometric grid can be considered a suitable alternative to the Martin anthropometer for use in anthropometric studies and that the reliability of measurements can be improved with the training and experience of observers. Overall, this study provided valuable insights into the validity and reliability of anthropometric measurements using a designated anthropometric grid, which could improve the accuracy and quality of anthropometric data collection in future studies.

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REFERENCES

Arroyo, M., Freire, M., Ansotegui, L., & Rocandio, A. M. (2010). Intraobserver error associated with anthropometric measurements made by dietitians. Nutricion Hospitalaria, 25(6), 1053–1056. https://doi.org/10.3305/nh.2010.25.6.4854

Carsley, S., Parkin, P. C., Tu, K., Pullenayegum, E., Persaud, N., Maguire, J. L., & Birken, C. S. (2019). Reliability of routinely collected anthropometric measurements in primary care. BMC Medical Research Methodology, 19(1), 1–8. https://doi.org/10.1186/s12874-019-0726-8

Conkle, J., Ramakrishnan, U., Flores-Ayala, R., Suchdev, P. S., & Martorell, R. (2017). Improving the quality of child anthropometry: Manual anthropometry in the Body Imaging for Nutritional Assessment Study (Bina). PLOS ONE, 12(12), e0189332. https://doi.org/10.1371/journal.pone.0189332

Hardy, J., Kuter, H., Campbell, M., & Canoy, D. (2018). Reliability of anthropometric measurements in children with special needs. Archives of Disease in Childhood, 103(8), 757–762. https://doi.org/10.1136/archdischild-2017-314243

Jamaiyah, H., Geeta, A., Safiza, M. N., Khor, G. L., Wong, N. F., Kee, C. C., Rahmah, R., Ahmad, A. Z., Suzana, S., Chen, W. S., Rajaah, M., & Adam, B. (2010). Reliability, technical error of measurements and validity of length and weight measurements for children under two years old in Malaysia. Medical Journal of Malaysia, 65, Suppl A, 131–137

Jamaiyah, H., Geeta, A., Safiza, M. N., Wong, N. F., Kee, C. C., Ahmad, A. Z., Suzana, S., Rahmah, R., Khor, G. L., Ruzita, A. T., Chen, W. S., Rajaah, M., & Faudzi, A. (2008). Reliability and technical error of Calf Circumference and Mid-half Arm Span measurements for nutritional status assessment of elderly persons in Malaysia. Malaysian Journal of Nutrition, 14(2), 137–150

Krishan, K., & Kanchan, T. (2016) Measurement Error in Anthropometric Studies and its Significance in Forensic Casework. Annals of Medical and Health Sciences Research, 6(1), 62–63. https://doi.org/10.4103/2141-9248.180277

Ikhwan, Mohd. N., S., Raemy, M. Z., Mohd Esa, B., Evelyn, T., Sarah, Siti N., Z., Siti Zaharah, A. R., … Nor Sahira, S. (2021), Digital Health: Stepping into the Future of Medicine. Development of Malaysian anthropometric portal. In, 8th National Health seminar. Journal of Public Health Medicine. https://doi.org/https Maizatul Azma Masri, Ruhi Fadzlyana Jailani, & Liyana Azmi (Eds.). Nilai: Malaysian, (15). https://doi.org/10.37268/mjphm/vol.22/no.Suppl.1

Perini, T. A., de Oliveira, G. L., Ornelia, J. dos S., & de Oliveira, F. P. (2005). Technical error of measurement in anthropometry. Revista Brasileira de Medicina do Esporte, 11(1), 86–90. https://doi.org/http. https://doi.org/10.1590/S1517-86922005000100009

Ryan-Stewart, H., Faulkner, J., & Jobson, S. (2022). The impact of technical error of measurement on somatotype categorization. Applied Sciences, 12(6). https://doi.org/10.3390/app12063056

Siti Nurani, H., Rosnah, M., Raemy, M., Mohd Rizal, H., & Hari Krishnan, T. (2015). Anthropometric data of Malaysian workers. New Ergonomics Perspective – Selected Papers of the 10th Pan-Pacific Conference on Ergonomics (January), 353–360. https://doi.org/10.1201/b17990-61

Ulijaszek, S. J., & Kerr, D. A. (1999). Anthropometric measurement error and the assessment of nutritional status. British Journal of Nutrition, 82(3), 165–177. https://doi.org/10.1017/s0007114599001348

Original Article

Occupational Safety and Health Across Small and Medium Sized Enterprises: Investigation of Risk Management Practices in Malaysia

Marziana Madah Marzuki,[a,*] Wan Zurina Nik Abdul Majid,[a] Hatinah Abu Bakar,[b] Mohamad Rahimi Mohamad Rosman,[c] Khalid Abdul Wahid,[c] Mohd Zafian Mohd Zawawi[c]

[a] Faculty of Accountancy, Universiti Teknologi MARA, Cawangan Kelantan Kampus Machang, Malaysia.
[b] Faculty of Business Management, Universiti Teknologi MARA, Cawangan Kelantan Kampus Machang, Malaysia.
[c] Faculty of Information Management, Universiti Teknologi MARA, Cawangan Kelantan Kampus Machang, Malaysia.

*Corresponding author: marzianamadah@uitm.edu.my

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ABSTRACT: *Using quantitative and qualitative methods, this study explored the implementation and effectiveness of the Occupational Safety and Health (OSH) risk management system and the effectiveness of the Malaysian OSH regulations in reducing occupational accidents and injuries. The participating Malaysian small and medium sized enterprises (SMEs) in this study reported that implementing OSH risk management systems have minimized occupational accidents and injuries. Nevertheless, several firms managed OSH using manual rather than electronic software or system. The existing OSH-related system was also perceived as less effective, unhelpful, and inconvenient. The obtained results also highlighted the need for subsequent improvement in the regulations of OSH concerning employee enforcement and discipline. This study further revealed new technology as an essential predictor of effective risk management system implementation. The obtained findings of this study may benefit regulators and SMEs in their efforts to improve OSH regulations and the risk management system enforcement.*

Keywords: *Awareness, Occupational Safety and Health, Regulations, Risk Management, Small and Medium Sized Enterprises*

1.0 INTRODUCTION

There has been a dramatic surge in research concerning the effectiveness of Occupational Safety and Health (OSH) risk management system implementation, regulations, and legislation. For example, the ineffectiveness of the risk management system was reflected in the 2008 financial crisis reports and the more recent coronavirus disease 2019 (COVID-19) pandemic in 2020 (Polinkevych et al., 2021). Specifically, it was reported that the weaknesses of practiced risk management were attributed to technical issues and the lack of attention given to the critical situations that affected organizations. Furthermore, top management lacks decision-making involvement concerning risks was revealed (Settembre-Blundo et al., 2021). Thus, the lack of involvement illustrates a lack of convergence between the risk management system and corporate strategy. Top management delegated all risk assessment and mitigation strategies to area-specific technical experts. Ramos et al. (2020) emphasized that the knowledge and effectiveness of OSH standards among small and medium sized enterprises (SMEs) remains to be seen in a case study involving a solid waste treatment company in Portugal. It was subsequently found that although occupational accident records improved with the help of an integrated management system (IM), the organization still failed to encourage greater employee involvement in intended risk management activities. Thus, the organization failed to recognize its importance, although proper risk management systems were in place.

Furthermore, the risk management processes in the United Arab Emirates (UAE) and China revealed the centrality of organizational culture (Kim & Jung, 2019; Vijayan & Sharma, 2020). Specifically, organizational commitment to risk management processes influences the relationship between organizational culture and risk perception (Kim & Jung, 2019). An analysis of the relationship among international normative values, legal documents, and OSH risk management identified several shortcomings: (1) uncertainty regarding risk management goals, (2) complexity of appropriate procedural performance and inadequate substantiation, and (3) inadequate approaches to optimal risk management due to limited resource business capacities, particularly financial resources. Thus, the study recommended a direct optimization strategy that can minimize the risk event probability at the assigned constraint for the total costs of the OSH (Bochkovskyi & Gogunskii, 2018). Reverse problems focus on reducing the average costs of preventing and eliminating risks and consequences.

Despite the pervasiveness of these studies, OSH risk management system regulations and the implementation and effectiveness of OSH risk management systems among Malaysian SMEs are still not clear. Examining these issues remains prevalent, as Malaysian SMEs contribute 99% of business establishments and 36% of Malaysia's Gross Domestic Product (GDP). Malaysian SMEs face insurmountable challenges. One of the hurdles SMEs face is monitoring compliance with OSH requirements, given limited capital or financial support. Another difficulty is increased workplace accident rates, which may affect employee health, safety, and business goodwill. By mitigating OSH-related issues, employee involvement and appropriate penalties are critical predictors of low death rates, accidents, and lost workdays (Surienty, 2019).

The recorded Department of Occupational Safety and Health (DOSH) accident statistics demonstrated that occupational accidents and injuries in Malaysia soared over the years, a constant rise in cases from the rate of 2.81 per 1,000 employees in 2015 to 2.93 per 1,000 employees in 2017. Similarly, an increase in fatality rate was recorded, with a rate of 4.84 per 100,000 employees in 2015 to 4.90 per 100,000 employees in 2017. Referring to Table 1, the manufacturing sector in Malaysia recorded the highest occupational accident statistics. Even though the statistic specific to SME-related occupational safety and health is still unavailable, according to Hong et al. (2011), 80 percent of workplace accidents involved SMEs.

Table 1 Occupational Accident Statistics by Sector in Malaysia until April 2021

Sector	Non-Permanent Disability (NPD)	Permanent Disability (PD)	Deaths	Total
Hotels and restaurants	50	1	0	51
Utilities (electricity, gas, water, and sanitary services)	68	0	3	71
Finance, insurance, real estate, and business services	121	5	4	130
Construction	56	5	25	86
Transport, storage, and communication	106	0	3	109
Manufacturing	1604	77	20	1701
Wholesale and retail trades	81	1	0	82
Public services and statutory authorities	29	0	0	29
Mining and quarrying	15	1	2	18
Agriculture, forestry, and fishery	342	5	1	348

Therefore, the present study explored the implementation and effectiveness of the OSH risk management system and Malaysian OSH regulations in reducing occupational accidents and injuries in SMEs.

2.0 LITERATURE REVIEW

2.1 Malaysian OSH Risk Management Regulations and Enforcement

Malaysia has made progressive efforts to enforce laws and regulations for employers and employees. DOSH, regulated by the Malaysian Ministry of Human Resources, is responsible for OSH in Malaysia. DOSH is an OSH standard setter, legislation enforcer, and OSH-related promotional activity coordinator. DOSH ensures employees' safety, health, and welfare and protects individuals from safety and health hazards across various sectors: (1) manufacturing; (2) mining and quarrying; (3) construction; (4) hotels and restaurants; (5) agriculture, forestry, and fishing; (6) transport, storage, and communication; (7) public services and statutory authorities; (8) utilities (gas, electricity, water, and sanitary services); (9) finance, insurance, real estate, and business services; (10) wholesale and retail trades. By administering and enforcing OSH-related legislation, the DOSH creates a safe and healthy work culture that can enhance employees' workplace quality.

The DOSH enacted several acts, including the Factories and Machineries Act of 1967 (FMA 1967), the Occupational Safety and Health Act of 1994 (OSHA 1994), and the Petroleum Safety Measures Act of 1984. The FMA 1967 accords the privilege to factories to control individuals' safety, health, and welfare; therefore, the registration and inspection of machinery and matters connected in addition to that. The most comprehensive act, OSHA 1994, covers nearly all sectors, excluding employees working on board ships and the armed forces. The OSHA 1994 covers approximately 90% of the Malaysian workforce.

Malaysian statutory bodies or companies directly related to OSH, the National Institute of Occupational Safety and Health (NIOSH), and the Social Security Organization (SOCSO) are under the Ministry of Human Resources' purview. It should be noted that NIOSH and DOSH play different roles. Although the DOSH plays a more significant role in enforcement, it is instrumental in ministry-sanctioned training skills. The national workforce can obtain necessary skills training through the

NIOSH by focusing on the Ministry of Human Resources. Skilled workers comprised only 28% of the workforce as of 2019, and the government targeted at least 35% of the national skilled workforce by the end of 2021 (The Star, 2020).

The SOCSO was established to administer, implement, and enforce the Employees' Social Security Act of 1969 and the Employees' Social Security (General) Regulations of 1971. The SOCSO status was changed to a Statutory Body on July 1, 1985. SOCSO provides employees social security protection for their dependents through (1) the Employment Injury Scheme and (2) the Invalidity Scheme. The Employment Injury Scheme protects employees from occupational injuries, including occupational and commuting accidents. The Invalidity Scheme provides employees with 24-hour protection against (1) invalidity, (2) deaths due to any cause outside working hours, and (3) non-occupation-related incidents. Both schemes provide employees with medical treatment, physical rehabilitation, vocational training, and cash benefits in the event of unforeseen circumstances. SOCSO also conducts accident prevention activities by implementing OSH awareness programs for employers and employees. Fig. 1 summarizes the OSH-related laws and regulations in Malaysia.

Meanwhile, the Labor Department was established in 1912 and is one of the 12 departments and agencies under the jurisdiction of the Ministry of Human Resources. Before the 1960s, the department's objective was to protect the interests of workers in the plantation and mining sectors. In 1970, the Labor Department merged with the Department of Industrial Relations. The coalition focused on resolving disputes involving workers and unions. The restructuring of labor institutions continues to be made to realize their functions and responsibilities more effectively. Among the changes made was separating the Department of Labor from the Department of Industrial Relations (JPP) and further outlining their duties and functions. The Labor Department is responsible for preserving the welfare and interests of workers by creating harmony between employers and workers.

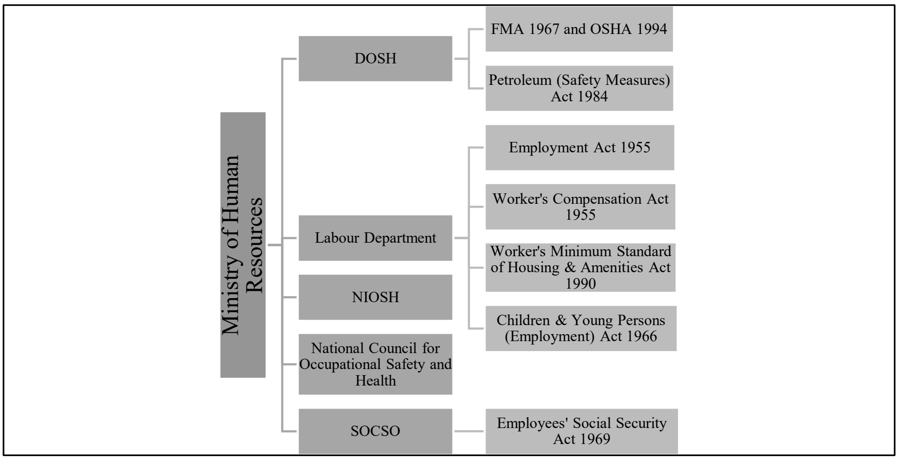

Figure 1 OSH-related Laws and Regulations in Malaysia (Source: Yusoff, 2014)

Malaysian Hazard Identification, Risk Assessment, and Risk Control (HIRARC) were introduced in 2008 as part of the OSH management system. HIRARC is generally known as a risk management system that prevents accidents. Implementing existing measures and methods can prevent or eliminate occupational injuries and accidents. In recent years, HIRARC has become central to essential planning, management, and business operation practices.

HIRARC is extremely important for identifying, analyzing, and assessing hazardous organizational risks. Once the hazards and risks are identified, analyzed, and evaluated, suitable control measures are proposed for implementation. Consequently, Malaysian organizations can proactively monitor, manage, and generate consciousness of the risks associated with organizational strategic objectives. Accordingly, risk monitoring indicates the importance of evolution and permanent measurement of organizational risk severity. However, risk severity maintains an overall risk profile that aligns with organizational strategic objectives (Van Staveren, 2009). Meanwhile, risk management reveals the centrality of organizations, organizational processes, and the potential upsides and downsides of organizational risks. By focusing on risk management, the impact of alternatives on future organizational performance can be detected early (Hopkin, 2002).

2.2 Occupational Safety and Health Risk Management Practices

Accordingly, risk management is typically understood as the proactive means of contending potential risks rather than being responsive (Taofeeq & Adeleke, 2019). As Section 15 of the OSHA 1994 stipulated, the primary safety and health provision obligations are placed on the employers defined as the "principal employer" or "immediate employer" of an organization. Risk management and risk assessment plans are the cardinal principles of the self-regulatory philosophy in the context of management aspects (*Plan, Do, Check, and Act*) (Ab. Rahman, 2015). According to Wanberg et al. (2013), a project with poor-quality performance is usually linked to a higher likelihood of injury. Therefore, an increase in OSH practices is expected to improve safety performance in the workplace (Hinze, 2013). Thus, organizations must adopt a holistic strategy to improve the physical environment, conduct safety risk assessments, and elevate employees' knowledge.

Prior studies highlighted the contribution of adopting safety measures in the workplace, particularly in enhancing safety performance (Teo & Phang, 2005). The practical implementation of OSH practices can moderate accidents and decrease compensation costs (Surienty, 2019). Proper equipment handling, installation and dismantling of heavy devices, site inspection, and supervisory practices closely contribute to safety management factors, particularly in the construction sector (Kerry et al., 2021). Therefore, SMEs must acknowledge the centrality of OSHA 1994; they can generate higher returns by reducing the costs incurred as compensation (Laukkanen, 1999). Furthermore, safety problems severely affect workplace health and economic competitiveness (Surienty, 2019). Through occupational risk prediction and management, overall organizational safety and organizational occupational damage can be appropriately addressed. In addition, occupational risk prediction and management may be more effective in assessing, forecasting, and handling occupational risks across business organizations (Semeykin et al., 2020).

Different SMEs and large multinational organizations demonstrate varying organizational characteristics, which have raised several issues that may affect the implementation of OSH (Surienty, 2019). Extensive studies have also revealed a relationship between company size and the effectiveness of OSH implementation (Hong, 2011). Large multinational organizations have the financial strength and structure to implement an effective OSH system, unlike SMEs. A large organization with many employees leads OSH programs that benefit more stakeholders, resulting in lower costs per person. Conversely, the implementation of OSH in SMEs has been reported to be irrelevant due to the workforce size. Moreover, implementing OSH in SMEs cannot be directly explained regarding monetary gains, which may appear irrelevant or less significant for a company's sustainability. Among other challenges is the implementation of OSH that focuses more on adopting established safety practices than compliance with OSH regulations (Surienty, 2019). Its performance is evaluated based on the organizational ability to meet the minimum requirements outlined by the local OSH Act of 1994 and the International Labour Organization (ILO) Standards on OSH. The implementation of OSH does not rely on an individual basis but must be interdependent and coordinated across various capacities, departments, work shifts, and even locations.

The existing risk assessment guidelines centralized by the HIRARC (HIRARC, 2008) comprise general guidelines for implementing industrial risk assessment systems (Kadir et al., 2020). The framework generally involves a qualitative risk assessment table or matrix, a simple calculation of risk rating, and a three-level categorization of risks, excluding existing control measures. The current HIRARC framework has been widely used in studies on hotel services, hydroelectric power generation plants, schools or education, crane operations, road accidents, and manufacturing. Studies on risk management mainly consider the following four key steps that govern the processes related to HIRARC: (1) risk classification, (2) risk identification, (3) risk analysis and estimation, and (4) risk control. Nevertheless, the extent of these processes among Malaysian SMEs is still not clear.

3.0 METHOD

The present study focused on employees of SMEs registered under SOCSO. A stratified random sampling strategy was employed to generalize the findings to the entire population (Bryman & Bell, 2003). Owners, managers, or supervisors were specifically targeted based on the following justifications: (1) they are responsible for corporate and business-level strategic decisions, and (2) they are in the best position to describe various organizational characteristics of their companies. The search generated 1,060 companies with more than 75 employees across 14 districts in Malaysia. The list of companies was retrieved from the official website of SOCSO. Based on Krejcie and Morgan's (1970) guidelines for determining the sample size, the recommended sample size for a population of 1,060 companies was 285; owners, managers, or supervisors from 285 companies were targeted as respondents.

The multi-item questionnaire constructs were measured using a five-point Likert scale. All six constructs used in this study (context, ease of use, personal innovativeness, perceived usefulness, trust, and effectiveness of risk management system) were developed and researched by Gaoa, Krogstiea, and Siau (2011). Questionnaires were distributed using Google Forms; however, only 55 respondents responded. Notably, despite assuring anonymity and confidentiality, the approached respondents expressed fear that tax authorities may go after them, as most of them may not have fulfilled their tax obligations, resulting in difficulty in acquiring information related to SMEs (Ackah & Vuvor, 2011). The model was tested using SmartPLS software (version 3.3.6). This study simultaneously assessed the measurement and structural models by minimizing the error variance and analyzing the relationships among the variables. A bootstrapping function with 5,000 re-samples was employed to determine the statistical significance of the paths.

Moreover, this study employed the interview method to explore the involvement of related stakeholders in OSH risk management activities to gain in-depth views of OSH practitioners on the subject. This method allows the interviewer to deeply explore informants' feelings and perspectives on a specific subject (Guion, 2001). Consequently, it enriches background information that can stimulate relevant questions regarding the topic under study. Furthermore, the in-depth interview allowed informants to discuss their feelings, opinions, and experiences freely. Specifically, this method provides an opportunity to gain valuable insights into how specific individuals or groups interpret and view the world (Milena et al., 2008). The present study targeted individuals directly involved in OSH-related risk management activities. A list of relevant practitioners was generated. To meet the objectives of this study, informants were selected based on their experience in OSH or related risk management departments. Consequently, three OSH-related officers and one technical service division officer were invited to participate. As shown in Table 2, most participants had more than ten years of experience with OSH.

Table 2 Details of Participants

Identification Details	Positions	Years of Experience in OSH
Interviewee 1	Chairman of the Occupational Safety (OSH) Committee and Senior Manager	More than 30 years
Interviewee 2	Head of Health, Safety, Security, and Environment (HSSE) Department	15 years
Interviewee 3	Head of Technical Service Division	More than 20 years
Interviewee 4	Safety and Health Officer (SHO)	Seven years

However, due to the COVID-19 pandemic, this study conducted online semi-structured interviews using Google Meet. All interviews lasted between two and three hours. A list of questions aligned with the study's objectives guided the interviews. The questions were framed based on the following main issues: (1) OSH risk awareness at the workplace, (2) risk identification mechanisms, (3) risk evaluation processes, (4) risk prevention or control mechanisms, (5) risk monitoring, (6) risk management process mechanisms, (7) OSH regulation awareness, and (8) problems in OSH risk management processes. Subsequently, several probing questions were asked to ensure comprehensive discussion sessions on OSH-related topics. Information on anonymity and confidentiality was relayed to participants to ensure honest and autonomous responses. All participants were informed that their identities would not be disclosed in any publication. Finally, all interview recordings were transcribed to generate general ideas, and the responses were coded into themes.

4.0 FINDING

4.1 Quantitative Results

4.1.1 Demographic Profile of Respondents

This study managed to gather completed questionnaires collected from 55 participants. The respondents were from two electrical and electronics companies (3.6%), one transportation company (1.8%), one investment company (1.8%), and 34 manufacturing companies (65.5%). Furthermore, most respondents were from companies with more than 50 employees (85.4%). Only three respondents reported working in a company with 20–50 employees (5.5%); the remaining four respondents were from companies with 6–19 employees (1.8%) and fewer than five employees (7.3%). Regarding the operation period, most respondents had worked for more than 20 years (83.6%). Approximately 5.5% of the respondents had 16–20 years of experience, while the other 7.3% had less than five years of experience. Only two respondents had 11–15 years of experience. Additionally, most respondents (25.5%) worked south of Peninsular Malaysia (Negeri Sembilan, Melaka, and Johor) and west coast of Peninsular Malaysia (Pulau Pinang, Perak, and Kedah) (25.5%). The remaining 10.9% worked on the east coast of Peninsular Malaysia (Pahang and Terengganu). Among the respondents, 16.3% worked on the eastern coast of Malaysia (Sabah and Sarawak). The remaining 18.2% worked in Selangor. The respondents' demographic profiles are presented in Table 3.

Table 3 Demographic Profile of Respondents

Demographic Characteristics	Frequency (n = 55)	Percentage (%)
Gender		
Men	27	49.1
Women	28	50.9
Designation		
Manager	27	49.1
Engineer	1	1.8
OSH staff	16	29.1
Head departments	5	9.1
Others	6	10.9
Company type		
Electrical and electronics	2	3.6
Transportation	1	1.8
Investment	1	1.8
Manufacturing	36	65.5
Others	15	27.3
Number of employees		
Less than five	4	7.3
6–19	1	1.8
20–50	3	5.5
More than 50	47	85.4
Operation period		
Less than five years	4	7.3

Demographic Characteristics	Frequency (n = 55)	Percentage (%)
11–15 years	2	3.6
16–20 years	3	5.5
More than 20 years	46	83.6
Company location		
Johor	3	5.5
Kedah	3	5.5
Kuala Lumpur	2	3.6
Melaka	1	1.8
Negeri Sembilan	10	18.2
Pahang	2	3.6
Perak	2	3.6
Pulau Pinang	9	16.4
Sabah	6	10.8
Sarawak	3	5.5
Selangor	10	18.2
	4	7.3

4.1.2 Safety and Health Risk Knowledge

Table 4 summarizes the respondents' safety and health risk knowledge. Almost all respondents (98.2%) knew of safety and health risks. Furthermore, all respondents reported implementing a workplace safety and health risk management system. In particular, all the respondents confirmed that their company relied on the manual implementation of a safety and health risk management system instead of an automated system.

Table 4 Health and Safety Knowledge

Knowledge of Safety and Health (OSH 1994)	Frequency	Percentage
No	1	1.8
Yes	54	98.2
Implementation of safety and health risk management system		
Yes	55	100.0
Mode of implementation of safety and health risk management system		
Manual	55	100.0
Electronic software	0	0.0

4.1.3 Effectiveness of Risk Management System

Respondents were required to rate the effectiveness of the existing risk management systems. This study used convergent validity, including loadings, Average Variance Extracted (AVE), Composite Reliability (CR), discriminant validity (Hair, Ringle, & Sarstedt, 2011), and the heterotrait–monotrait ratio of correlations (HTMT) (Henseler, Ringle, & Sarstedt, 2015). In Table 5, the indicator loadings for all items exceed the recommended value of 0.6 (Hair et al., 2010). Furthermore, the AVE values were in the range of 0.708–0.972, exceeding the recommended value of 0.5. The recorded CR values ranged from 0.935 to 0.999, exceeding the recommended 0.7 (Hair et al., 2010).

Table 5 Model Results

Constructs		α	Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)
Context	CT1	0.916	0.744	0.935	0.708
	CT2		0.765		
	CT3		0.934		
	CT4		0.889		
	CT5		0.867		
	CT6		0.832		
Ease of Use	EOU3	0.985	0.989	0.99	0.972
	EOU4		0.989		
	EOU5		0.979		
Effectiveness of Risk Management System	ES1	0.768	0.911	0.896	0.811
	ES2		0.890		
Personal Innovativeness	PIC1	0.957	0.921	0.966	0.824
	PIC2		0.899		
	PIC3		0.863		
	PIC4		0.962		
	PIC6		0.899		
	PIC7		0.899		
Perceived usefulness	PU1	0.969	0.892	0.976	0.89
	PU2		0.947		
	PU3		0.972		
	PU4		0.971		
	PU5		0.931		
Trust	TU1	0.984	0.948	0.987	0.914
	TU2		0.954		
	TU3		0.936		
	TU4		0.970		
	TU5		0.970		
	TU6		0.951		
	TU7		0.965		

The discriminant validity of the measurement items was tested using Fornell and Larcker's (1981) criteria. Table 6 presents the results of discriminant validity, which demonstrated that all the square root values of AVE for the matrix diagonal elements were higher than all cases for the off-diagonal details in their corresponding rows and columns. In other words, appropriate discriminant validity was established in this study.

Table 6 Discriminant Validity

	CT	ES	EOU	PIC	PU	TU
CT	0.944					
ES	0.897	0.901				
EOU	0.786	0.720	0.986			
PIC	0.841	0.895	0.802	0.908		
PU	0.656	0.622	0.839	0.734	0.943	
TU	0.785	0.753	0.944	0.819	0.814	0.956

Notes: CT denotes context, ES denotes effectiveness of risk management system; EOU denotes ease of use; PIC denotes personal innovativeness; PU denotes perceived usefulness; TU denotes trust.

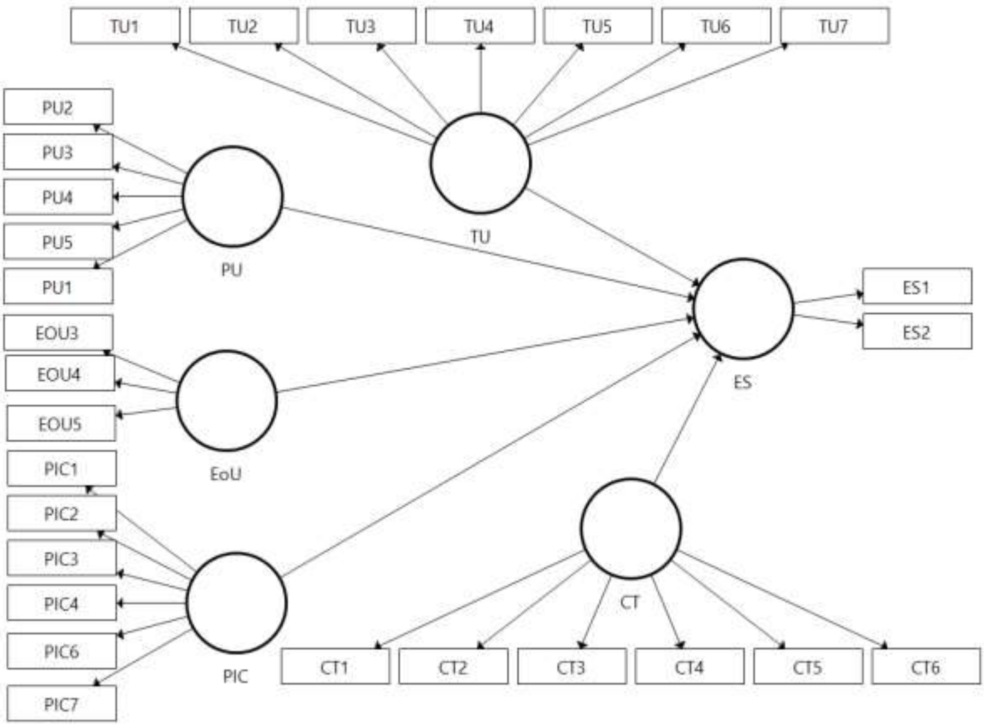

Figure 2. Structural Model

Table 7 shows that the recorded R^2 for the effectiveness of the risk management system was 0.743. Using the bootstrapping technique in the structural model (Fig. 2) with 500 resampling, the path coefficients and t-statistics were determined for the hypothesized relationships. Referring to the tabulated results in Table 7, the path coefficient and t-value (0.036) show an insignificant influence of perceived usefulness on the effectiveness of the risk management system. In other words, H1 is not supported. Meanwhile, the results showed a negligible impact of ease of use on the effectiveness of the risk management system (t-value = 1.390). In other words, H2 is not supported. Similarly, the results demonstrate an insignificant relationship between trust and the effectiveness of the risk management system (t-value = 1.162). Thus, H3 was not supported. Furthermore, the results depicted another insignificant relationship between personal innovativeness and the effectiveness of the risk management system (t-value = 1.556). Thus, H4 is not supported. However, the relationship between context and effectiveness of the risk management system was found to be statistically significant (t-value = 5.106). Thus, H5 is supported.

Table 7 Direct Relationship Results

Hypotheses	Beta	R^2	t-value	p-value	Result
H1: PU → ES	-0.003		0.036	0.486	Not supported
H2: EOU → ES	-0.300		1.390	0.083	Not supported
H3: TU → ES	0.206	0.743	1.162	0.123	Not supported
H4: PIC → ES	0.279		1.556	0.060	Not supported
H5: CT → ES	0.769		5.106	0.000	Supported

Notes: Significance level was recorded at 1.645; PU denotes perceived usefulness; ES denotes effectiveness of risk management system; EOU denotes ease of use; TU denotes trust; PIC denotes personal innovativeness; CT denotes context.

The results demonstrate the ineffectiveness of these companies' current risk management systems. In particular, the current system lacks usefulness, ease of use, trust, and personal innovation. According to the technology acceptance model theory, perceived effectiveness and ease of use are central to an effective and efficient system. However, the findings of this study contradict those of previous studies (Lin, Juan, & Lin, 2020; Teo, 2011). The only significant criterion found in this study was context. Context provides an understanding of circumstances and activities (Basole, 2004). Therefore, an effective and efficient risk management system must be established.

4.2 Qualitative Findings

In addition to the presented quantitative results, this study conducted interviews to obtain in-depth insights into the implementation and other related issues of risk-management processes and OSH regulations in SMEs. The following subsections present the findings of the interviews.

4.2.1 Occupational Safety and Health Risk Awareness at The Workplace

Workplace OSH risk awareness ensures managers can cope with significant threats from increased organizational volatility and competition, mainly through newly developed technologies. New technologies have exposed organizations to new forms of risk and a greater risk frequency. Thus, effective and holistic risk management approaches require organizations to be aware of the importance of risk mitigation, for example, by developing risk management policies (Smith, 2001). This led to the first interview question on how subordinates and employees create OSH risk awareness. The mechanisms employed by the interview participants included providing training and safety briefings on the importance of OSH risk mitigation to avoid accidents and injuries in the workplace. Apart from delivering materials such as brochures and fliers concerning workplace risks and ways to mitigate them, other interview participants highlighted the following points:

Concerning awareness, we have a patrol team. Every day, we appoint one department representative to make an observation. If we find something that affects the safety, we file a report. Patrols are carried out between 3 p.m. to 4.30 p.m. on Fridays.… We know the DOSH-sanctioned OSH guidelines. But frankly speaking, we comply with the guidelines prescribed by our parent company. We adopt Japanese Industrial Standards (JIS) and follow all Japanese-related regulations.

(Interviewee 1)

We have established the Safety & Health (S&H) committee, which comprises representatives from management and employees as committee members. The S&H committee is the primary platform for consultation and participation among the organizational staff of various levels. Staff participated in consultations concerning policymaking, objectives, and target settings.

(Interviewee 2)

4.2.2 Occupational Safety and Health Risk Identification Mechanisms

Organizations can mitigate OSH risks by highlighting critical tasks that pose significant risks to employees' health and safety. These include hazards involving specific equipment due to energy sources, working conditions, or activities performed. This step is critical because unidentified risks may have severe and immediate (acute) implications or cause long-term (chronic) health issues. This led to a second interview question on how SMEs identify OSH risks.

Accordingly, Interviewee 4 listed how the company identifies OSH risks: (1) conducts safety inspections, (2) examines the work processes, (3) reads machine manuals, and (4) scrutinizes related studies. Some OSH-related risks were identified in previous accidents. Implemented measures are essential for preventing future recurring accidents. The following interview participants highlighted other valuable points.

To us, risks do not mean they must involve complicated things. Even small actions can involve risks. For example, both handling machines and pressing machine switches may generate risks. Thus, whatever we do, we need to think of risks. In our company, we have warning signs in all risky spots. These warning signs indicate that we have the Standard Operating Procedure (SOP) and work instructions (WI) in place. Even WI are provided by the machines. So, everybody must understand the WI.

(Interviewee 1)

Multiple risk assessment tools have been used in our risk management processes. Generally, we use HIRARC guidelines by DOSH, Job Hazard Analysis, and Noise Risk Assessment for noise. Chemical Health Risk Assessment was employed for chemicals, and Ergonomics Risk Assessment (ERA) was referred to for ergonomic hazards.

(Interviewee 2)

OSH risks are identified from SOP or work procedures. The operator or person in charge must understand the SOP or work procedures.

(Interviewee 3)

Nevertheless, as highlighted by Interviewee 1, accidents are generally inevitable due to human error, which can be minimized by being vigilant at all times. Additionally, reminders were placed at high-risk locations in the workplace for all employees to exercise safety precautions for their families.

5.2.3 Occupational Safety and Health Risk Evaluation Processes

Regarding the OSH risk management system, the identified potential hazards must be analyzed to estimate hazard or risk severity levels. Such identification is instrumental for organizations to determine and prioritize different types of hazards in the workplace. For example, high-risk threats may require immediate action. Based on the OSH risk management system, the levels of risk priority were determined based on the relative risk involved by multiplying the risk likelihood (likelihood of risk occurring) by risk severity. This led to the next interview question on how the SMEs classified their levels of risk priority. One interview participant responded as follows:

The level of risks differs from one type of assessment to another. Generally, a risk matrix table was used in quantitative or semi-quantitative assessments to classify high, medium, or low risks.

(Interviewee 2)

Interviewee 4 responded favorably in determining the levels of risk priority using the HIRARC table issued by the DOSH. Meanwhile, Interviewee 3 provided a standard response: the DOSH matrix table was employed to prioritize risk. Interviewee 3 specifically explained that the levels of risk priority are based on a risk matrix that is based on the multiplication of risk likelihood and risk severity: a risk matrix of four and below are categorized as low, a risk matrix of five and 12 is classified as medium, and a risk matrix of 13 and above is considered high.

Conversely, Interviewee 1 highlighted the use of subjective evaluation to determine specific risk levels and explained that they did not rely on any particular rubric for that purpose:

The injury severity determines the level of risk. The level of risk is high if it is possible to lose an arm or if it is possible to break a leg. However, if it concerns a slight injury, the risk is low. Therefore, we look at the potential level of harm that is expected to occur.

4.2.4 Occupational Safety and Health Risk Preventive or Control Mechanisms

In the OSH risk-management system, control mechanisms for all hazards were identified, particularly for high-priority risks. Organizations should determine short- and long-term control mechanisms for the identified threats to control risks. Short-term control mechanisms are employed until permanent control mechanisms are implemented. In contrast, long-term control mechanisms are implemented based on practicality. Hazardous risks can be controlled at the source level through engineering, administrative control, or PPE use (DOSH, 2008). At the source level, hazardous risks can be eliminated (e.g., stopping buying and cutting up scrapped bulk fuel tanks owing to explosion hazards) or substituted (e.g., a hazardous chemical is substituted by a less hazardous one). Interviewee 2 stressed the importance of prevention:

Prevention is a must. Prevention is always better than cure. Identified hazards are assessed and prioritized based on risk rating. The preventive actions are implemented based on the magnitude of the effects.

Interviewee 1 also highlighted the following points:

The OSH risk control mechanisms are generally determined in a meeting and decided by the Managing Director. So, our Managing Director has the final say. Our Managing Director changes once in five years. He must take precautions against OSH risks. He usually asks us to give opinions and suggestions on OSH risk controls. After that, he will decide. If the risk is high, he will instruct and ask us to take more risk precautions.

Interviewees 3 and 4 shared similar risk control mechanisms. Interviewee 3 expressed the following:

After identifying hazards, we will review the control measures and decide whether to eliminate, substitute, isolate, engineer, administer, or use PPE.

Interviewee 4 highlighted the implementation of hierarchical control mechanisms for OSH risk prevention. Hierarchy control mechanisms typically rank risk prevention according to effectiveness (most effective to least adequate). The risk prevention controls using hierarchical controls are presented in Fig. 3. Elimination and substitution are the most effective control mechanisms (NIOSH, 2015). However, elimination and substitution methods are challenging, particularly in well-established processes. Implementing elimination and substitution requires significant organizational changes involving various procedures and equipment. However, depending on engineering controls to remove hazards is more effective because this control mechanism examines and removes threats at the source before employees are involved. This control mechanism is considerably more expensive for short-term plans than administrative control or PPE. However, in the long term, the implementation of engineering controls reduces operating costs. Administrative controls and PPE are the least effective and expensive mechanisms; however, maintaining both is costly.

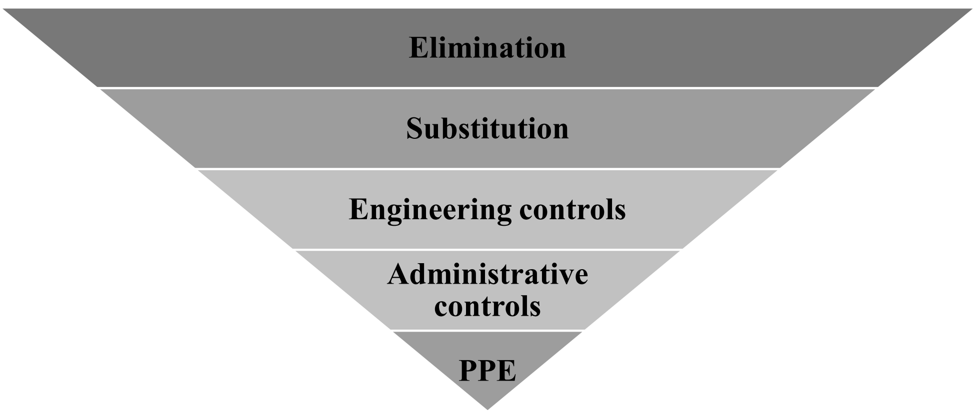

Figure 3. Hierarchy Control Mechanisms (NIOSH, 2015)

4.2.5 Occupational Safety and Health Risk Monitoring

Although organizations refer to and comply with OSH risk-monitoring guidelines, hazardous risks are not mitigated or prevented earlier if the effectiveness of controls is not regularly determined, monitored, checked, and evaluated. Therefore, the last step in a risk management system is essential. The determined control mechanisms require regular checks to assess (1) whether the controls have successfully solved hazardous risks and (2) whether other control measures are required. Evaluating the effectiveness of control mechanisms and identifying hazardous risks can help prevent hazards.

Organizations may practice various methods for monitoring risk-preventive control. This leads to the next question regarding how SMEs monitor the implementation of the proposed control mechanisms. Interviewee 2 highlighted the culture of regular meetings to ensure the performance of agreed-upon preventive control mechanisms. Interviewee 2 explained the following:

Yes, it was monitored by the department heads. Monitoring done by the department heads is essential. Sometimes we will have meetings with the manager, but I am sorry to say that we have many meetings. There are many kinds, but our forum is not long, capped at one hour.

Interviewee 3 provided a standard response to implementing safety meetings and walks to ensure well-implemented preventive control mechanisms. Interviewee 4 expressed the creation of deadlines for implementing all agreed-upon control mechanisms. Interviewee 1 explained the use of the different methods as follows:

Yes, we have a monitoring system in places such as S&H Committee Inspection and Audit. Staff is authorized to issue a Non-Conformance Report for non-conformance prevention controls. Employees also conduct Unsafe Conditions Unsafe Act (UCUA) programs.

4.2.6 Occupational Safety and Health Risk Management Process Mechanisms

The advancement of technology today due to the advancement of Industrial Revolution 4.0 led to the next interview question in this study on using any new technology or software to manage OSH risk-management processes. All interviewees provided standard responses, and no software was used to manage the risks. Instead, risks were managed manually, for example, using spreadsheets (Microsoft Excel) to control and record the identified risks. The monitoring processes were also performed manually by tracking the spreadsheet risks. Interviewee 4 highlighted the following points.

Our risk management process is implemented by documenting it as part of SOP. All departments have their own HIRARC.

Interviewee 2 provided the following standard response:

Risk management was integrated into the processes and activities. All staff need to understand the risk of activities and the adoption of mitigation measures.

Interviewee 3 highlighted the manual implementation of risk management processes, such as conducting safety walks before safety meetings and random checks on factories and employees. The interview participants did not note using any software to monitor the risk management processes in the organization.

4.2.7 Occupational Safety and Health Regulation Awareness

Malaysia has made progressive efforts to enforce laws and regulations for employers and employees. However, little is known about how employers and employees perceive enforcement. This led to the next interview question on the perceptions of the adequacy of Malaysia's current enforcement (e.g., OSHA, 1994) in OSH risk prevention. Most interview participants responded as follows:

Yes, we refer to OSHA, FMA, and DOSH regulations. (Interviewee 3).

It is adequate, but it still needs improvement in the future. (Interviewee 4)

Interviewee 2 agreed on the need to improve related regulations:

We always believe in continual improvements, as the improvement processes should not be halted at any point.

Conversely, Interviewee 1 noted the adequacy of the existing regulations. Current regulations were not the main issue:

To me, this is how we work. The regulations are more than enough. It's just that the enforcement is lacking.

Interviewee 1 subsequently described the following points:

The enforcement is less, and the understanding given to the employees is also less. There will be no problem if we comply with the existing regulations. It is just that sometimes there is a discipline problem among our people.

5.0 DISCUSSION OF RESULTS AND FINDING

Overall, most survey respondents in this study demonstrated knowledge of OSHA 1994. All survey respondents confirmed implementing the OSH risk management system. However, the risk management system was implemented manually without electronic software. Based on the results, this study did not provide adequate evidence to determine the convenience, trustworthiness, effectiveness, usefulness, or personal innovativeness of the manual system implemented in these SMEs. Although the results revealed that the existing system fulfilled the requirements of a risk management system, the implemented system was reported to be less effective.

The ineffectiveness of the risk management system may be due to its manual implementation of the risk management system without any electronic software. Some of the challenges in risk management performance are that all risk data are scattered across organizations, and the data may not be shared across business units and departments (Patterson & Executive, 2015). Therefore, organizations require tools to capture adequate risk information and evolution in computing and risk technology, and the development of new technologies can help them implement effective risk management (Patterson & Executive, 2015). Big data analytics and cloud computing can capture, extract, transform, and use legacy databases to conduct risk assessments, stress tests, and risk scenario analyses. Although it is costly to purchase systems, the costs of technological advancements can be reduced, and organizations may benefit from risk management process technologies.

Interviews were also conducted to explore how SMEs implement OSH risk management systems. First, the interview findings indicated the understanding of several SMEs on the importance of vigilance regarding OSH-related risks. Second, some SMEs in this study established S&H committees to help mitigate OSH-related risks. Third, SMEs implemented preventive organizational measures by mandating SOP, conducting audits, fixing deadlines, and showing warning signs to encourage OSH risk alertness. Furthermore, some SMEs highlighted their compliance with the DOSH guidelines using the HIRARC system in the context of risk evaluation and control. Non-conformance reports, auditing processes, and regular OSH meetings and inspections were identified as risk-monitoring mechanisms for SMEs to effectively and efficiently implement the OSH risk management system. The interview participants also emphasized the importance of top management's involvement in the OSH risk management system to ensure effective OSH risk mitigation.

Finally, interview participants reported the adequacy of existing OSH regulations and the need for practical improvements to mitigate OSH-related risks. One interview participant highlighted the need to improve employee awareness of OSH risk mitigation and enforcement. Specifically, employees' self-discipline was stressed as lacking in implementing the OSH risk-management system. Similarly, Sharma (2020) highlighted the need to implement a proper risk management system and initiatives to inculcate a robust organizational culture of risk management, which supports the present study's findings.

6.0 CONCLUSION

This study explored the implementation and effectiveness of an OSH risk management system and Malaysian OSH regulations for reducing occupational accidents and injuries. This study reveals that an OSH risk-management system has been implemented in SMEs to mitigate occupational accidents and injuries. However, OSH risk management was implemented manually without using electronic software to monitor risks effectively. Furthermore, this study revealed the adequacy of existing OSH regulations and the need for improvements in regulatory enforcement, employee discipline, and understanding of OSH from practitioners' viewpoint.

This study successfully expands the existing knowledge on implementing OSH risk management systems in Malaysian SMEs. SMEs play an essential role in the Malaysian economy, and knowledge of OSH-related performance is vital for regulators to formulate and design adequate risk management systems or processes. Organizations can mitigate occupational injuries and accidents that impede productivity. Based on the findings of this study, an effective technology-enhanced risk management process using electronic software or systems to capture, analyze, and predict existing prospective risk information is recommended. Better-informed management decisions may lead to actions that produce more reliable outcomes. Additionally, SMEs can connect and align organizational risks with appropriate resources to meet strategic objectives. Finally, this study provides valuable insights for OSH regulators to improve existing OSH regulations and develop better mechanisms to ensure compliance with OSH regulations.

However, the small sample size of survey respondents limited the study's findings' generalizability due to the lack of responses during the COVID-19 pandemic. Nevertheless, the data covered SMEs in all Malaysian states. Future research should increase the sample size to include more SMEs. Furthermore, insights or views from lower-level employees are essential to help SMEs improve their OSH risk management processes. Therefore, future studies should comprise employees at all levels.

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REFERENCES

Ab. Rahman, R. (2015). Managing Safety at Work Issues in Construction Works in Malaysia: A Proposal for Legislative Reform. Published by Canadian Center of Science and Education, Modern Applied Science, 9, 13.

Ackah, J., & Vuvor, S. (2011). The Challenges Faced by Small & Medium Enterprises (SMEs) in Obtaining Credit in Ghana.

Basole, R. C. (2004). The Value and Impact of Mobile Information and Communication Technologies. In *Proceedings of the IFAC Symposium on Analysis, Modeling & Evaluation of Human-Machine Systems,* 9, 1–7.

Bochkovskyi, A., & Gogunskii, V. (2018). Development of The Method for The Optimal Management of Occupational Risks. *Восточно-Европейский журнал передовых технологий*, 3(3), 6–13.

Bryman, A. & Bell, E. (2003). Business Research Methods. Oxford: Oxford University Press.

Gaoa, S., Krogstiea, J., & Siaub, K. (2011). Developing an Instrument to Measure the Adoption of Mobile Services. *Mobile Information Systems, 7*, 45–67.

Guion, L. A., Diehl, D. C. & McDonald. D. (2011). Conducting an In-depth Interview. Archival copy: for current recommendations, see http://edis.ifas.ufl.edu or your local extension office.

Hair, J. F. Ringle, C. M. & Sarstedt, M. (2011). PLS-SEM: Indeed, a Silver Bullet. *Journal of Marketing Theory and Practice, 19*(2), 139–151.

Hair, Joseph F., William C. Black, Barry J. Babin, & Rolph E. A. (2010). Multivariate Data Analysis. Upper Saddle River, NJ: Prentice Hall.

Henseler, J., Ringle, C. M. & Sarstedt, M. (2015). A New Criterion for Assessing Discriminant Validity in Variance-Based Structural Equation Modeling. *Journal of the Academy of Marketing Science,* 43, 115–135.

Hinze, J., & Hallowell, M. (2013). Construction-Safety Best Practices and Relationships to Safety Performance. *Journal of Construction Engineering and Management*, 139, 1–8.

Hong, K.T., Surienty, L. & Mui Hung, D.K. (2011). Occupational Safety and Health (OSH) in Malaysian Small and Medium Enterprises (SME) and Effective Safety Management Practices. *International Journal of Business and Technopreneurship*, 1(2), 321–338.

International Labour Organization (ILO). (2021). Press Releases: WHO/ILO: Almost 2 Million People Die from Work-Related Causes Each Year. Retrieved on November 5, 2021, from https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_819705/lang--en/index.htm.

Kadir, Z. A., Siti Hawa Mohammad, R., Othman, N., Amrin A., Muhtazaruddin, M. N., Abu-Bakar, S. H., & Muhammad-Sukki, F. (2020). Risk Management Framework for Handling and Storage of Cargo at Major Ports in Malaysia towards Port Sustainability, *Sustainability, 12*, 516. doi:10.3390/su12020516.

Kerry, T. V., Abas, N. H., Mohd Affandi, H. & Md. Amin, S. (2021). Stakeholder's Perceptions on the Significant Factors Affecting Safety Management Implementation at Construction Sites. *MCRJ, 13*(2), 68–80.

Kim, S. & Jung, D. (2019). Analysis of Environmental Complaints for Receptor-oriented Risk Management: Busan as a Case Study. *Journal of Environmental Health Sciences*, *45*(6), 605–612.

Krejcie, R.V. and Morgan, D.W. (1970). Determining Sample Size for Research Activities. *Educational and Psychological Measurement*, 30, 607–610.

Laukkanen, T. (1999). Construction Work and Education: Occupational Health and Safety Reviewed. *Construction Management and Economics, 17*, 53–62.

Milena, Z. R., Dainora, G., & Alin, S. (2008). Qualitative Research Methods: A Comparison Between Focus-Group and In-Depth Interview. *Psychology, Annals of Faculty of Economics.*

National Institute of Occupational Safety and Health (NIOSH). (2015). Hierarchy Controls. Retrieved on November 1, 2021, from https://www.cdc.gov/niosh/topics/hierarchy/default.html

Patterson, T., & Executive, C. C. S. (2015). The Use of Information Technology in Risk Management. *Complex Solutions Executive IBM Corporation*. Retrieved on November 18, 2021, from https://us.aicpa.org/content/dam/aicpa/interestareas/frc/assuranceadvisoryservices/downloadabledocuments/asec-whitepapers/risk-technology.pdf

Polinkevych, O., Khovrak, I., Trynchuk, V., Klapkiv, Y., & Volynets, I. (2021). Business risk management in times of crises and pandemics. *Montenegrin Journal of Economics*, 17(3), 99–110.

Ramos, D., Afonso, P., & Rodrigues, M. A. (2020). Integrated Management Systems as A Key Facilitator of Occupational Health and Safety Risk Management: A Case Study in A Medium Sized Waste Management Firm. *Journal of Cleaner Production*, *262*, 121346.

Semeykin, A. Y., Klimova, E. V., Nosatova, E. A. & Khomchenko, Y. V. (2020). Using Automated Risk Assessment Systems to Ensure the Safety of Personnel at Construction Sites. IOP Conf. Series: Materials Science and Engineering 9450, 12022 IOP Publishing. doi:10.1088/1757-899X/945/1/012022

Settembre-Blundo, D., González-Sánchez, R., Medina-Salgado, S., & García-Muiña, F. E. (2021). Flexibility and Resilience in Corporate Decision Making: A New Sustainability-Based Risk Management System in Uncertain Times. *Global Journal of Flexible Systems Management*, 1–26.

Smith, K. (2001). Environmental Hazards. Assessing Risk and Reducing Disaster (3rd ed.). London: Routledge.

Surienty, L. (2019). OSH Implementation in SMEs in Malaysia: The Role of Management Practices and Legislation: Volume II: Safety and Health, Slips, Trips and Falls. Research Gate. https://www.researchgate.net/publication/326850505.

Taofeeq, D. M. and Adeleke, A. Q. (2019). Factor's Influencing Contractors Risk Attitude in the Malaysian Construction Industry. *Journal of Construction Business and Management*, *3*(2), 59–67.

Teo, E.A.L., Ling, F.Y.Y., & Ong, D.S.Y. (2005). Fostering Safe Work Behaviour in Workers at Construction Sites. *Engineering, Construction, and Architectural Management, 12*(4), 410–422.

The Star (2020). Towards a Skilled Workforce. The Star, Available at https://www.thestar.com.my/opinion/letters/2020/09/07/towards-a-skilled-workforce.

Vijayan, V. K. & Sharma, N. (2020). A Study on the Impact of Dimensions of Risk Management on Risk Management Practices in It Projects in the UAE. *International Journal of Management*, 11(9), 754–769.

Wanberg, J., Harper, C., Hallowell, M. R., & Rajendran, S. (2013). Relationship Between Construction Safety and Quality Performance. *Journal of Construction Engineering and Management, 139*, 1–10.

World Health Organization (WHO). (2021). WHO/ILO: Almost 2 million people die from work-related causes each year. Retrieved from https://www.who.int/news/item/16-09-2021-who-ilo-almost-2-million-people-die-from-work-related-causes-each-year, on November 12, 2022.

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