CURRENT SCIENCE AND TECHNOLOGY (CST)
VOL. 02, ISSUE 1, 59 – 66
DOI: https://doi.org/10.15282/cst.v2i1.8841

ORIGINAL ARTICLE

Causes of Accidents in Construction Industries during Covid -19

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ABSTRACT – Construction industry is the most critical industry which deals with high-risk activities every day. In fact, this industry reported the highest death rate for five years in a row, with 63 deaths in 2017, 118 deaths in 2018, 84 deaths in 2019, 58 deaths in 2020 and 23 deaths until March 2021. Although significant improvements have been made in occupational safety, the management and monitoring of the risks of such workplace activities are still challenging. Besides, working at construction site during pandemic increase the risk of accident when employees attempt to comply with both safety measures at the construction site and during the pandemic. Therefore, this paper intends to risk level of the selected accident types, investigate the causes of construction accidents and the correlation between the likelihood of the factors of accidents. Result shows that the most to the least risky types of accidents ranking are falling from height, falling objects, slips, trips, and falls, getting caught-in or -between moving or stationary objects, getting struck by moving objects, electric shock, exposure to chemical and sunstroke. Result also shows that eight subfactors are found to be the most influence root causes of accidents while three subfactors are the least influence. Six out of eight type of accidents are found to have a positive correlation with several factors of the accidents.

ARTICLE HISTORY
Received: 01st July 2022
Revised: 07th Nov 2022
Accepted: 09th Dec 2022

KEYWORDS
Construction industry, accidents causes, COVID-19

INTRODUCTION

At any construction site, the environment, the work to be completed, and the workforce are constantly changing, exposing workers to new and unfamiliar hazards. According to the statistic of occupational accidents by sector until March 2021 published by the Department of Occupational Safety and Health (DOSH) Malaysia, the construction sector recorded the fifth-highest total number of casualties and the highest death rate for five years in a row, with 63 deaths in 2017, 118 deaths in 2018, 84 deaths in 2019, 58 deaths in 2020 and 23 deaths until March 2021 [1]. According to conservative estimates, workers are involved in 270 million workplace accidents and 160 million occupational diseases each year [2].

The casualties in the construction industry have severe consequences, not only for the workers but their families, the public, the company itself and the project. Although significant improvements have been made in occupational safety, an alarming number of accidents and deaths indicate that managing and monitoring the risks of such workplace activities are still challenging for safety practitioners in the Malaysian construction sector. In addition, at the beginning of December 2019, the global population began to experience a novel coronavirus disease (COVID-19) outbreak.

The pandemic has adversely impacted numerous sectors, and the construction industry is no exception. Malaysia's Construction Industry Development Board (CIDB) has established a set of infection prevention guidelines and recommendations to halt the disease's spread. Individuals may need to alter their daily operations to adhere to these guidelines and suggestions[3]. Furthermore, the inherent labour-intensive nature of construction projects creates additional obstacles, as construction tasks must be completed onsite, and the Covid-19 safety measures must be adopted at the same time. Therefore, this study is conducted to explore the common factors of construction accidents, rank them based on risk levels and then test the relationships between the type of the accidents and selected factors. On top of that, workers' perceptions of the new standard operating procedures adapted from CIDB were also collected to see the trend of agreement or disagreement.

METHODOLOGY

A cross-sectional survey was conducted among construction workers in Malaysia. The criteria required by participants to be included in the study are (1) they are working during pandemic COVID-19 (between May 2021 and December 2021) and (2) the company they are working with is compliant with the COVID-19 standard operating procedure at the construction industry which CIDB sets. The questionnaire was developed by selecting common construction accidents and factors of accidents based on an extensive literature review and validated by an expert. The questionnaire of the survey consists of 54 questions divided into five parts. **Part I** consists of personal information questionnaires. The respondents were asked about their gender, age, level of education, current job position, and years of work experience. **Part II** of the questionnaire consists of several COVID-19 standard operating procedures at the construction site by CIDB as updated on 24th May 2021. Respondents were required to rate the scale of agreement according to their personal opinion, knowledge and experience based on the Likert Scale form with the rating from 1 to 5, which represents "1" as strongly disagree, "2" is disagree, "3" is neutral, "4" is agree and "5" is strongly agree**. Part III** of the questionnaire consists of several

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selected common construction accident types. Respondents were required to rate the likelihood of the accident types chosen from "1", which means inconceivable, "2" is remote, "3" is conceivable, "4" is possible, and "5" is most likely, based on their knowledge and experience. **Part IV** consists of similar accident types as part IV. But, respondents were required to rate the usual severity of the selected accident types in Part V from "1", which is negligible, "2" is minor, "3" is moderate, "4" is major, and "5" is catastrophic. **Part IV** consists of several selected construction accident factors categorised according to the Ishikawa diagram: Man, Machine, Materials, Method, Management and Environment. Respondents were required to rate the scale of influence for each factor based on the Likert Scale form with a rating from 1 to 5, which represents "1" as a lack of influence, "2" as a small influence, "3" as an average influence, "4" as big influence and "5" as a very big influence. The questionnaire was distributed through social media platforms such as LinkedIn, Facebook, Telegram, WhatsApp and Twitter.

RESULTS AND DISCUSSION

Demographic Information

In this study, the total number of respondents was 44. Most respondents are male (82%), and most have 5-15 years of experience working in the construction industry. In terms of age, most respondents (43%) are in the range of 31 to 40 years old. Based on the survey, 48% of the total respondents have a bachelor's degree, and 30% of respondents have a diploma or equivalent in terms of their educational background.

Covid-19 Standard Operating Procedure

Since the study was conducted during Covid 19 outbreak, workers in the construction industry need to adapt to the additional standard operating procedure. So, this study also took the opportunity to explore workers' perception of the mentioned procedures using the five Likert scale, as shown in Table 1. Most respondents agreed that the standard operating procedure required to comply by construction personnel during working activities could cause risk to the workers. This study found that 44.12% of the respondents agreed that the limitation of workers' capacity to 60% might cause manpower shortage and increase the worker's tiredness. 32.35% of the respondents agreed that the requirement for workers to wear face masks while doing vigorous tasks might cause breathing difficulty. 35.29% of the respondents agreed that wearing a face mask together with other PPE such as safety goggles might cause visibility problems as goggle get misty. Meanwhile, 47.06% of the respondents agreed that the pause of physical training or online training is ineffective; thus, workers are incapable of working efficiently due to a lack of training. However, most respondents (35.29%) do not have an exact opinion on whether to agree or disagree that a physical distance of 1 meter between employees could increase the difficulty for workers to complete the task as construction project delivery requires practitioners to collaborate with each other at the construction site. Findings show that complying with COVID-19 standard operating procedure during working at a construction site could cause risk to the workers.

Table 1 Perception of workers with Covid-19 Standard Operating Procedure

Description	Percentage (%)				
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
The limitation of workers' capacity to 60% might cause manpower shortage and increase the worker's tiredness.	8.82%	11.76%	20.59%	44.12%	14.71%
Physical distancing 1 meter between employees increases the difficulty of completing the task as construction project delivery requires practitioners to collaborate with each other on the construction site.	5.88%	23.53%	35.29%	29.41%	5.88%
Wearing face mask while doing vigorous tasks might cause breathing difficulty.	5.88%	17.65%	29.41%	32.35%	14.71%
Wearing face masks and other PPE such as safety goggles might cause visibility problems as goggles get misty.	8.82%	11.76%	20.59%	35.29%	23.53%
Workers are incapable of working efficiently due to a lack of training or inadequate online training.	5.88%	2.94%	26.47%	47.06%	17.65%

Types of Accidents and the Likelihood and Severity

Table 2 shows the respondent's agreement toward the likelihood and severity of the accident type in the construction industry. Falling objects and slips, trips and falls are the types of accidents agreed by 52.9% of respondents to be most likely to happen, followed by the accident of falling from height (47.1%). However, sunstroke is not the most likely accident to occur in the Malaysian construction industry, although the outside temperature (sun) is considered high compared to other countries. Referring to the severity column in

Table 2, accidents such as falling from height and electric shock may cause fatal (which is agreed by the majority of respondents); meanwhile, falling objects and slips, trips and falls may cause serious injury.

Table 2 Likelihood and severity of accident types

ACCIDENT TYPES	LIKELIHOOD: Frequency (%)					SEVERITY: Frequency (%)				
	Inconceiv-able (1)	Remote (2)	Conceiv-able (3)	Possible (4)	Most Likely (5)	Negl-gible (1)	Minor (2)	Serious (3)	Fatal (4)	Catastro-phic (5)
Falling from height	1 (2.9)	2 (5.9)	2 (5.9)	13 (38.2)	16 (47.1)	0 (0)	1 (2.9)	9 (26.5)	18 (52.9)	6 (17.6)
Electric shock	1 (2.9)	6 (17.6)	7 (20.6)	13 (38.2)	7 (20.6)	0 (0)	1 (2.9)	12 (35.3)	19 (55.9)	2 (5.9)
Falling objects	1 (2.9)	3 (8.8)	2 (5.9)	10 (29.4)	18 (52.9)	0 (0)	3 (8.8)	20 (58.8)	8 (23.5)	3 (8.8)
Slips, trips and falls	1 (2.9)	1 (2.9)	2 (5.9)	12 (35.3)	18 (52.9)	0 (0)	10 (29.4)	19 (55.9)	4 (11.8)	1 (2.9)
Getting struck by moving objects	1 (2.9)	2 (5.9)	6 (17.6)	14 (41.2)	11 (32.4)	0 (0)	4 (11.8)	13 (38.2)	13 (38.2)	4 (11.8)
Getting caught in or between moving or stationary objects	1 (2.9)	1 (2.9)	9 (26.5)	15 (44.1)	8 (23.5)	0 (0)	4 (11.8)	14 (41.2)	14 (41.2)	2 (5.9)
Sunstroke	2 (5.9)	7 (20.6)	11 (32.4)	8 (23.5)	6 (17.6)	1 (2.9)	15 (44.1)	13 (38.2)	4 (11.8)	1 (2.9)
Exposure to chemical	2 (5.9)	5 (14.7)	11 (32.4)	9 (26.5)	7 (20.6)	0 (0)	7 (20.6)	14 (41.2)	7 (20.6)	6 (17.6)

Types of Accidents and the Risk Level

Table 3 shows the risk level of each accident type. The likelihood and severity of the accident are obtained from the highest percentage in Table 2. Then, based on the value, the risk level is calculated. The result shows that falling from height recorded the highest risk level which is 20, as most of the construction tasks entail high-altitude activities such as working on a building's rooftop or repairing and installing wall tiles on the building's exterior surfaces [4]. Falls are classified into 11 categories which are falls from stairs or steps, falls through existing floor openings, falls from ladders, falls through roof surfaces, falls from roof edges, falls from scaffolding or staging, falls from building girders or other structural steel, falls while jumping to a lower level, falls through existing openings, falls from floors, docks, or ground level, and other non-classified falls to lower levels [5]. Previous research shows that out of all falling from height accidents, 28.36% fell from the outer surface, 19.39% fell from a building, and 11.33% fell from stairs [6]. In Malaysia, falls are a significant source of accidents, with 1042 incidents per year on average [1].

Getting caught in or between moving or stationary objects and getting struck by moving objects have the same high-risk level which is 16. This type of accident is more likely to occur as most construction activities involve machinery and vehicles like lifting equipment, crane, truck, etc [7]. In most cases, these two accidents have a high probability for the victim having severe injuries if she/he was not killed [8]. Most struck-by accidents occurred when a truck or dump truck was reversing, which might result in a fatality if the reverse alarm was tripped [8]. Getting caught in between the trucks could cause amputation or death [8]. Result also shows that electric shock accounted for 16 risk levels. 38.2% of the respondents agreed that electric shock accidents have a good chance of occurring, even not usual in the construction industry. Even though the likelihood is only possible, once it occurred, 55.9% of the respondents agreed that electrocution could cause fatality. Electrocution could cause serious burns, nerve and muscle damage, stop the heart and which lead to death [9]. This is because, in construction sites, the electricity voltage is very high as it usually comes from power lines, telecom lines, etc.

However, slips, trips, and falls, and falling objects recorded the highest percentage of most likely accident types to occur in construction, with 52.9%. The study shows that 80% of slips, trips and falls incidents involve running, walking, machine maintenance, turning on and off machinery, and repairing and handling materials [10]. 55.9% of the respondents even agreed that slips, trips, and falls could only cause serious injury instead of fatality. This accident could cause a broken bone, amputation, or other serious injuries. Therefore, the risk level of slips, trips and falls is 15. 58.8% of respondents agreed that falling objects could also cause severe injuries like head injuries. The majority of incidents caused by falling objects happened during form assembly or disassembly (21.71%), product manufacture or handling (12.51 %), loading or unloading (11.43 %), and worker transportation (10.44%) [11]. These are the typical

work activities in the construction site. For example, falling on sharp objects could cause severe head injuries without proper personal protective equipment like safety helmets [12].

Table 3 shows that the risk level of chemical exposure is 9. Construction workers are exposed to various chemical threats at the stage of design, construction and use of the building [7]. Construction works use various raw materials produced from potentially harmful substances. The potential chemical risk could be directly from the materials used at the building site or during the production of composites, such as clinker and dust from cement production [9]. Painting is the most common task that exposes workers to chemical hazards. Workers are exposed to resins, solvents, and pigments containing chemical agents that could pose risks if they contact the human body [13]. This accident rarely occurs, but it could happen anytime in the future. However, 44.1% of the respondents agreed that it could cause serious health disorders. Exposure to chemicals could cause severe burns, respiratory problems or poisoning. A study showed that it would not cause fatality but permanent disability like organ damage or congenital disabilities [13]. Heatstroke or other health hazards associated with hot climates like heat cramps and heat exhaustion are not very common in Malaysia [14]. 44.1% of the respondents thought working under Malaysia hot weather in construction sites could cause minor injuries to the workers. This is because they are only exposed to heat cramps like hyperthermia, heat exhaustion like fatigue and collapse without causing permanent disability [14]. Thus, data shows sunstroke is the least critical type of accident with a risk level of 6.

Table 3 The risk level of each accident type

Accident Types	LIKELIHOOD (L)	SEVERITY (S)	RISK LEVEL (L x S)
Falling from height	5	4	20
Getting caught in or between moving or stationary objects	4	4	16
Getting struck by moving objects	4	4	16
Electric shock	4	4	16
Falling objects	5	3	15
Slips, trips and falls	5	3	15
Exposure to chemical	3	3	9
Sunstroke	3	2	6

Factors of Accidents

Based on the Ishikawa diagram, the factors of construction accidents were further explored. The finding shown in Table 4, non-compliance workers (in Man row) and bypassing the safety control system (in Method row), are the "very big" influences on accident occurrence. Workers tend to violate construction rules, regulations or other requirements for self-comfort [12]. Certain workers consider the safety control system to complicate the task or process [12]. Therefore, workers tend to bypass the control system so that work can be done faster. Machinery defects or errors and improper working procedures are the second highest factor with 25%. When workers use defective equipment, they risk themselves. In most cases, warning light damage is one of the most critical defects as the machine could go wrong without warning [15]. Every task in a construction site comes with a proper procedure. However, most of accidents happen when workers choose to complete the job without following the provided procedure [15]. Other factors are lack of awareness and experience among construction personnel, machinery lack of inspection and terrible tidiness of workplace which recorded a high percentage of "very big" influence with 18.18%. Besides, a certified person should inspect machinery and maintain it [15]. Machinery with even the slightest damage should not be used. This is because it will also cause risk to the workers. 36.36% of "big influence" shows that providing insufficient training (see Management row) to the workers also could be the main cause of accidents [16]. This is because, without training, workers have less knowledge on how to perform the task, which could lead to an accident if the task is performed incorrectly [12]. On the other hand, season and atmospheric conditions shown of "small to lack of influence". These two factors are considered unimportant when considering Malaysia's weather [14]. The poor health state of workers (in Man row) only have a "small influence" with 43.18% of respondents agreed.

Table 4 Scale of influence for each factor (in Percentage)

Area	Factors	The Scale of Influence (Percentage) to Accident				
		Lack of influence	Small	Average	Big	Very big

MAN	Lack of awareness and experience among construction personnel	6.82%	15.91%	27.27%	31.82%	18.18%
	Poor health state of workers	9.09%	43.18%	29.55%	13.64%	4.55%
	Unqualified workers	6.82%	29.55%	27.27%	20.45%	15.91%
	Non-compliance workers	9.09%	13.64%	25.00%	25.00%	27.27%
MACHINE	Machinery defect or errors	4.55%	25.00%	31.82%	13.64%	25.00%
	Machinery lack of inspection	9.09%	20.45%	22.73%	29.55%	18.18%
	Age of machinery	6.82%	20.45%	38.64%	18.18%	15.91%
	Lack of guarding or safety features	6.82%	22.73%	29.55%	27.27%	13.64%
	Delayed maintenance of machinery	11.36%	22.73%	29.55%	22.73%	13.64%
MATERIAL	Use of dangerous materials	6.82%	20.45%	38.64%	20.45%	13.64%
	The use of substitute materials	2.27%	31.82%	40.91%	18.18%	6.82%
	Low-quality of construction materials	9.09%	20.45%	38.64%	18.18%	13.64%
	Improper working procedures	6.82%	15.91%	27.27%	25.00%	25.00%
METHOD	Inadequate use of personal protective equipment	6.82%	18.18%	36.36%	22.73%	15.91%
	Product handling mistakes	9.09%	22.73%	22.73%	31.82%	13.64%
	Bypassing safety control system	6.82%	13.64%	29.55%	22.73%	27.27%
	Inadequate accident prevention method	6.82%	20.45%	31.82%	29.55%	11.36%
MANAGEMENT	Inadequate special safety meeting	9.09%	22.73%	40.91%	18.18%	9.09%
	Delayed hazard elimination	2.27%	27.27%	25.00%	34.09%	11.36%
	No safety and health officer	11.36%	34.09%	25.00%	18.18%	11.36%
	Inadequate safety warning signs	6.82%	34.09%	38.64%	15.91%	4.55%
	Lack of inspection by safety committee	9.09%	22.73%	40.91%	20.45%	6.82%
	Lack of continuous training provided	6.82%	20.45%	29.55%	36.36%	6.82%
ENVIRONMENT	Season	20.45%	25.00%	38.64%	11.36%	4.55%
	Atmospheric conditions	20.45%	25.00%	38.64%	9.09%	6.82%
	Unsafe work location	9.09%	18.18%	25.00%	31.82%	15.91%
	Terrible tidiness of workplace	9.09%	11.36%	25.00%	36.36%	18.18%

Correlations Between Type and the Factors of Accidents

Spearman's rank-order correlations were run to examine the relationships between the type of the accidents and selected factors of accidents, as shown in Table 5. The result shows that most factors positively correlate with falling from height. Data indicates a moderate positive correlation between lack of awareness and experience among construction personnel, non-compliance workers, product handling mistakes, inadequate special safety meetings, delayed hazard elimination, and terrible tidiness of workplace with falling from height. Data also shows a strong positive correlation between improper working procedures and bypassing safety control systems. Next, falling objects also has a positive correlation with several factors. Findings show a moderate positive correlation between non-compliance workers, delayed maintenance of machinery, inadequate use of personal protective equipment, bypassing safety control system, and delayed hazard elimination with falling objects.

There is also a strong positive correlation between lack of awareness and experience among construction personnel, improper working procedures, product handling mistakes and terrible tidiness of workplace with falling objects and moderate positive correlation between improper working procedures and terrible tidiness of workplace with slips, trips and falls. Construction worksites are very common in disorganised environments, and terrible tidiness of the workplace could increase the risk of falling objects and slips, trips, and falls [10]. Therefore, good housekeeping is very crucial to minimise these accidents from happening. The study also found a moderate positive correlation between inadequate use of personal protective equipment with getting struck by moving objects and delayed hazard elimination with getting caught in or -between moving or stationary objects. There is also a moderate positive correlation between machinery defects or errors, the use of substitute materials, improper working procedures, and bypassing safety control systems with chemical exposure. In most cases, the use of substitute materials was meant to reduce the cost of materials but substituting with lower-cost chemicals without considering the effect or the characteristics of the chemical could increase the risk of chemical exposure [17].

Table 5 Correlation between likelihood and subfactors of accidents

Factors	Likelihood of Accidents / Subfactors	Falling from height	Electric shock	Falling objects	Slips, trips and falls	Getting struck by moving objects	Getting caught in or between moving or stationary objects	Sunstroke	Exposure to chemical
Man	Lack of awareness and experience among construction personnel	**0.362***	0.149	**0.443****	0.269	0.210	0.226	-0.095	0.188
		0.016	0.336	0.003	0.077	0.170	0.141	0.541	0.223
	Non-compliance workers	**0.312***	0.213	**0.301***	0.234	0.218	0.200	0.028	0.146
		0.039	0.164	0.047	0.126	0.154	0.194	0.855	0.346
Machine	Machinery defect or errors	0.278	0.171	0.251	0.202	0.176	0.171	0.017	**0.325***
		0.068	0.268	0.100	0.187	0.254	0.268	0.913	0.031
	Delayed maintenance of machinery	0.127	0.130	**0.310***	0.120	0.202	0.131	0.085	0.143
		0.410	0.401	0.041	0.437	0.189	0.398	0.583	0.355
	The use of substitute materials	0.246	0.076	0.239	0.190	0.200	0.180	-0.071	**0.334***
		0.108	0.625	0.117	0.217	0.192	0.244	0.649	0.027
Method	Improper working procedures	**0.404****	0.117	**0.429****	**0.370***	0.131	0.115	0.064	**0.320***
		0.007	0.450	0.004	0.013	0.395	0.459	0.681	0.034
	Inadequate use of personal protective equipment	0.294	0.287	**0.382***	0.096	0.190	0.244	0.171	0.231
		0.053	0.059	0.011	0.534	0.216	0.111	0.268	0.131
	Product handling mistakes	**0.343***	0.227	**0.424****	0.236	0.082	0.220	0.205	0.250
		0.023	0.139	0.004	0.122	0.595	0.152	0.182	0.102
	Bypassing safety control system	**0.419****	0.086	**0.307***	0.191	0.157	0.151	0.004	**0.332***
		0.005	0.581	0.043	0.214	0.310	0.328	0.982	0.028
	Inadequate accident prevention method	**0.332***	0.296	0.254	0.162	**0.309***	0.180	0.203	0.265
		0.028	0.051	0.096	0.292	0.042	0.242	0.186	0.082
Management	Inadequate special	**0.311***	0.235	0.229	0.084	0.086	0.188	0.071	0.133

safety meeting	0.040	0.125	0.135	0.590	0.581	0.221	0.646	0.389
Delayed hazard elimination	**0.352***	0.249	**0.347***	0.199	0.093	**0.345***	0.037	0.297
	0.019	0.104	0.021	0.196	0.549	0.022	0.811	0.050
Terrible tidiness of workplace	**0.322***	0.211	**0.402****	**0.372***	0.195	0.160	0.080	0.167
	0.033	0.170	0.007	0.013	0.204	0.300	0.606	0.279

**Correlation is significant at the 0.01 level (2-tailed).
*Correlation is significant at the 0.05 level (2-tailed).

CONCLUSION

It can be concluded that the most to the least risky types of accidents ranking are falling from a height, falling objects, slips, trips, and falls, getting caught in or between moving or stationary objects, getting struck by moving objects, electric shock, exposure to chemical and sunstroke. Eight subfactors are found to be the most critical causes of accidents, while three subfactors are the least important. Results also found that falling from a height, falling objects, slips, trips and falls, getting struck by moving objects, getting caught in or -between moving or stationary objects, and chemical exposure has a positive correlation with several factors of the accidents. As construction is one of the most high-risk industries, safety precautions should be continuously applied. The number of accidents should be minimised by keeping implementing and improvising safety elements at the construction site. In addition, as this study's findings show that complying with COVID-19 standard operating procedure could cause risk to construction workers, safety measures should be taken to avoid accidents. Without a doubt, managing occupational safety and health risk in the construction industry is not easy. With a new thread (Covid-19), the tasks are now becoming tougher. So, everyone involved with the job at any construction must work together to ensure workers in the workplace are protected from harm. More research is warranted to explore the existing safety measure further, and whether the current techniques are still effective or require further modification must be checked and validated.

ACKNOWLEDGEMENT

The author would like to thank individuals who directly and indirectly contribute to the research. Special thanks to the Faculty of Industrial Sciences and Technology, Universiti Malaysia Pahang (www.ump.edu.my), for the facilities provided.

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