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Safety Risk Assessment Using the HIRARC Method in Malaysian TVET Institutions

Rodzidah Mohd Rodzi*[1], Noor Ezlin Ahmad Basri[2], Zulkifli Mohd Nopiah[2]

[1]Manpower Department, Ministry of Human Resources,
Federal Government Administration Centre, 62530 Putrajaya, MALAYSIA

[2]Department of Civil Engineering, [3]Department of Engineering Education,
The National University of Malaysia, Bangi, 43600, Selangor, MALAYSIA

Email: rodzidah@mohr.gov.my

Abstract: Technical and Vocational Education and Training (TVET) institutions are exposed to various risks, as they involve industrial training that contributes to potential hazards. The problem statement of this study is to address risk management within an institution that operates 33 branches, each specializing in a different field. This study aims to assess occupational safety and health risks present in Malaysian TVET institutions. The study employs the Hazard Identification, Risk Assessment, and Risk Control (HIRARC) methodology. The study collected n = 190 qualitative reports, which were subsequently mapped onto a 5×5 two-dimensional matrix grid. The quantitative HIRARC assessment revealed that 139 risks (73.2%) were classified as low, 43 (22.6%) medium, and 8 (4.2%) high. The risk assessment identified the dominant contributing factors to be facility 61 cases or 32.1%, followed by maintenance 58 cases (30.5%), personal protective equipment 49 cases (25.8%), and ergonomics 22 cases (11.6%). This study enhances the understanding of risk assessment by utilizing mixed methods, which provide more detailed insights. The study recommends that future research broaden the scope of safety risk assessments to include educational institutions beyond TVET settings.

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*Corresponding Author:

Rodzidah Mohd Rodzi,
Manpower Department, Ministry of Human Resources,
Federal Government Administration Centre, 62530 Putrajaya, MALAYSIA.
Email: rodzidah@mohr.gov.my; rodzidah.mohr@gmail.com

1. INTRODUCTION

Occupational safety and health (OSH) is a critical component for ensuring operational continuity and protecting employees within an organisation [1]. Educational centres, particularly Technical and Vocational Education and Training (TVET) institutions, are also subject to this responsibility, as they provide industrial practicals involving manual labour, the use of machinery, sharp tools, and hazardous chemicals [2]. Therefore, systematic and effective risk management is essential to ensure that the safety of students, instructors, and institutional staff is consistently maintained throughout the teaching process [3].

Implementing safety and health risk assessments in TVET institutions with multiple branches and diverse skill areas presents a complex challenge. The diversity of training environments, coupled with varying levels of risk, complicates the standardisation of effective assessment methods across all institutions. In light of this, the objective of this study is to assess the OSH risks within Malaysian TVET institutions.

The scope of this study encompasses TVET institutions operated by the Manpower Department, Ministry of Human Resources Malaysia, which have been established since 1967. These institutions have 33 branches across Malaysia and offer training in ten main fields: Welding, Manufacturing, Production, Transportation, Engineering Services, Electronics, Electrical, Printing, Civil Engineering, and Information and Communications Technology (ICT).

The motivation for this study is to enhance occupational safety and health within TVET institutions, ensuring a safe and conducive learning environment for all members of the institution. Furthermore, this study could serve as a valuable reference for other educational policymakers in developing effective risk management strategies and fostering a culture of safety awareness among students, instructors, and institutional personnel.

2. LITERATURE REVIEW

Risk management plays a crucial role in OSH by systematically identifying, assessing, and controlling potential hazards in the workplace [4][5]. These processes are fundamental in preventing accidents, reducing workplace injuries, and promoting a safe and healthy environment for employees [6]. In the context of this study, which focuses on TVET institutions, emphasis on risk management is vital due to the daily use of technical equipment and hazardous materials [7]. Effective risk management not only protects instructors and students but also strengthens organisational productivity and ensures compliance with legal and regulatory requirements [8][9].

This approach aligns with Ulrich Beck's Risk Theory, which emphasises that modern society faces various man-made risks resulting from technological advancements and the transformation of social structures [10]. According to Beck, risks in contemporary society must be managed consciously, systematically, and structurally [11]. TVET institutions, especially technical workshops and labs, face considerable risks that must be managed effectively [12][13].

At the international level, risk management guidelines are outlined in the ISO 31000 standard, which establishes general principles and a framework for implementing risk management regardless of size or sector [14]. ISO 31000 states that risk management should be integrated into an organisation's structure, involving strategic leadership and a continuous process that includes risk identification, assessment, control, monitoring, and improvement [15].

Fig. 1 - Clause 6, ISO 31000:2018

Figure 1 displays the risk management process (Clause 6) as outlined in ISO 31000:2018. Clause 6.4 specifies the risk assessment process, which includes risk identification, risk analysis, and risk evaluation. Other subclauses are communication and consultation (Clause 6.2), scope, context and criteria (Clause 6.3), risk treatment (Clause 6.5), monitoring and review (Clause 6.6), and recording and reporting (Clause 6.7).

In Malaysia, a widely used method for OSH management is the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method, as implemented by the Department of Occupational Safety and Health (DOSH), Ministry of Human Resources Malaysia, in accordance with risk management principles [16][17]. HIRARC is a structured process that entails three main components: (1) identifying hazards, (2) assessing the level of risk, and (3) implementing appropriate controls [18]. This method not only complies with the requirements of the Occupational Safety and Health Act 1994 (OSHA 1994) but also serves as a safety practice guide for government training institutions [19].

A study by Abu et al. (2022) [20] demonstrated that the implementation of HIRARC has consistently been successful in reducing accident rates in technical training workshops at several TVET polytechnics. However, Ibrahim and Burhanuddin (2023) [21] found that risk analysis, data documentation, and safety monitoring are not standardized in their implementation. Therefore, strengthening the implementation of HIRARC by adopting the principles outlined in ISO 31000 has the potential to optimize the overall effectiveness of the safety management system. Additionally, this initiative supports compliance with local legal requirements and fosters a safety culture based on global standardization.

3. METHODOLOGY

This study employed the HIRARC (Hazard Identification, Risk Assessment, and Risk Control) method, a systematic approach for identifying hazards, assessing risks, and implementing control measures in the workplace. The aim was to assess OSH risks associated with specific activities or processes, and to devise suitable preventive and control measures. Risk data were analysed with reference to ISO 31000, as imposed under risk assessment (Clause 6.4), which comprises risk identification (Clause 6.4.2), risk analysis (Clause 6.4.3), and risk evaluation (Clause 6.4.4).

3.1 Hazard Identification

Hazard identification is a systematic process of finding, recognising, and recording potential hazards that can cause injury, illness, or damage in the work environment. This is a crucial first step in risk management and workplace safety.

The hazard identification within the institution was conducted through a survey form distributed to each employee. The study instrument consisted of 6 questions covering the name of the institute, description of the hazardous incident, location of the incident, frequency of occurrence, impact of the incident, and suggestions for improvement.

3.2 Risk Assessment

In this study, the HIRARC process was conducted in accordance with the guidelines provided by the DOSH, Malaysia. Risk assessment is a process used to determine the likelihood of a hazard occurring and the severity of its consequences, which is then used to evaluate the level of risk tolerance. The risk level was calculated using Equation 1.

$$Risk\ Level = Likelihood\ (L) \times Severity\ (S) \quad (1)$$

The risk likelihood and severity levels were represented by a 5 x 5 matrix that maps frequency levels against impact levels, as demonstrated in Table 1. Risk levels are categorized on a scale from low to high, represented by different colours: low risk (green), medium risk (yellow), and high risk (red).

Table 1 - Risk Matrix

	Severity (S)				
Likelihood (L)	**1**	**2**	**3**	**4**	**5**
5	**5**	**10**	**15**	**20**	**25**
4	**4**	**8**	**12**	**16**	**20**
3	**3**	**6**	**9**	**12**	**15**
2	**2**	**4**	**6**	**8**	**10**
1	**1**	**2**	**3**	**4**	**5**

Likelihood (L) refers to the probability of occurrence for a specified hazardous event, while Severity (S) pertains to the consequences of that event. Table 2 presents the levels of risk likelihood, and Table 3 categorises the different types of hazard severity.

Table 2 - Likelihood Levels

Likelihood	Description	Level
Certain	Hazard occurs frequently	5
Likely	Has occurred before and may recur	4
Possible	It may happen at some time	3
Unlikely	Not expected, but could occur	2
Rare	Has not occurred, but is possible	1

Table 3 - Severity Levels

Severity	Description	Level
Catastrophic	Death, permanent disability, severe environmental damage, or major disruption	5
Major	Serious injury or illness, significant impact on operations or environment	4
Moderate	Medical treatment required, moderate impact on operations or environment	3
Minor	Minor injury or illness, slight impact on operations or environment	2
Insignificant	No injuries, minimal or no impact on operations or environment	1

The calculated risk level determines the priority of action, classified as low (1–4), medium (5–12), or high (15–25) based on the risk score indicator. Table 4 displays risk level indicators on a scale of low to high.

Table 4 - Risk Level Indicator

Risk Score (Likelihood x Severity)	Risk Level	Colour code
15 to 25	High	Red
5 to 12	Medium	Yellow
1 to 4	Low	Green

These classifications help organisations to implement appropriate risk management strategies tailored to each category. Consequently, resources can be allocated effectively to mitigate potential threats and enhance overall safety.

3.3 Risk Control

The next step is risk control. Risk control refers to the actions and strategies taken to manage and reduce the likelihood or negative impact of risks. It involves choices such as completely avoiding risk, transferring risk, reducing risk through process controls, and periodic risk assessments to ensure preventive measures are effective. Table 5 shows the risk control measures.

Table 5 - Risk Control Measures

Risk Score	Risk Level	Action
15 - 25	High	Immediate action required
5 - 2	Medium	Take action to reduce risk where possible
1 - 4	Low	Tolerable. Monitor and ongoing observation.

4. RESULTS

The study collected a total of n = 190 qualitative responses, which were used as input for the risk report. The reports received detailed safety measures for workers, students, contractors, and guests. Each piece of feedback was assigned a unique Risk ID, based on the institute, date, and time sequence (R001-R190).

All risk IDs were mapped onto a two-dimensional matrix grid (5x5) represented in colour-coded form as low (green), medium (yellow), and high (red). This mapping aims to facilitate the monitoring of risk control actions with a keen eye. The findings of the safety and health risk assessment conducted at ILJTM are presented in a risk matrix map, as illustrated in Table 6.

Through the quantitative risk assessment, all identified hazards were categorised into three distinct risk levels: low, medium, and high. This categorization enables a more structured approach to prioritizing risk management efforts and implementing appropriate safety measures across the institutions. The HIRARC assessment of the study revealed a total of 139 low-risk, 43 medium-risk, and 8 high-risk cases. Figure 2 presents a pie chart illustrating the percentage distribution of these risk levels, which were 73.2% low (139), 22.6% medium (43), and 4.2% high (8).

Figure 3 illustrates the distribution of risk factors, which include facilities, maintenance, personal protective equipment (PPE), and ergonomics. According to the analysis results, the most significant reported risk was associated with facility hazards, comprising 32.1% (61) of responses. Followed by maintenance at 30.5% (58), PPE at 25.8% (49), and ergonomic at 11.6% (22).

Figure 4 demonstrates the highest risk levels associated with each hazard classification. The detailed breakdown of risks per factor is as follows: facilities (44 low, 14 medium, 3 high), maintenance (40 low, 15 medium, 3 high), PPE (38 low, 9 medium, 2 high), and ergonomics (17 low, 5 medium, 0 high).

Table 6 - Risk Matrix Map

	Severity (S)				
Likelihood (L)	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Catastrophic (5)
Certain (5)	R002, R020, R031, R067, R069, R077, R086, R094, R097, R102, R118, R119, R128, R141, R160, R176, R178	R035, R059, R147, R166, R184	-	R076, R179	R050
Likely (4)	R004, R009, R019, R026, R027, R038, R041, R053, R071, R091, R107, R133, R144, R154, R180, R188	R051, R149, R158	-	-	R012, R081
Possible (3)	R001, R006, R022, R036, R039, R044, R072, R085, R096, R106, R111, R120, R121, R124, R145, R168, R170, R174	R010, R023, R114, R162, R172	R115, R167	-	R101, R161, R181
Unlikely (2)	R003, R005, R007, R008, R011, R015, R016, R017, R018, R029, R032, R033, R037, R042, R047, R049, R054, R055, R056, R060, R063, R065, R074, R079, R083, R084, R088, R089, R093, R095, R098, R100, R103, R105, R109, R125, R126, R131, R139, R146, R150, R151, R152, R153, R156, R159, R163, R164, R165, R169, R182, R183, R185, R186	R061, R064, R078, R082, R099, R116, R122, R138, R171, R175, R187, R190	R052, R090, R117, R123, R134, R135, R136, R137	-	R030, R157
Rare (1)	R013, R014, R021, R024, R028, R040, R043, R046, R057, R058, R068, R070, R075, R080, R087, R092, R104, R108, R127, R140, R143, R155, R173, R177, R189	R045, R066, R110, R112, R113, R130, R132, R148	R025, R034, R048, R062, R073, R142	-	R129

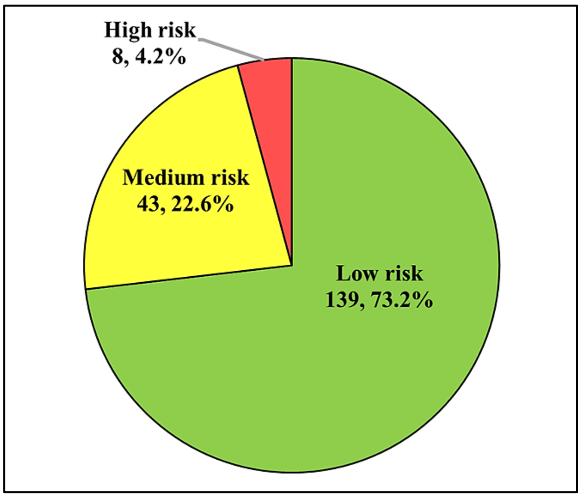

Fig. 2 - Risk levels of safety hazards

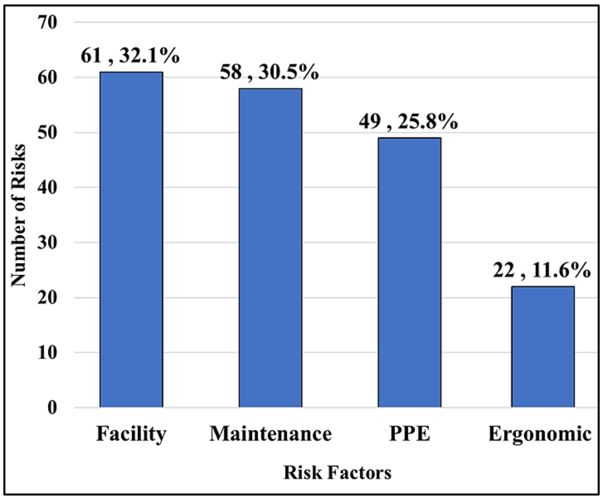

Fig. 3 - Distribution of risks by factor

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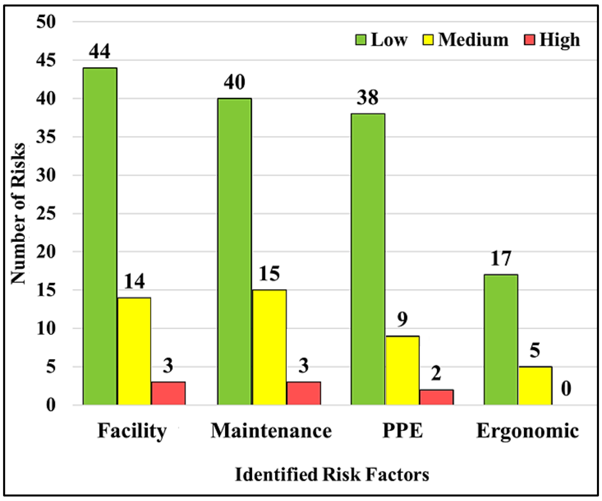

Fig. 4 - Breakdown of risks by factor

5. DISCUSSION

Based on the risk descriptions provided in the survey, several factors could potentially pose a danger. These include issues related to facilities, maintenance, PPE, and ergonomics. The identified risks affect the safety of various groups, including workers, students, contractors, and guests within the TVET institute's campus. The results also discovered 17 safety issues, which encompassed electrical, confined spaces, indoor air quality, slip, trip, and fall hazards, structural, chemical, mechanical, environmental, physical, fire and emergency risks, as well as the use of gloves, goggles, masks, aprons, boots, chairs, and stairs.

The dominant factor is facility hazard, which refers to risks arising from the physical environment and support systems of the workplace. These hazards can impact the health, safety, and comfort of both workers and students [22]. Among the reported facility hazards are electrical hazards, confined space hazards, indoor air quality hazards, and slip, trip, and fall hazards, as shown in Table 7.

The second factor is maintenance hazard, which refers to any risks arising from the maintenance, repair, or servicing of equipment, machinery, buildings, or systems [23]. These hazards have the potential to cause harm if appropriate precautions are not taken [24]. The reported maintenance hazards include structural, chemical, mechanical, and environmental hazards, as presented in Table 8.

The third factor pertains to PPE hazard, which encompasses two primary concerns. These include the inadequacy of PPE and the improper use of the supplied PPE. Risks related to PPE have been reported in Table 9.

The last factor is ergonomic hazard, which arises when the design of tasks, tools, or the work environment does not match an individual's physical capabilities and limitations. Such hazards can lead to musculoskeletal disorders (MSDs), fatigue, discomfort, or long-term injuries [25]. Some of the reported ergonomic hazards are listed in Table 10.

Table 7 - Facility Hazards

No.	Hazard	Risk Description
1	Electrical hazard	Scattered computer cables and disorganized plug points pose a safety hazard. At times, students have tripped and nearly fallen after hitting a heavy-duty PVC conduit and plug lying on the floor.
2	Confined space hazard	The number of students exceeds the capacity of the practical workshop space. For example, the grinding area is narrow, causing sparks to nearby students. Additionally, the limited space for storing equipment and performing machine maintenance results in instructors' and students' feet nearly getting trapped between the I-beam and hollow steel.
3	Indoor air quality hazard	The ventilation system is inadequate. Trainers and students often detect the smell of smoke from the welding process due to the absence of a chimney. Moreover, the lack of an industrial exhaust fan causes dust and dirt to accumulate, resulting in unpleasant odours daily.
4	Slip, trip, and fall hazards	There is no scissor lift available, so practical training is conducted using regular wooden ladders, which are wobbly and unstable. There have been incidents of students falling while practicing electrical maintenance. Also, the workshop loading bay lacks railings, creating a risk of students falling from the first floor.

Table 8 - Maintenance Hazards

No.	Hazard	Risk Description
5	Structural hazard	The leaking roof caused water to drip into the lecture room, resulting in standing water that has led to a mosquito problem. In the practical workshop, the floor was slippery, and several students tripped over cracks in the flooring. Meanwhile, in the laboratory, part of the ceiling collapsed as trapped animals tried to escape. Another issue occurred in the toilet, where students nearly slipped because the floor was mouldy.
6	Chemical hazard	The workshop floor was slippery and oily due to spilled hydraulic and engine oil, as well as a leak from the production machine. The students nearly slipped, and the floor was also covered with iron dust. A gas leak from a metal cutting tool ignited a fire at the source of the leak. Wood dust waste is dispersing throughout the workshop due to a faulty dust extraction system, leading to daily respiratory discomfort for the students.
7	Mechanical hazard	The machine tools used for student practical training were damaged, yet there was no maintenance budget. Malfunctioning local exhaust ventilation and blowers are exposing students to welding fumes. The air conditioner in the enclosed laboratory has remained unrepaired for an extended period, causing discomfort for students during learning sessions.
8	Environmental hazard	A flash flood at the entrance is making it difficult for staff to enter or leave the Institute. Improper waste management is creating an unpleasant smell. The presence of snakes, bees, and wasps poses a danger to students and staff.
9	Physical hazard	Students are at risk of slipping because of a leaking water dispenser. Missing drain covers increase the risk for students, particularly during heavy rainfall and overflow. A broken stair railing in the girls' hostel poses a hazard to students. The window mirror latch is loose. A near-miss incident happened when the fluorescent lamp casing fell off.
10	Fire and Emergency Hazard	Insufficient availability of fire extinguishers increases the risk of harm and death during emergencies.

Table 9 - PPE Hazards

No.	Hazard	Risk Description
11	Gloves	There are not enough supplies of gloves. Students have incurred hand injuries while operating grinder machines. During electronics training, students sustained a minor finger injury while using a wire cutter to install components on a PCB. Hand injuries occurred because the student did not wear fitting gloves.
12	Goggles	Suitable goggles are not currently provided for skills training. Students must wear anti-fog goggles during welding to ensure clear vision and maintain safety.
13	Masks	Some students did not wear safety masks to protect themselves from toxic chemicals, dust, sparks, and metal debris.
14	Aprons	The supply of aprons for students during welding work is inadequate.
15	Boots	Some students did not wear safety boots or appropriate attire during the technical training session.

Table 10 - Ergonomic Hazards

No.	Hazard	Risk Description
16	Chairs	The chairs provided in classrooms are not ergonomic, causing many students to experience back pain. There have been frequent incidents of students falling backwards due to the plastic chair legs suddenly bending or breaking. Similarly, the seating in computer labs is not designed for extended use. Instructor chairs are also in poor condition, primarily due to age and wear.
17	Stairs	The campus stairs are uneven, vary in size, and steep, making them unsafe for daily use. Students frequently slip, especially during rainy weather, when descending from the dormitory to the classrooms. Both students and staff have had near falls due to these non-ergonomic stairs.

6. CONCLUSION

This study successfully achieved its objective of examining risk assessment within the context of TVET institutions in Malaysia by applying the HIRARC method. The risks that potentially compromise the safety and health of instructors, students, and staff were identified and assessed. Key contributing factors include facility, maintenance, PPE, and ergonomic concerns. The HIRARC method proved effective in categorizing risk levels and proposing appropriate control measures to mitigate accidents and injuries. Overall, the identified risks align with those commonly encountered in TVET educational settings.

Recent years have seen students increasingly prefer institutions that provide a conducive learning environment and ample facilities. This risk assessment serves as a channel for instructors and students to communicate their safety precaution needs within daily teaching and learning activities. Given the inherently high-risk nature of TVET training, the institution prioritizes safeguarding the welfare of all personnel involved. Institutional spending is primarily focused on the provision of PPE and the enhancement of safety standards in both training sessions and residential campus areas.

Ultimately, this study highlights the significant impact of implementing risk assessments within TVET institutions. Notably, the institutions may allocate more resources to safety measures rather than extravagant events. Leveraging social media platforms remains an effective promotional strategy, considering the widespread use of mobile phones. The study recommends that future research broaden the scope of safety risk assessments to include educational institutions beyond TVET settings.

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