Original Article

An Effective Safety and Health Implementation through Malaysia's Manufacturing Hazard Database

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ABSTRACT: *The manufacturing industry in Malaysia has recorded the highest number of workplace incidents, with 7,994 cases in 2021 compared to other economic sectors. These incidents are expensive and a hindrance for the industry to achieve its targeted productivity. Non-identification of workplace hazards has been identified by the Occupational Safety and Health Authority (OSHA) USA as one of the root causes of workplace incidents. However, conducting a proactive and ongoing process to identify and assess such hazards is highly challenging for industry players. Therefore, an online hazard database was developed to minimise the non-identification of hazards through a centralised repository database of mapped hazards, risk controls, and manufacturing parameters. Data were sourced from both primary (i.e. focus group discussion) and secondary (i.e.* Statistik Kemalangan Pekerjaan *(Occupational Accident Statistics), data from other health and safety organisations, and relevant research papers) source. The online hazard database is an accessible web-based application, which provides flexibility to enable a proactive and ongoing process for the identification of hazards by manufacturing companies in Malaysia.*

Keywords: *Hazard Identification, Hazard Data Gathering, Health And Safety, Online Hazard Database, Manufacturing Hazard*

1.0 INTRODUCTION

Clause 3.19 of ISO 45001:2018 Occupational Health and Safety Management Systems defines a hazard as a "source or situation with a potential to cause injury and ill health". OSHA considers the non-identification of hazards as one of the "root causes" of workplace injuries, illnesses and incidents and that a proactive, ongoing process to identify and assess such hazards is a critical element of any effective safety and health program [1]. Therefore, a thorough hazard identification process is the foundation of effective risk management, without which risks may be missed, misunderstood and mismanaged [2]. With the highest workplace incidence in 2021, ensuring that the hazard identification process is conducted systematically and effectively in Malaysia's manufacturing industry is imperative.

2.0 MOTIVATION AND RESEARCH CONTEXT

The manufacturing industry is inherently complex and involves numerous processes, machinery, and materials. As these processes evolve, identification, assessment, and mitigation of workplace hazards become paramount. Malaysia's manufacturing industry faces persistent challenges in hazard management due to a lack of knowledge and skills [3]. In addition, there is a lack of safety culture and non-compliance with the requirements of the Occupational Safety and Health Act 1994 [3]. These challenges increase the risk of workplace hazards and necessitate a proactive approach to hazard management.

This study addresses the critical need for an advanced and proactive approach to hazard management by designing and developing an online database of hazards. An online hazard database refers to a structured collection of relevant data on various hazards that may pose threats to safety, health, and the environment. This study investigated the use of an online hazard database as a proactive tool, facilitating a structured and systematic approach to hazard identification in Malaysia's manufacturing industry.

3.0 EFFECTIVENESS IN OCCUPATIONAL SAFETY AND HEALTH (OSH) IMPLEMENTATION

The costs related to workplace incidents go beyond loss of life and injuries. Employers reportedly pay almost USD 1 billion per week for direct workers' compensation costs alone [4]. Therefore, ensuring complete and comprehensive hazard identification is crucial to increasing the effectiveness of OSH implementation and reducing workplace incidents. Hazard identification will be more accessible and user-friendly if translated into an electronic system in line with industrial globalisation [5]. The digitalisation of hazard-related processes through an online hazard database will enable more effective and inclusive OSH implementation in the manufacturing industry. The online hazard database offers a structured and technology-enabled mechanism for navigating the intricacies of manufacturing safety by automatically listing all possible manufacturing hazards and process information faced by workers [6]. This is similar to the construction hazard database developed by Mihin (2018), which enables the automatic listing of possible hazards based on construction processes [6]. The online hazard database can reduce workplace incidents through complete and effective hazard identification with a central data repository, which eliminates the need for scattered spreadsheets or paper records, improves data accessibility, enables data standardisation, and automates reporting generation.

Based on a literature review of best practices in hazard identification, an effective implementation of hazard identification was modelled as SMARF3D with the following criteria:

i. International STANDARD and guidelines
ii. MAPPINGS of parameters, hazards and risk control
iii. Standardised REPORTING
iv. FLEXIBLE
v. Reputable DATA source
vi. Pre-defined DATABASE
vii. DIGITALISATION

The SMARTF3D model is the foundation for designing and developing the online hazard database. This approach ensures that the developed online hazard database is built with features and functionalities that can address problems and issues related to manual practice and implementation of hazard identification. In addition, the online hazard database was built from data sourced from reputable safety and health-related organisations, such as the International Standard Organisation (ISO), International Labour Organization (ILO), Health and Safety Executive (HSE) UK, OSHA, and the Canadian Centre for Occupational Health and Safety (CCOHS). In addition, a series of international standards provide data on hazards and risk controls for various types of machinery and packaging machines, such as preformed rigid container packaging machines and form, fill, and seal machines [8,9]. Examples of hazards were also sourced from research papers, such as hazard studies for corrugated box manufacturers [10]. All data were extracted, collected, and compiled as input for the online hazard database.

4.0 METHOD

The design and development of the online hazard database employs a mixed-methods research design and model, as depicted in Figure 1, with the most important element being data (primary and secondary) collection activities. The first step was the identification of primary and secondary sources, from which a list of data sources was developed. Once the data sources were identified, data collection was conducted, which included activities such as focus group discussions (FGD) and gathering and collecting data from secondary sources such as workplace incident data from the Department of Occupational Safety and Health (DOSH) and research papers. All data were compiled using Microsoft Excel and transferred to a cloud-based MySQL database. Data compilation and transfer also includes the design of a database to facilitate the design and functionality of a web application to host and manage the database. Finally, a validation process was conducted through reviews and user acceptance tests by manufacturing companies from various subsectors during the FGD. Figure 1 illustrates the flow of these activities.

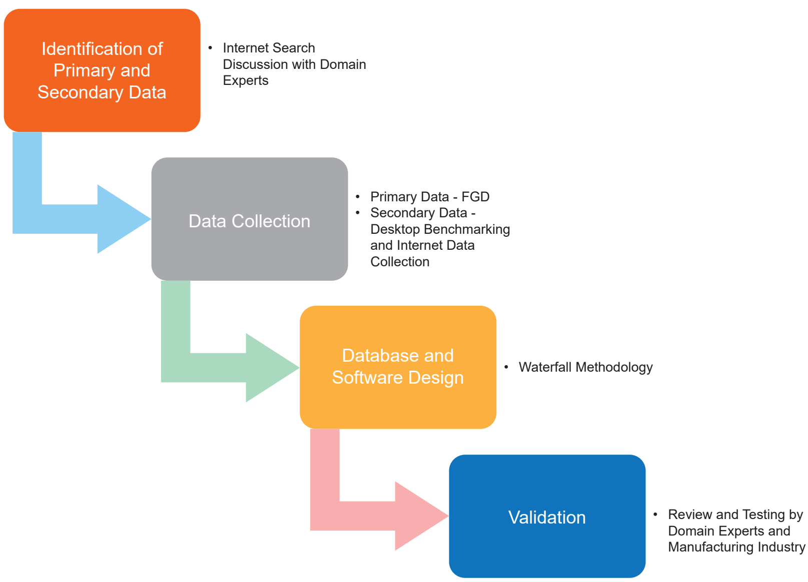

Figure 1: Research Activities and Methods

4.1 Identification of Primary and Secondary Data

The sources for primary data identification were gathered from the input and feedback of domain experts and research papers. The domain experts were OSH experts from NIOSH, the Department of Occupational Safety and Health (DOSH), the Social Security Organisation (PERKESO), and the Ministry of Health (MOH). A template for data collection (i.e. the Workshop Worksheet) was developed to record the input and feedback from domain experts and manufacturing companies during data collection. Data were collected on the manufacturing process flow and manufacturing parameters such as machines and materials, hazards, and risk controls.

Secondary data identification involved Internet searches and recommendations by domain experts. Data sources for secondary data, such as the *Daftar Kes Kemalangan, Kejadian Berbahaya, Keracunan Pekerjaan dan Penyakit Pekerjaan,* Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease (NADOPOD) and ILO's Occupational Hazards Datasheet, were recommended by domain experts and sourced from Internet searches with keywords such as hazard database, hazard listing, hazard for manufacturing, dataset hazards, and risk control listings. Section 4.0 Data Sources provides a more detailed list of Data Sources in the online hazard database.

4.2 Data Collection

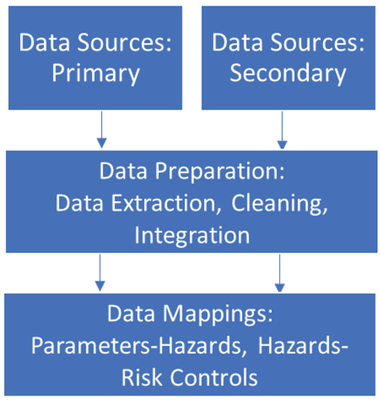

Figure 2: Data Collection Activities

Figure 2 shows the data collection activities conducted for both the primary and secondary data. To ensure that sufficient responses and data collected from the manufacturing industry were related to hazard identification, a compilation of an extensive list of manufacturing companies as respondents for data collection activities in this project was required. The manufacturers' list and database were compiled from SIRIM's Manufacturer Database, the Federation of Malaysian Manufacturers website, and internet searches. A total of 46 representatives from manufacturing companies from different subsectors based on the Malaysia Standard Industrial Classification (MSIC) agreed to participate in the data collection activities.

The method used for primary data collection with the domain experts and manufacturing companies was a collaborative workshop that encompassed brainstorming sessions and FGD to obtain more data related to hazard identification and implementation in manufacturing. Discussions were conducted in groups in which manufacturing companies exchanged ideas, practices, and suggestions under the facilitation of SIRIM. In addition to the FGD, all manufacturing companies were given access to the online hazard database (with their usernames and passwords). Data on hazard-related parameters in the manufacturing environment, such as process flow, machines, materials, hazards, past hazards, risk assessment factors, risk controls, and other relevant data, were collected using the Workshop Worksheet and directly from the online hazard database. A validation session was also conducted during the workshop, where the domain experts and manufacturing companies reviewed the online hazard database in terms of data and functionalities, and input was also recorded in the Workshop Worksheet with data on production process flow, top hazards, locations, and risk controls (Figure 3).

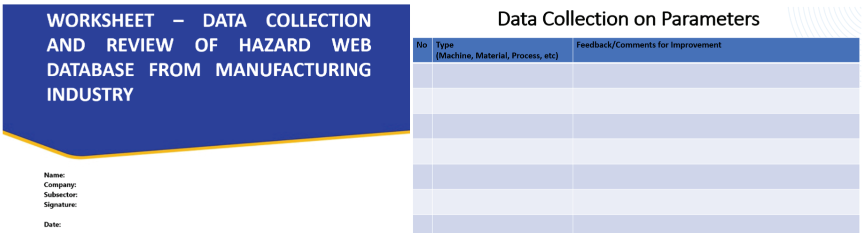

Figure 3: Workshop Worksheet

In terms of ethical considerations, the data collection process adhered to ethical guidelines, ensuring the confidentiality and anonymity of the participants. Informed consent was obtained from all interviewees and worksheet respondents, who were made aware of their right to withdraw from the study at any point without consequences. In terms of ethics and data protection, the project implemented the Personal Data Protection Act Policy under SIRIM Berhad to ensure respondents' data confidentiality. This Policy statement is also included on the online hazard database homepage.

Secondary data collection includes the consolidation and compilation of elements, such as parameters, hazards, and risk controls. Secondary data were gathered, mined, and collected via desktop research on the websites of OSH-related agencies, such as HSE UK and NIOSH US. Secondary data were sourced from books as well as scientific and professional papers on OSH. Examples of safety hazards, safety and design suggestions, and other information from books, journals, and conference papers dealing with manufacturing safety were used to identify hazards in the database. All data were analysed, categorised, and included in the online hazard database. The primary secondary data were workplace incident data from NADOPOD as depicted in Figure 4.

YEAR	SUB-SECTOR	OSHA	JANTINA	UMUR	GROUP FAEDAH	GROUP SEBAB KEMALANGAN	GROUP JENIS	GROUP BAHA	GROUP AGEN	NEGERI
2020	Pembuatan	Pengilangan	Lelaki	31	BUKAN MAUT	[100]Falls of persons	[41]Other wou	[712]Other ger	[232] Lorries	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	40	BUKAN MAUT	[400]Caught in or between objects	[41]Other wou	[408]Hand (exc	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	35	BUKAN MAUT	[400]Caught in or between objects	[41]Other wou	[408]Hand (exc	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	33	BUKAN MAUT	[400]Caught in or between objects	[41]Other wou	[409]Fingers (i	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	26	BUKAN MAUT	[120]Fall of the person on the sam	[20]Dislocation	[408]Hand (exc	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	22	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[105]Eye (inclu	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	33	BUKAN MAUT	[400]Caught in or between objects	[41]Other wou	[100]Head	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	34	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[409]Fingers (i	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	69	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[409]Fingers (i	[122]Transmis	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	55	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[712]Other ger	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	20	BUKAN MAUT	[400]Caught in or between objects	[41]Other wou	[408]Hand (exc	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Perempuan	24	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[408]Hand (exc	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	29	BUKAN MAUT	[400]Caught in or between objects	[10]Fractures.	[409]Fingers (i	[100]Machines	JOHOR
2020	Pembuatan	Pengilangan	Perempuan	58	BUKAN MAUT	[100]Falls of persons	[41]Other wou	[401]Shoulder	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	24	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[409]Fingers (i	[700]Agencies	JOHOR
2020	pembuatan	Pengilangan	Lelaki	29	BUKAN MAUT	[900]Other types of accident, not	[41]Other wou	[408]Hand (exc	[700]Agencies	JOHOR
2020	Pembuatan	Pengilangan	Lelaki	26	BUKAN MAUT	[400]Caught in or between objects	[41]Other wou	[409]Fingers (i	[700]Agencies	JOHOR

Figure 4: List of Cases under NADOPOD

4.3 Database and Software Design

The online hazard database was developed using a modular architecture that leverages modern web development technologies. It follows the Waterfall Methodology, which is a traditional software development methodology consisting of several phases, such as requirement analysis, design, development, testing, and deployment. Detailed information on the activities conducted for each process is as follows.

i. Requirement analysis
    a. Identify the specific data elements.
    b. Consider the types of data (numerical, textual, and multimedia) and their formats.

ii. Design
    a. Identify the attributes (data points) associated with each entity.
    b. Define the cardinality (one-to-one, one-to-many, many-to-many) of relationships between the entities.
    c. Translate the ERM into a logical data model using a specific database management system (DBMS), i.e. MySQL.
    d. Normalise the data model to minimise redundancy and ensure data integrity.

iii. Development
    a. Define the physical characteristics of the database, including data types (e.g. integers and strings) for each attribute and storage considerations.
    b. Optimise the database structure.

iv. Testing and Deployment
    a. Populate the database with hazard-related data.
    b. Test the functionality and integrity of the database by developing a web-based application.

The online hazard database comprises a front-end interface for users, back-end database for data storage, and robust application layer for processing and analysis. The database is designed to accommodate diverse industries with customisable data fields for hazard types, risk levels, and control measures. It follows best practices in relational database design, ensuring scalability, interoperability, and data integrity. The main output of Phase 1 is the database, which can be in any format, such as Microsoft Excel. However, in preparation for Phases 2 and 3 of the project, a web-based application was developed which enables the database to be displayed and used interactively by potential users. The web-based application is only a vehicle for displaying the developed hazard database conveniently to domain experts and the manufacturing industry during the process of reviewing and validating the data.

4.4 Validation

The review was conducted during a collaborative workshop with domain experts and manufacturing companies. This process includes the demonstration, review, testing, and use of the online hazard database. Simulations of the hazard identification process were conducted by OSH practitioners in manufacturing companies using the online hazard database system. Hazard identification reports were generated according to the input and use of the system for each manufacturing company. Manufacturing companies then provided inputs and feedback to ensure that the online hazard database system fulfils their needs and requirements. In addition to manufacturing companies, domain experts reviewed, tested, and used the system.

5.0 DATA SOURCE

Table 1 depicts the secondary data (e.g. standards, guidelines, research papers, and models) used as the input for the online hazard database and reference to determine its design and features

Table 1 Secondary Data and Relevance to Online Hazard Database

No.	Source	Description and Relevance to the Online Hazard Database
1	ISO 45001:2018 Occupational Health and Safety Management System	The standard provides definitions and requirements related to hazards and their identification.
2	ICOP Risk Management	The Industrial Conduct of Practice (ICOP) Risk Management provides the process of OSH management, including hazard identification. The online hazard database can generate reports based on the ICOP, i.e. *Borang Penaksiran Risiko (Risk Assessment Form).*
3	BS EN 425:2014 Safety of Packaging Machines	The data related to hazards and risk controls are extracted and included in the online hazard database.
4	Guidelines on Occupational Safety and Health (OSH) Risk Management for Small and Medium Enterprises in ASEAN Member States	This guideline provides a systematic and objective approach to identifying the hazard, assessing the risk, controlling the risk and monitoring and reviewing the risk management process and performance to ensure continuous improvement.
5	DOSH (2019), Industry Code of Practice on Chemical Classification and Hazard Communication	This document provides guidelines to classify chemicals used in the workplace Generation of Safe Work Procedure (SWP). The online hazard database shall be based on these guidelines.
6	ANSI B11.0-2015 American National Standard for Machines – Safety of Machinery	The data related to hazards and risk controls are extracted and included in the online hazard database.
7	International Labour Organisation, International Hazard Datasheets on Occupation	Inclusion of the data from the datasheet as well as relevant parameters in the design and development of the online hazard database.
8	Sri Indrawati and Atyanti Dyah Prabaswari (2018). Risk control analysis of furniture production activities using hazard identification and risk assessment method	The online hazard database is built upon the identification and mappings of parameters identified in the papers which are process, job, machine and material.
9	Canadian Centre of Occupational Health and Safety (CCOHS), Hazards: Hazard Identification MA + $H_2SO^{4\,d}$	Important for HIRARC to be done as comprehensively as possible with various sources of data. Provide suggestions from the article on the CCOHS website with the sourcing of data from sources as indicated.
10	Norazli Othman et al. (2017), Risk assessment and control measures for the printing ink production process	The identification of hazards in the online hazard database also follows the process as stated in the paper, i.e. identification of process.
11	Database Hazard Analysis by Precon-Food website	Hazard inventory lists all hazards that could possibly ever be present in the production process. Elements to be taken into consideration are materials, processes and others. The online hazard database also has a function to enable manufacturers to key in their hazards based on their experience.
12	Peter Hasle (2019), Safety and health in small businesses – between a rock and a hard place, ILO website	This paper emphasises the need for systematic hazard identification and practices. The design and development of the online hazard database is to assist and increase efficiency in health and safety implementation through a pre-defined database and easy-to-use web-based application.
13	Hazard Map	A hazard map is a map that highlights areas that are affected by or are vulnerable to a particular hazard. Implement the concept of the online hazard database with visualisation of process flow, which can highlight the top three hazards
14	Hazard and Operability Study (HAZOP)	The elements in HAZOP depicted in the example template are processes/steps, possible causes, consequences, safeguards and remarks. The online hazard database also includes elements of processes, causes, consequences and risk controls.
15	Hazard identification template from the Safety Culture website	The hazard identification template is used to easily identify and document potential sources of injury or damage from performing a task in a specific work area. Elements in the template are location, hazard type, hazard description, risk rating, and attachment. All the elements related to hazard identification in this template are also incorporated into the online hazard database.
16	Khoo Nee Kah, Hanipah Hussin and Norida Abdullah (2018). Managing Occupational Safety and Health Culture Practices at Small and Medium Malaysia Manufacturing Sector	This research highlighted the problems of accident cases in the Malaysian workplace in the manufacturing sector. Among the problems are a lack of knowledge, skills and other resources to implement OSH in their workplace, and lack of safety culture and non-compliance with the requirements of the Occupational Safety and Health Act (OSHA) 1994.
17	Marzuki Mardiana et.al (2022). Implementation	

Table 1 Secondary Data and Relevance to Online Hazard Database (continued)

No.	Source	Description and Relevance to the Online Hazard Database
	of OSH Risk Management among SMEs in Malaysia: A Systematic Review	Hazard Identification, Risk Assessment and Risk Control (HIRARC) system would be more accessible and user-friendly if translated into an electronic system in line with industrial globalisation. Ultimately, the shift into a more efficient system may encourage more SMEs to invest in the OSH risk management system. Accordingly, an electronic system is more user-friendly, easy to understand, and easy to monitor, saving more time, especially in the documentation process.
18	Matej Mihic (2018), Developing Construction Hazard Database for Automated Hazard Identification Process	The research proposes to develop a construction hazards database to automatically list all possible construction hazards faced by construction workers. This database needs to contain all relevant construction hazards and construction process information. The online hazard database, similar to the construction hazard database, enables the automatic listing of possible hazards based on manufacturing processes.
19	Adnan Khasavneh (2014), Improving occupational health and workplace safety in Saudi Arabia	In Saudi Arabia, there should be a National Centre for Healthy Working People to provide all database information and advise employers and workers concerning workplace health. The online hazard database is available as a web-based application that can provide information to employers and workers on workplace health and safety.

These standards, guidelines, research, and studies were used as inputs for the development of the web online hazard database, as depicted in Table 1. Regarding data and web applications, the online hazard database follows the best practices, requirements, and compliance of all these data sources.

6.0 RESULTS

The compilation, consolidation, cleaning, and collection of data, as explained in Sections 3 and 4, were materialised in the form of a data repository using Microsoft Excel. Microsoft Excel was later used to develop the structured database format MySQL, which categorises data based on defined tables and fields. Figure 5 shows the main tables and fields of the online hazard web database.

No	Table Name	Description	Rows of Data
1	tbl_hazardlisting	Table consisting of main hazard data with additional data such as hazard types, reference source, remark, etc.	793
2	tbl_hazarf type	Table consisting of hazard type data	5
3	tbl_process	Table consisting of manufacturing processes data-with additional data such as subsector, remark, reference source.	226
4	tbl_processty pe	Table consisting of process type data	3
5	tbl_activity	Table consisting of activity data. The activity is further mapped/correspond to the process data (process_id)	587
6	tbl_material	Table consisting of material data including chemical and raw materials with additional data such as remark and reference source.	216
7	tbl_machine	Table consisting of machine data with additional data such as remark and reference source.	149
8	tbl_location	Table consisting of location data related to manufacturing environment	173
9	tbl_riskcontrol	Table consisting of risk control data with additional data such as type, description and reference source.	666
10	tbl_hazardrisk	Table consisting of mappings of risk control and hazard	338
11	tbl_hazardprocess	Table consisting of mappings of hazard and process	340
12	tbl_hazardmaterial	Table consisting of mappings of hazard and material	310
13	tbl_hazardmachine	Table consisting of mappings of hazard and machine	175
14	tbl_job	Table consisting of job data (e.g. Welder)	38
15	tbl_jobhazard	Table consisting of hazard data related to job based on ILO datasheet	265
16	tbl_hazardjob	Table consisting of mappings job (11) and hazard (12)	274
17	tbl_infra	Table consisting of hazards related to infrastructure	55
18	tbl_warehouse	Table consisting of hazards related to warehouse	55

Figure 5: Database Tables

The database was deployed via a web-based application for easier and more systematic access. The web-based application is accessible at https://hirarc.sirimir.my/public/home and has two main roles/user types: Administrator and Company. The Administrator has access to the main hazard database (add/edit/update), while the Company is limited to viewing the main hazard database, selecting relevant data for the company, and generating its main hazard listing based on the selection. The amount of available data in the online hazard database is depicted in Figure 6, and the defined manufacturing sectors, as specified by MSIC, are depicted in Figure 7.

Figure 6: Total data in the online hazard database

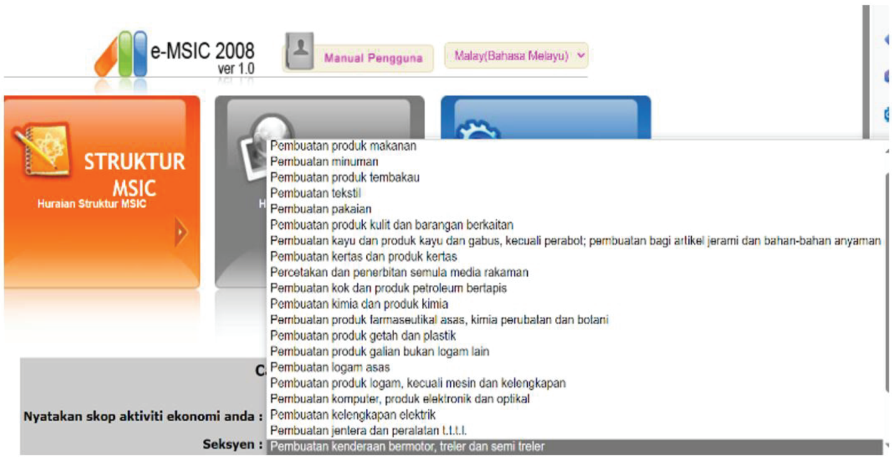

Figure 7: MSIC for Manufacturing

The online hazard database was also tailored for manufacturing environments that encompass various components from manufacturing-related parameters (e.g. machines, processes, and materials) mapped to hazards and risk control to comprehensively address potential risks. This is an important feature that sets it apart from other OSH-related software programs in that it consists of two separate but interconnected parts. The first is a manufacturing parameter database (containing manufacturing parameters), and the second is a hazard information database (containing manufacturing hazards and risk controls). Risk controls are information on the measures in place to control or reduce the risks associated with each hazard. This could include safety protocols, engineering controls, personal protective equipment (PPE), etc. The mapping of these elements is shown in Figure 8 below:

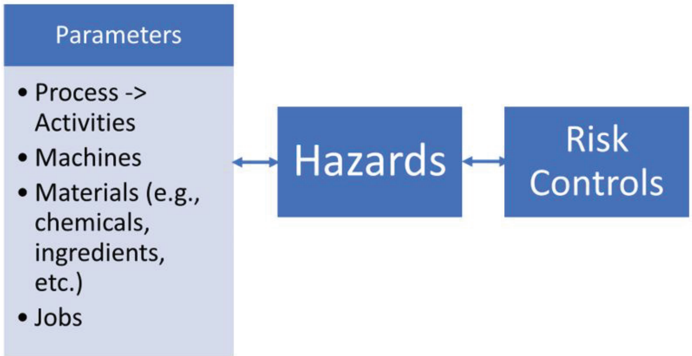

Figure 8: Mapping of Parameters, Hazards and Risk Controls

The online hazard database enables the manufacturing industry, based on its MSIC category, to select relevant displayed parameters (i.e. processes, materials, and machines). Once the processes are selected, manufacturing companies can select the mapped hazards relevant to them. These processes are repeated until all the processes related to manufacturing companies are completed. Next, the hazard mapping process continues for other parameters, such as machines and materials. This approach minimises unidentified hazards, as all possible hazards are automatically displayed based on all parameters relevant to the manufacturing company. Hazard data were mapped and matched with relevant risk controls. Each hazard in the online hazard database shall have multiple risk controls available to be picked and chosen by manufacturing companies based on their relevance, as depicted in Figure 9.

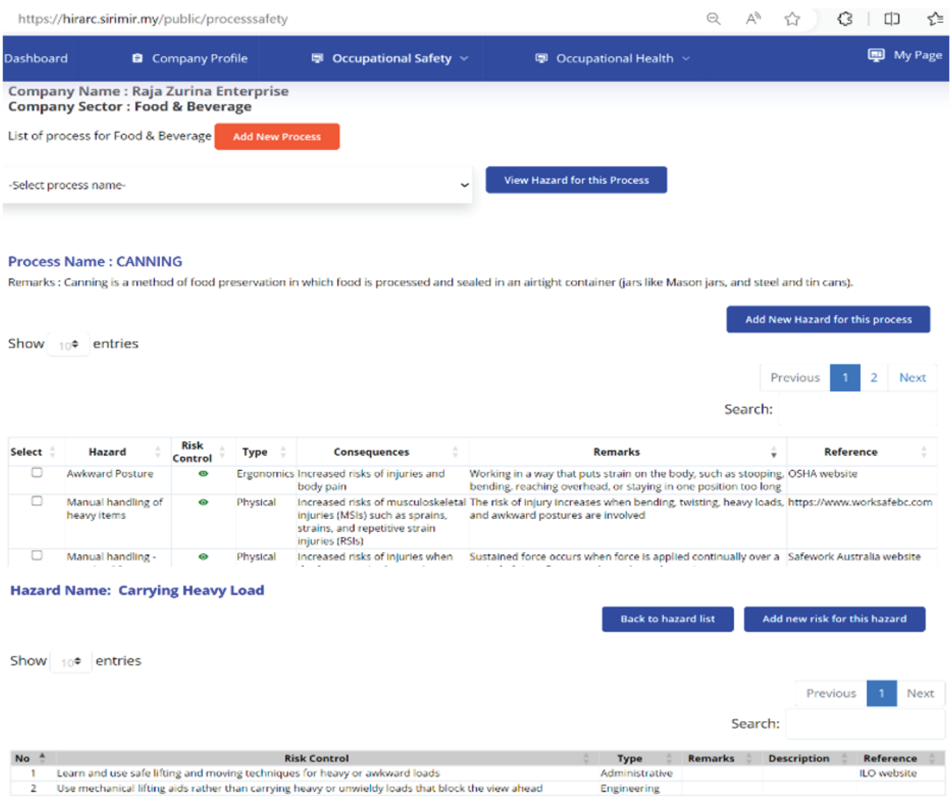

Figure 9: Mapped Parameters, Hazards and Risk Controls

One of the features of the online hazard database is its flexibility. Although the hazards are mapped with parameters and risk controls, companies have the flexibility to select relevant hazards and risk controls. This feature enables manufacturing companies to customise hazard data to suit their unique environments. Manufacturing companies can also add new hazards to ensure that complete hazard identification is conducted with the assistance of the online hazard database.

Another important feature of the online hazard database is its reference and compliance with relevant regulations and guidelines. Based on feedback during the validation activities of the online hazard database by domain experts, the online hazard database was developed based on the guidance and regulations related to hazard identification and management, that is, the Industry Code of Practice (ICOP) Risk Management. All data were curated and designed to meet these requirements. For example, based on the ICOP, there are five types of hazards: chemical, biological, physical, ergonomic, and psychosocial. The online hazard database data should follow these hazard types.

The compliance aspect of the online hazard database was also evident in the hazard identification reporting. The online hazard database follows *Borang Penaksiran Risiko* (Figure 10), in line with the ICOP Risk Management and Guidelines on Occupational Safety and Health (OSH) Risk Management for Small and Medium Enterprises in ASEAN Member States. They were used as a control mechanism to determine if all relevant activities were identified, as they also listed all activities, detailing conduct at the workplace. In addition to generating *Borang Penaksiran Risiko*, the online hazard database can also generate safe work procedures for machines and chemicals based on pre-defined input from manufacturing companies.

Borang Penaksiran Risiko

Department/Bahagian/		Penaksir risiko		Diluluskan oleh		RA Rujukan No:
Proses		Ahli RM 1		Tandatangan		
Lokasi		Ahli RM 2		Nama		
Tarikh penaksiran/ Tarikh kajian semula*		Ahli RM 3		Jawatan		
Tarikh penaksiran akhir		Ahli RM 4		Tarikh		

No.	PENGENALPASTIAN HAZARD								PENILAIAN RISIKO					KAWALAN RISIKO	PENILAIAN RISIKO SEMULA				KENYATAAN
	Aktiviti kerja	Hazard	klasifikasi Hazard					Peristiwa dan akibat	Kawalan risiko sedia ada (jika ada)	Justifikasi kemungkinan	Kemungkinan (L)	Keterukan (S)	RMN	Kawalan risiko tambahan	Kemungkinan (L)	Keterukan (S)	RMN	PIC (Tarikh akhir)	
			Fizikall	kimia	Biologi	Ergonomik	Psychosocial												

Figure 10: ***Borang Penaksiran Risiko***

7.0 DISCUSSION

This study introduces an online hazard database as a new knowledge base for OSH, with mapped hazards and parameters such as production processes (e.g. mixing, cooking, transfer, and packaging) and production machinery (e.g. mixing tanks, cookers, packaging machines, and sealer machines). The online hazard database, which is a consolidation and compilation of unstructured data (e.g. datasheets, hazard listings, questionnaires, and interviews), enables real-time and systematic hazard identification through digitalisation. Additionally, it is a transformative tool for the effective development and management of OSH, which is an ongoing process [10]. The identification of hazards through digitalisation is more accessible, user-friendly, easy to understand, easy to monitor, and time-saving, particularly in the documentation process [11]. Based on feedback from the manufacturing industry during FGD, the digitalisation of the hazard identification process, which is currently conducted using paper-based documents, can significantly improve hazard management. The online hazard database allows users to promptly input hazard information and fosters a culture of immediate reporting.

However, the online hazard database deployed as a web-based application has several challenges, such as data security and user training. Data security relates to the ability of the database to preserve its confidentiality, integrity, and availability because it is a cloud-based web application. User training has emerged as another challenge, particularly in industries with diverse skill sets and varying levels of technological familiarity. Addressing these challenges requires tailored training programs and ongoing support to ensure that all users can fully leverage the capabilities of online hazard databases.

8.0 CONCLUSION

Traditionally, hazard management in manufacturing has been reactive, responding to incidents rather than preventing them. However, a paradigm shift towards proactive hazard management strategies has been observed in recent years. A crucial tool developed to enable proactive hazard management is the online hazard database, which is a comprehensive repository designed to enable manufacturing to identify, assess, and mitigate potential hazards. Deploying a database in the form of a web application system provides greater flexibility for collaborative and inclusive hazard management. The online hazard database helps organisations proactively manage risks, enhance workplace safety, and comply with regulations.

The output of this study, the online hazard database, contributes to central repositories for hazard-related information. This facilitates effective OSH implementation through the comprehensive identification of hazards which has been proven to assist in reducing workplace accidents [12]. With digitalised hazard-related data in the online hazard database, it is possible to incorporate frontier technologies, such as artificial intelligence and big data analytics, to facilitate data-driven OSH development and management through the creation of an innovative descriptive/predictive dashboard. This dashboard, using data from NADOPOD,, provides forecasting and prediction of the likelihood and severity of hazards. The incorporation of this dashboard will increase its usability and guide users in conducting hazard assessments in a more accurate and informed manner. Predictive analytics is beneficial for assessing risk factors. It predicts the possibility of incidents, helps to identify relevant mitigation measures, and can be used to establish data-driven safety programs [13]. This can be further specified for top hazards, such as in the study of severity prediction models of falling risk for workers at height [14]. It can also be incorporated into IoT devices (e.g. sound sensors for noise detection) for real-time hazard detection. By incorporating sensors and monitoring devices, the online hazard database can evolve into a proactive system that not only relies on user input but also detects hazards autonomously.

In conclusion, the online hazard database represents a significant advancement in OSH risk management, as evidenced by its features of hazard reporting, data availability, and flexibility. It provides sufficient OSH knowledge and experience for employers and workers using hazard-related data from best practices and research studies. It also assists manufacturing companies in complete hazard identification by mapping hazards using manufacturing parameters. As technology evolves, addressing challenges and embracing future developments are essential to ensure its effectiveness and relevance. The collaborative and data-driven approach promoted by online hazard databases is valuable for the ongoing pursuit of safer workplaces for diverse industries.

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