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RISK ASSESSMENT OF THE MALAYSIAN AGRICULTURE, FORESTRY, AND FISHING FATALITIES USING FAULT TREE ANALYSIS

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Abstract

Malaysia's agriculture, forestry and fishing sector has persistent fatality risks, shaped by mechanisation, remote work settings, and informal employment. This study analysed 103 fatal AgFF accidents investigated by the Malaysian Department of Occupational Safety and Health (DOSH) between 2010 and 2020, using structured extraction from case summaries to derive accident type, activity, employment status, state, exposure set, and source of injury. Descriptive analysis summarised distributions, and associations were tested using chi square with effect size measures. A fault tree model was then constructed to represent plausible causal pathways linking exposure sets and sources of injury to accident types. In descriptive counts, "struck by object" was the most frequent fatal accident type. In the fault tree results, "fall from height" ranked higher because the model estimates scenario contributions along dominant exposure source pathways, rather than reporting raw marginal frequencies only. The findings prioritise prevention efforts around transport related tasks and tractor or trailer scenarios, alongside targeted controls for struck by object events.

Keywords: fatal injury, agriculture, forestry and fishing, fault tree analysis.

1.0 INTRODUCTION

According to annual reports from the Department of Occupational Safety and Health of Malaysia (DOSH), the number of reported injuries has increased rapidly in the past decade from 2010 to 2020 [1]. Three thousand and one hundred thirty-one work-related injuries were reported in 2015, while 7984 were reported in 2019 and 6686 in 2021 [1]. The Department of Occupational Safety and Health investigates accidents reported by employers in the agriculture, forestry, and fishing (AgFF) sector to ascertain the scenarios of these accidents, their causes, and a brief description explaining the events leading to the accident. Under the Occupational Safety and Health Act of 1994 (Act 514), AgFF employers in Malaysia must record and report work-related injuries, and DOSH is required to investigate all reported accidents [2].

Between 2015 and 2021, there was an apparent uptick in the total number of agriculture, forestry, and fishing-related injuries in Malaysia, whether it is a fatal injury, permanent disability, or non-permanent disability, requiring prompt action to prevent further injuries [1]. Injuries in the Agriculture, Forestry, and Fishing (AgFF) industries nearly doubled from 2015 to 2021; 2015 recorded

480 injuries, while 2021 recorded 973 injuries. The highest number of injuries was reported by DOSH in 2019, with 1176 injuries (Table 1). Arifin et al. [3] also highlighted the industry sector with the highest mortality rates in agriculture, forestry, fishing, and hunting (32.5 per 100,000 workers). Statistics published by DOSH indicate that the construction sector is the most hazardous industry, with the highest number of recorded fatalities [4]. However, Tamrin [5] found a severe case of under-reporting injuries and deaths within the AgFF sector, which further supports the findings from Arifin et al. [3].

Table 1 agriculture, forestry, and fishing accidents in Malaysia from 2015-2021 (DOSH, 2021)

Year	Non-permanent disability	Permanent disability	Death	Total
2015	440	9	31	480
2016	435	9	23	467
2017	488	11	23	522
2018	709	14	26	749
2019	1111	22	43	1176
2020	916	20	43	979
2021	939	18	16	973
Total	5038	103	205	5346

Despite recurring concerns about under reporting and the safety impacts of mechanisation, Malaysian AgFF safety research has largely remained descriptive, with limited application of causal pathway modelling that can translate brief investigation summaries into structured accident chains. This limits the ability to prioritise controls based on how exposure contexts and injury sources combine to produce fatal outcomes. Therefore, this study applies fault tree analysis to complement descriptive patterns with an explicit causal structure. These conditions increase human factors and ergonomic risks, including reduced tolerance to physical demands, higher likelihood of slips and loss of balance, variable competence with machinery, and weaker supervision and emergency response in remote settings, which together can amplify fatal accident pathways.

To investigate the causes and factors around fatal AgFF injuries in Malaysia using data from the Department of Occupational Safety and Health (DOSH), including variables such as the workers in the AgFF sector activities and the nature of the fatality. This research aims to investigate fatal injuries in the AgFF sector and determine the sources of exposure and the leading causes behind them. As more research is conducted into the causes and mechanisms of such fatalities, better countermeasures can be created to prevent them from happening again. This research helps shed light on the most common causes of death in the AgFF industry in Malaysia, which worker activities are at the most risk, the occupational safety and health exposure sets, and the sources of AgFF fatalities.

1.1 The Malaysian agriculture, forestry, and fishing sector

The late Deputy Prime Minister Tun Abdul Razak made a central focus of his 1969 speech announcing the establishment of the Malaysian Agricultural Research and Development Institute (MARDI). He argued that "the rapid increase in palm oil production, the expansion of acreage planted to high-yielding padi varieties, the recent increases in tapioca production, and the current interest in sugar cane, cocoa, maize, soya beans, groundnuts, sorghum, and other crops" all showed that the country was making steady progress toward diversifying the Malaysian agriculture [6]. Since then, rubber, palm oil, and cocoa have dominated agricultural exports in Malaysia. The Malaysian government devotes nearly 24% of its land to agriculture, and around 43,000 different types of machinery and tools are used on this land [7]. Peninsular Malaysia rarely experiences hurricanes or droughts, making the country's tropical climate ideal for growing various exotic fruits and vegetables [7]. However, from 1984 to 1991, the "unfavoured" agricultural sector lost some of its economic prominences due to the rapid expansion of other industries. However, it still contributed significantly to the gross domestic product (GDP) [8].

Furthermore, the AgFF GDP numbers have decreased annually from 7.5% of total GDP in 2010 to 6.4% in 2015 and, finally, 5.2% in 2020, and as income increases, the share of AgFF GDP will continue to drop [9]. Finally, as the number of farmers in Malaysia decreases, the average age of those still working on the land increases [7].

The Third National Agricultural Policy inspired advances in the agricultural use of land. It increased workers' participation to meet the demands of the current market for agricultural produce. Approximately 1.4 million people are now employed in agriculture, up from 1.2 million [10]. Additionally, new accidents are more likely to occur in the AgFF industry due to the rising workforce and demand. The International Labour Organization (ILO) reports that agricultural work is one of the most dangerous jobs in the world, and similar trends can be seen in the AgFF industry in Malaysia [10].

An ageing workforce may increase susceptibility to falls, fatigue, and reduced recovery capacity after an incident, while mechanisation increases exposure to moving plant, entanglement, run over events, and vehicle related loss of control. Remote work locations can delay rescue and reduce enforcement presence, making preventative controls more critical. These interacting features support the need for an approach that can model multi step causal pathways rather than only reporting frequencies, which is why the present study integrates fault tree analysis with descriptive statistics.

In practice, mechanisation changes the dominant energy sources in work tasks, increasing exposure to moving vehicles, rotating machinery, and dynamic loads during transport and handling. Remote sites reduce the reliability of supervision, emergency response time, and enforcement coverage, which can increase tolerance for unsafe short cuts. An ageing workforce can increase vulnerability to slips, trips, and balance related failures, and may also interact with fatigue and heat stress during peak periods. These contextual drivers motivate a modelling approach that distinguishes exposure sets, injury sources, and accident types.

1.2 Work related injuries in the Malaysian AgFF sector

Research on work related injuries and fatalities in Malaysia has been dominated by studies of the construction and manufacturing sectors. Numerous investigations have examined construction fatalities [4], [11]–[14], [17]–[21], manufacturing injuries [22]–[25], fatal falls from height [4], [19]–[21], struck by accidents [26], and organisational safety culture [23], [24]. In contrast, fatalities in the agriculture, forestry, and fisheries (AgFF) sector have received comparatively limited analytical attention, despite the sector’s recognised economic importance and its consistently high exposure to occupational hazards. This imbalance in the literature constrains understanding of fatal risk patterns in AgFF and limits the development of evidence based prevention strategies tailored to the sector.

International studies indicate that AgFF work is characterised by persistent and multifaceted fatality risks. Bailer et al. [15], analysing fatal injury rates in United States agriculture, forestry, and fisheries industries from 1983 to 1992, reported that while crude fatality rates showed no statistically significant decline over time, regression based analysis revealed important associations between demographic factors and temporal trends. Similarly, Arcury et al. [16] documented widespread pesticide exposure among farmworkers, demonstrating how occupational risk is shaped by employment status, education, and task specific practices. These findings suggest that fatal outcomes in AgFF are rarely attributable to single hazards and instead emerge from interacting technical, behavioural, and organisational conditions.

In Malaysia, available evidence reinforces this complexity while also highlighting important data limitations. Abas et al. [26] found that traffic related incidents were the leading cause of fatalities among non governmental workers, and that agricultural accidents occurred more frequently than construction accidents. Farming environments involve routine interaction with vehicles and machinery in settings that are less controlled than industrial worksites and often shared with family members, extending exposure beyond formal workers [7]. Such conditions create overlapping occupational and domestic risk pathways that are not easily captured by sector level fatality counts or single cause classifications.

The interpretation of AgFF fatality patterns is further complicated by systematic underreporting. Tamrin [5] identified substantial underreporting of work related injuries in Malaysia, particularly in sectors with weak safety management and reporting systems. Workers were less likely to report incidents when procedures were unclear or when compensation mechanisms imposed additional financial burdens. These reporting deficiencies distort observed injury and fatality trends and limit the reliability of descriptive analyses that rely solely on officially reported cases.

Existing Malaysian AgFF studies have largely focused on specific hazard categories or behavioural factors rather than causal escalation mechanisms. Ergonomic risk assessments and musculoskeletal disorder prevention tools have been developed for plantation and agricultural work [10], [28], [29], while other studies have examined knowledge, attitudes, and practices related to pesticide exposure [10], [27], [30]. Although these studies provide valuable insight into individual risk factors, they do not model how multiple hazards, failures, and conditions interact to produce fatal outcomes. Similarly, descriptive analyses of DOSH accident data, such as those by Jemali et al. (2021), summarise observed patterns but stop short of identifying causal pathways or evaluating the relative contribution of upstream failures.

As a result, the current literature lacks a systematic approach for representing the combinations of events and conditions that lead to fatalities in the AgFF sector. Without explicit causal modelling, it remains difficult to identify dominant accident pathways, assess the role of intermediate failures, or prioritise preventive controls based on their position within the accident sequence. This limitation is particularly consequential in a sector characterised by heterogeneous work activities, incomplete reporting, and interacting technical and human factors.

Against this background, a pathway based analytical approach is required to move beyond frequency based descriptions toward a structured representation of how fatal accidents occur in the AgFF sector. Fault Tree Analysis offers a transparent and logically rigorous framework for decomposing fatal events into their contributing conditions and failure combinations, making it well suited for analysing complex occupational fatality mechanisms under data constrained conditions.

Given that available DOSH summaries are brief, a structured pathway method is required to systematically translate narrative cues into exposure set, injury source, and accident type relationships, enabling clearer prioritisation of prevention targets.

1.3 Fault Tree Analysis

It is common to practise conducting a workplace safety analysis using accident causation models [31]. Chi et al. [32] used FTA to illustrate the events and factors that led to fatal falls in the construction industry. Results found that unsafe behaviour was the leading cause of fatal falls in the Taiwanese construction industry. Giraud and Galy [33] used fault tree analysis to predict the potential outcomes of a cage crash inside a shaft and offered two different fault tree types as potential solutions. Bakeli and Hafidi [34] examined construction site incidents using the Fault tree analysis tool. The authors viewed the site as a complex system where problems can arise. Similar to Chi et al. [32], Zermane et al. [4] used a quantitative fault tree analysis to uncover fatal falls from heights accident scenarios and their immediate and root causes. Overall, FTA has shown its utility in investigating various accidents, both quantitatively and qualitatively, by analysing the accident scenario and identifying similarities, probabilities, and root causes.

Despite the sector's scale, Malaysian AgFF fatality evidence is still dominated by descriptive summaries and under reporting concerns, with limited application of causal or systems modelling that explicitly connects work context, exposure conditions, injury sources, and accident mechanisms. This is a practical limitation because administrative case summaries are short and heterogeneous, yet they still contain repeatable cues about equipment interaction, unsafe system states, and work organisation factors. A structured modelling approach is therefore needed to translate brief narratives into consistent prevention priorities, including human factors and ergonomics contributors such as training adequacy, task pacing, supervision constraints in remote locations, and equipment design interactions.

Fault tree analysis was selected because it provides a transparent deductive structure that can be populated using limited narrative information, allowing consistent mapping from exposure context to injury source to accident type even when case descriptions are short. In comparison, event tree methods start from an initiating event and model forward outcomes, while systemic approaches such as STAMP or AcciMap emphasise organisational control and socio technical factors. In this study, fault tree analysis is used as a practical bridge between brief narrative summaries and an explicit causal pathway representation suitable for quantification.

In this study the fault tree is not treated as a perfect reconstruction of causal history for each case. It is used as a structured representation of recurring scenario logic extracted from consistent narrative cues, enabling prioritisation when full investigative detail is unavailable. Alternative systemic methods such as bow tie, event tree, Accimap, or STAMP can also represent multi-level causation, but they typically require richer organisational and barrier information than what is available in short administrative summaries. Fault tree analysis is therefore used here as a pragmatic intermediate, linking exposure conditions and injury sources to accident mechanisms under clearly stated assumptions.

2.0 METHODOLOGY

This study was carried out to better understand the factors contributing to the increased rate of fatal occupational accidents with AgFF in Malaysia. Understanding the patterns across potential future AgFF accident scenarios is also recognized as an essential part of preventing such incidents in the future, which is the focus of this research. The initial part of this study's methodology is the statistical analysis of the data collected from DOSH. The second part is a quantitative risk assessment based on Fault Tree Analysis – Figure 1.

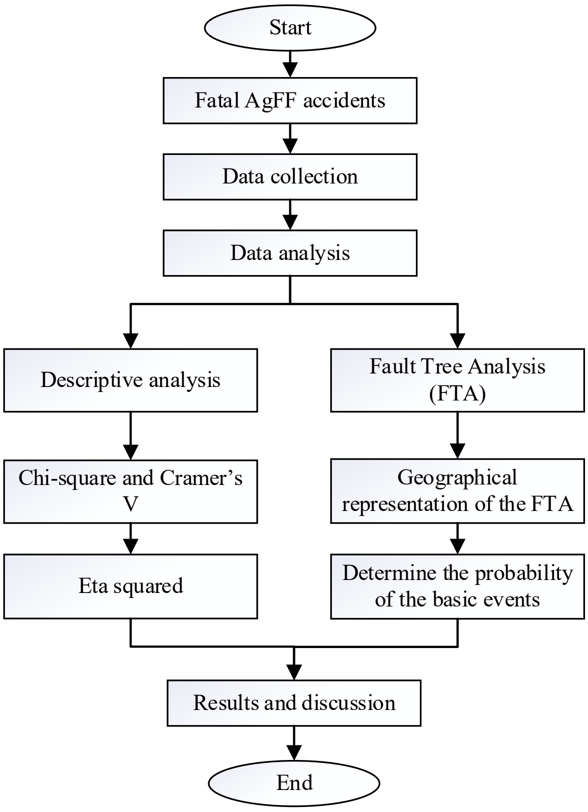

Figure 1 Visual representation of the methodology

2.1 Data collection

The Department of Occupational Safety and Health (DOSH) public accident database was used for this research [1]. The data included 103 fatal AgFF accidents investigated by DOSH between 2010 and 2020. The data set is frequently refreshed. Date, Name, Location, Case Summary, and Investigation Concentration comprise the five main types of information. Data served as the basis for this analysis by providing the fundamental variables of the study, such as year, location, and industry. Due to the descriptive nature and numerous anomalies in data entry, the DOSH data was not standardised. Therefore, it was required to normalise the data and extract the relevant information for analysis. Factors relevant to this investigation were added, while some were not omitted from the summary. The extraction of the information is displayed in Table 2. The authors have come to an understanding of which variables would be used in this study. In order to retrieve the data, the date column was subdivided into five different pieces as shown below (year, weekday, month, day, week of year). Section 32 of Act 514 states that the primary goal of reporting incidents is to allow the authority (DOSH) to investigate the root causes of the incidents and to take corrective measures to prevent future occurrences.

Furthermore, the collected information would serve as a valuable resource for DOSH analysis and the development of strategic plans for administrating and enforcing the law. To ensure the reliability of the statistics and enable analysis, it is crucial that the data recorded by the employers be consistent.

Table 2 Example of the useful information extracted from DOSH data

Accident Reference	State	Industry	Employment status	Activity	Accident Type	Year	Month	Weekday
My001	Kedah	Agriculture, Forestry and Fishing	Self employed	Agricultural, fishery and related labourers	Drowned or asphyxiated	2020	12	Friday

The case summary provided helpful details, such as the employment status. Accident types, employment status and industry values were based on the classification set by DOSH in Guidelines on Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations 2004 [NADOPOD] [2] - Table 3.

Table 3 The extracted useful information and their possible states

Relevant Factors	Values
State	All States of Malaysia
Industry	Agriculture, Forestry and Fishing
Employment status	Employee, Self employed
Activity	Agricultural and other mobile plant operators, Agricultural, fishery and related laborers, Locomotive engine-drivers and related workers, Machinery mechanics and fitters
Accident Type	Contact with electricity, contact with machinery, Drowned or asphyxiated, exposed to explosion, exposed to fire, fall from height, injured by an animal, Lifting and handling injuries, struck against, struck by moving vehicle, struck by object, trapped by something collapsing
Year	Years from 2010 to 2020
Month	Months from January to December
Day of week	Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, or Sunday

To enhance the credibility of the coding process, a reliability check was conducted through independent coding and structured adjudication. Two researchers independently coded a random subset of 20 cases using a predefined coding guide derived from the DOSH classification scheme and keyword interpretation rules. Coding outcomes were compared qualitatively to identify areas of disagreement. Discrepancies were resolved through discussion, and where agreement could not be reached, cases were reviewed against the original narrative and adjudicated by a third reviewer. Ambiguous cases lacking sufficient narrative cues were coded as “uncertain” and excluded from modelling steps requiring deterministic assignment, with the number of such cases explicitly reported.

2.2 Sources and nature of agricultural injuries

Table 4 indicates the sources of injuries among AgFF workers according to Tiwari et al. [35].

Table 4 injury–causing agricultural incidents [35]

Source of incidents	Nature of incidents
Tractors/trailers	Overturning, collision, run over, roll down, fall, crush, etc.
Wells/ponds	Fall, drowning, suffocation, etc.
Snakes	Snake bite
Live electric wires	Electrocution
Fire in farms/ threshing yards	Burns
Lightening	Electrocution
Pesticides	Poisoning (work exposure/accidental)
Bullock carts	Collision with other vehicles
Threshers	Crushing, laceration, entanglement, cuts, etc.
Other	Bitten, stuck by animals, fall from tree, etc.

Eight distinct classes of occupational hazards negatively impact the health of those employed in the AgFF industry, according to Arcury et al. [16]. Environment, toxic biological substances, transportation, the interface with manufacturing, mechanical and machines, physical and physiologic demands, chemicals, and medical care are all examples of exposure sets - Table 5.

Table 5 Exposure Sets Affecting the Occupational Health of Workers in the AgFF Sector [16].

Exposure sets	Examples
Natural environment	Solar radiation, high temperatures, adverse weather events, Dirt, Plants, Wild animals, Ponds and lakes
Toxic biological substances	Allergens, Organic dust
Transportation	Driver knowledge, Traffic accidents
Interface with manufacturing	Air quality and rapidly moving machinery
Mechanical and machine	Winches, Power-takeoffs, Noise
Physical and physiological demands	Vibrations caused by tools and equipment, Work on moving platforms
Chemicals	Pesticides, Fertilizers, petrochemicals, cleaning fluids
Medical care	Limited access to health care

2.3 Data analysis

Once the information was organised, it was coded and transferred to Python 3.9 and SPSS 25 for statistical analysis, while the FTA was constructed using Microsoft Visio. The causes of fatal AgFF occupational accidents were investigated using frequency analysis (accident types, activity, employment status and the states where the accident occurred). This research used crosstabs analysis and the contingency table using Cramer's V correlation analysis [36]. Cramer's V coefficients greater than 0.1 indicate a strong and significant relationship between the two variables [37]. Eta-squared test of variance was also used to analyse the correlation between continuous and categorical variables (e.g., accident types and the year); Michalos [38] defines a negligible effect as a value of 0.0099, a medium effect as a value of 0.0588, and a significant effect as a value of 0.1379 or more. Finally, a fault tree analysis was conducted to identify potential accident chains and scenarios that could result in a fatality in the AgFF sector. All potential outcomes have been mapped out in a fault line diagram.

Given the sample size ($n = 103$) and the number of categories across some variables, contingency tables can produce low expected cell counts, reducing statistical power and the interpretability of chi square asymptotics. To mitigate this, rare categories were grouped where conceptually defensible, and results are reported with effect size measures alongside p values. Findings from association tests are therefore interpreted as exploratory pattern detection rather than definitive causal inference.

The exposure sets and the source of injuries were derived from the organization's safety site supervisor (SSS) summary, DOSH officer observation, and a systematic approach. Critical words on the description will give a clue on which exposure and injury were sustained by the worker, as there was insufficient information on the accident description. The words in italics are those that were pivotal in identifying the exposure scenario and the cause of injury – Table 6.

Table 6 The interpretation of key words in the case reports.

Summary Case	Tractors/ Trailers	Wells/ Ponds	Snakes/ Wasps	Live electric wires	Fire in farms/ Threshing yards	Pesticides	Bullock carts	Threshers	Buildings	Natural environment	Transportation	Interface with manufacturing	Mechanical and machine	Physical and physiological demands	Chemicals
A self-employed man was found **drowned** while lying in a rice field		Yes								Yes					
A tractor driver died after **falling** from **the tractor** he was **driving** while the victim was about to pick up leftover fertilizer to store in the store.	Yes										Yes				

2.4 Construction of the fault tree

Understanding the causes of fatal AgFF accidents is the focus of the second section of the study. Fatal AgFF accidents were modelled out using fault tree analysis. In this section, the authors discuss the exposure sets, the source of accidents and finally, the types of accidents – Figure 2. It is possible for any of these scenarios to occur, which is why safety investigators will use the FTA as a resource to eliminate AgFF fatalities in the future. The fault tree has four sections: the top event, the exposure sets, the injury sources, and the accident types.

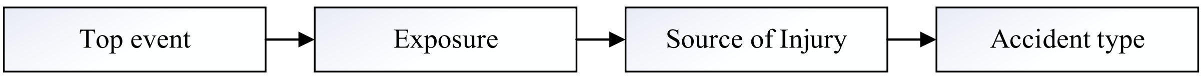

Figure 2 Flowchart of the fault tree analysis process

The top event was defined as a fatal occupational accident in the Malaysian AgFF sector. Intermediate events represented exposure sets and sources of injury, and basic events represented accident types. Probabilities for each node were estimated from the coded frequencies in the dataset and combined using standard fault tree logic. OR gates were used where any child event was sufficient to produce the parent event, while AND gates were used only where concurrent conditions were required, consistent with the causal interpretation adopted in the model.

3.0 RESULTS

This section may be divided by subheadings. It should provide a concise and precise description of the experimental results, their interpretation as well as the experimental conclusions that can be drawn. Authors should discuss the results and how they can be interpreted in perspective of previous studies and of the working hypotheses. The findings and their implications should be discussed in the broadest context possible. Future research directions may also be highlighted.

3.1. Descriptive Analysis

The results of the statistical analysis showed that the state with the highest AgFF fatalities was Johor, with 28 (27.2%) fatalities over ten years, followed by Sarawak with 22 (21.4%), Sabah with 15 (14.6%) and Pahang with 12 (11.7%) fatalities – Figure 3. Sarawak and Sabah recorded almost a third of all Malaysia AgFF accidents due to the nature of these states; Olaniyi et al. [39] mentioned in their research that the AgFF sector in Malaysia is divided into three major areas that share a third of the market between them, Peninsular Malaysia, Sarawak and Sabah. Furthermore, the fact that Sarawak is the largest state in Malaysian plays a significant role in their AgFF development [39]. Rozana et al. [40] ranked Johor as the highest fruit-producing state in Malaysia with 15263 Ha, followed by Sarawak with 6936 Ha and Pahang ranking third with 4700 Ha, which explains the high number of fatal AgFF accidents.

To no surprise, general agricultural, fish, and related labourers were more susceptible to fatal accidents compared to other categories, with 72 (69.9%) – Table 7. Agricultural and other mobile plant operators were the second highest affected category with 28 (27.2%) and machinery mechanics and fitters with 3 (2.9%). Since workers frequently shift jobs, there are more problems with surveillance and law enforcement, as well as increased health and safety dangers related to transportation in the AgFF industry [41].

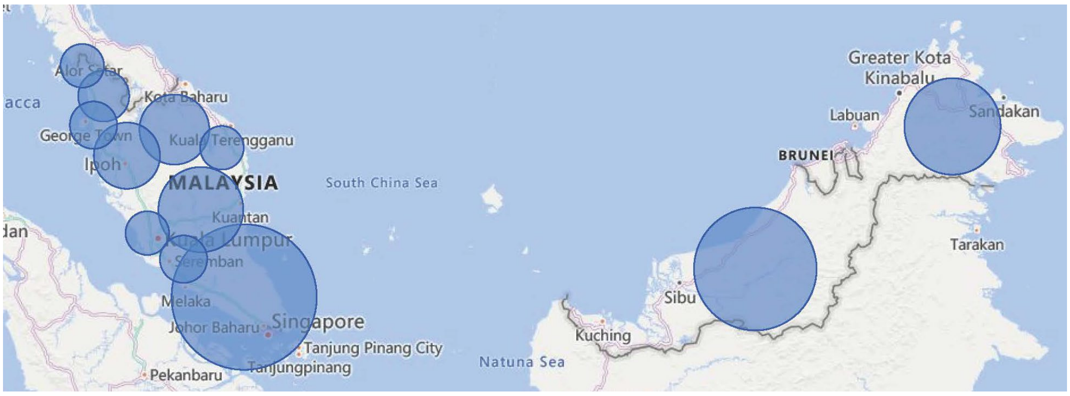

Figure 3 Distribution of fatal AgFF accidents by state

Contrary to other sectors, such as construction, the highest recorded accident type does not fall from a height but is struck by an object with 30 (29.1%) – Table 7. Due to the nature of the tasks in the AgFF, it makes sense that falls from heights have a lower impact. However, falls from heights are still recorded in 21 (20.4%) fatal accidents, followed by Contact with machinery with 13 (12.6%). Contrary to AgFF accidents in South Korea, where machinery-related accidents were the highest contributor to fatal accidents with 72 (35.64%) and fall from heights ranked third with 26 (12.87%) [42].

The year 2014 recorded the highest fatal AgFF accidents rate in Malaysia with 23 (22.3%), followed by 2020 with 20 (19.4%) – Table 7. There is a noticeable trend where accidents increase to a point and then start declining to increase again eventually. A similar trend has been recorded for fatal accidents in the construction industry in Malaysia [20]. As for the months where most accidents occurred, it seems that all months recorded closer results, where June is the highest with 13 (12.6%) and February is the lowest with 6 (5.8%) - Table 7. Finally, weekdays share similar trends as the months of accidents, where Friday, Thursday, and Tuesday share the highest recorded accident number with 18 (17.5%) and Wednesday is the lowest with 6 (5.8%) - Table 7. According to research by Shao et al., [37], fatal accidents occur randomly and are not affected by geographic location or time. According to Probst and Graso [43], production pressure was positively connected to a higher number of adverse outcomes of reporting accidents in the past (r =0.30, p .01) and negatively related to reporting attitudes (r =0.61, p 0.01).

Table 7 Distribution of Malaysian workplace fatal AgFF accidents

Relevant Factors	Possible states	Frequency	(%)
State	Johor	28	27.2
	Kedah	3	2.9
	Kelantan	8	7.8
	Negeri Sembilan	2	1.9
	Other	1	1.0
	Pahang	12	11.7
	Penang	2	1.9
	Perak	7	6.8
	Perlis	1	1.0
	Sabah	15	14.6
	Sarawak	22	21.4
	Selangor	1	1.0
	Terengganu	1	1.0
	Total	103	100.0
Activity	Agricultural and other mobile plant operators	28	27.2
	Agricultural, fishery and related labourers	72	69.9
	Machinery mechanics and fitters	3	2.9
	Total	103	100.0
Accident type	Contact with electricity	6	5.8
	Contact with machinery	13	12.6
	Drowned or asphyxiated	6	5.8
	Exposed to explosion	2	1.9
	Exposed to fire	1	1.0
	Fall from height	21	20.4
	Injured by an animal	2	1.9
	Lifting and handling injuries	4	3.9
	Struck against	5	4.9
	Struck by moving vehicle	8	7.8
	Struck by object	30	29.1
	Trapped by something collapsing	5	4.9
	Total	103	100.0
Year	2010	5	4.9
	2011	9	8.7
	2012	4	3.9
	2013	6	5.8
	2014	23	22.3
	2015	11	10.7
	2016	6	5.8
	2017	4	3.9
	2018	8	7.8
	2019	7	6.8
	2020	20	19.4
	Total	103	100.0
Month	January	10	9.7
	February	6	5.8
	March	7	6.8
	April	7	6.8
	May	9	8.7
	June	13	12.6
	July	9	8.7
	August	10	9.7
	September	9	8.7
	October	8	7.8
	November	8	7.8
	December	7	6.8
	Total	103	100.0
Weekday	Friday	18	17.5
	Monday	11	10.7
	Saturday	16	15.5
	Sunday	16	15.5
	Thursday	18	17.5
	Tuesday	18	17.5
	Wednesday	6	5.8
	Total	103	100.0
Employment	employee	18	17.5
	Self employed	85	82.5
	Total	103	100.0

3.2. Occupational Exposure sets of Workers in the Malaysian AgFF Sector

Workers in the AgFF sector who suffered a fatal injury were at risk to set of exposure sets – Table 8. The transportation task within the AgFF was the most hazardous task that caused 51 (48%) of all recorded accidents.

Table 8 Malaysian AgFF fatalities exposure sets

Exposure sets	Frequency	Percentage (%)
Natural environment	17	16.03
Transportation	51	48.11
Interface with manufacturing	2	1.88
Mechanical and machine	12	11.32
Physical and physiological demands	18	16.98
Chemicals	6	5.66

3.3. Sources and nature of agricultural injuries

The source of injury probability in the AgFF sector was calculated and imported in table 9. Tractors and trailers were the highest sources of injury, with 46 (44.66%) injuries in 10 years, followed by threshers recording 30 (29.12%) injuries. The rest of the sources recorded occurrences that ranged from 1 (0.97%) to 5 (4.85%), except wells and ponds recording 8 (7.76%) occurrences.

Table 9 Malaysian AgFF fatalities sources of injuries

Source of incidents	Frequency	Percentage (%)
Tractors/trailers	46	44.66
Wells/ponds	8	7.76
Wasps	2	1.94
Live electric wires	5	4.85
Fire in farms/ threshing yards	1	0.97
Pesticides	3	2.91
Bullock carts	5	4.85
Threshers	30	29.12
Buildings	3	2.91

3.4. Chi square and Cramer's V

In this investigation, the contingency table was used to study the association between the relevant factors, and the correlation coefficients were calculated with 95% confidence intervals shown in Table 10. The correlation between variables with more than 2xn categories was determined using Cramer's V correlation coefficient. Cramer's V and chi-square test show very minimal association between the factors used in the study. The only association was recorded between the employment status and the activity (p-value = 0.008), accident type (p-value = 0.049).

Table 10 Contingency table for correlation coefficients between relevant factors

Dependent variable	Independent variable	X^2	df.	Sig.	Phi	Cramer's V
Employment status	State	16.643	12	0.163	0.163	/
	Activity	11.808	3	0.008**	0.008	/
	Accident type	19.706	11	0.049*	0.049	/
	Weekday	3.749	6	0.711	0.711	/
	Month	14.269	11	0.218	0.218	/
Activity	Employment status	11.808	3	0.008*	0.008	0.293
	Weekday	24.313	18	0.145	0.145	0.143
	Accident type	35.200	33	0.364	0.364	0.079
	State	19.458	36	0.989	0.989	0.0
	Month	29.333	33	0.650	0.650	0.0

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State	Employment status	16.643	12	0.163	0.163	0.210
	Activity	19.458	36	0.989	0.989	0.0
	Accident type	126.516	132	0.618	0.618	0.0
	Weekday	63.685	72	0.747	0.747	0.0
	Month	144.759	132	0.211	0.211	0.106
Accident type	Employment status	19.706	11	0.049*	0.049	0.290
	Activity	35.200	33	0.364	0.364	0.079
	State	126.516	132	0.618	0.618	0.0
	Weekday	62.621	66	0.595	0.595	0.0
	Month	115.289	121	0.629	0.629	0.0

*P<0.05.
**P<0.01

3.5. Eta squared

Eta squared shows a range of effect size; all the relevant factors recorded a significant effect all the year (accident type η2= 0.566, activity η2=0.262, State η2= 0.436) except the employment status where the effect size recorded was medium with 0.136 - Table 11. For the week of the year, the effect size was large (accident type η2=0.298, State η2=0.377) or small (activity η2=0.05, employment status 0.05. Finally, the relevant factors recorded different effect sizes; the accident type effect size was significant at 0.348, and employment status and state were medium with 0.076 and 0.136, respectively. The activity recorded a small effect size on the day with 0.01.

Table 11 the effect size of relevant factors on the day, week of year and the year

Relevant factors	Day	Week of Year	Year
	Effect size η^2		
Accident type	0.348***	0.298***	0.566***
Activity	0.01*	0.05*	0.262***
Employment status	0.076**	0.0205*	0.136**
State	0.136**	0.377***	0.436***

*$0.0099 < \eta^2 < 0.0588$ (Small effect)
** $0.0588 < \eta^2 < 0.1379$ (Medium effect)
*** $\eta^2 > 0.1379$ (Large effect)

3.6. Fault tree analysis

The probability of occurrence of each accident type is further calculated using the fault tree analysis. The results showed that, unlike statistical analysis, the main contributor to fatal AgFF accidents is falling from height (27.35%), followed by strikes by objects (18.24%) – Table 12. Additionally, contact with machinery was still Malaysia's third-highest impactor on fatal AgFF accidents. Other factors recorded probabilities that ranged from 1.41% for fatalities due to being exposed to fires to 8.95% for fatalities resulting from lifting and handling injuries. These results are supported by other studies such as [11], [13], [19], [20] in the construction industry. However, in the AgFF sector, this study is the first to highlight the impact of fatal falls from heights as the leading contributor to fatalities in Malaysia. Figures 4, 5 and 6 are all part of a bigger FTA where the top event is an AgFF fatality, and all the scenarios that may lead to it, from the exposure set to the source of injury and finally, the basic event, which is the accident type.

Table 12 Accident types probability of occurrence based on the FTA

Accident type	Probability of occurrence (%)
Fall from height	27.35
Exposed to explosion	3.41
Exposed to fire	1.41
Drowned or asphyxiated	6.49

Struck by object	18.24
Lifting and handling injuries	8.95
Trapped by something collapsing	2.76
Injured by an animal	4.07
Contact with machinery	13.54
Struck against	3.01
Contact with electricity	4.78
Struck by moving vehicle	6

Although struck by object is the most frequent single accident type in the descriptive counts, the fault tree results reflect pathway contributions that incorporate upstream exposure sets and sources of injury rather than accident type counts alone. As a result, accident types that align with dominant upstream branches can contribute a larger share of the modelled probability even if they are not the most frequent category in Table 7.

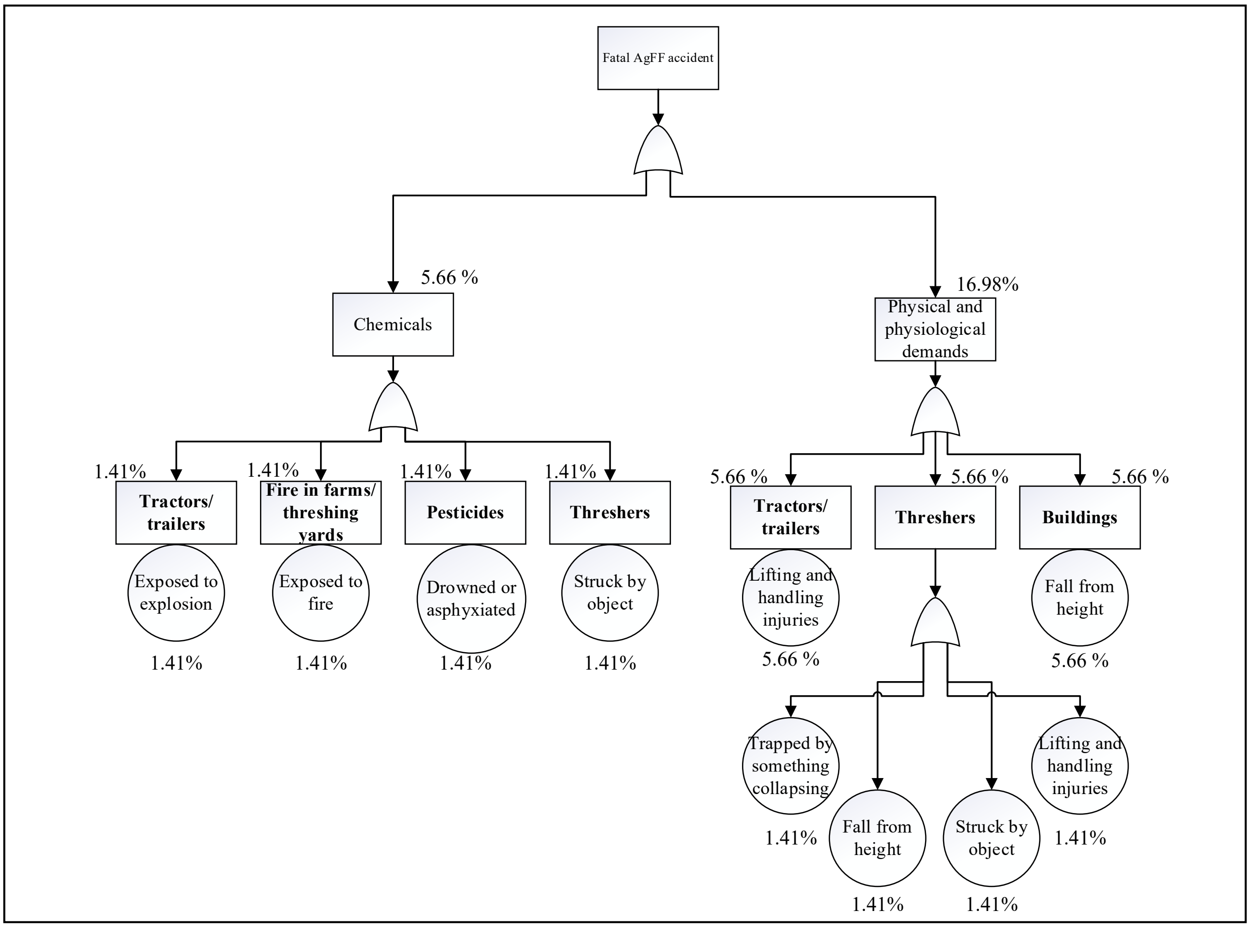

Figure 4 FTA of the chemical and physical and physiological demands exposure sets

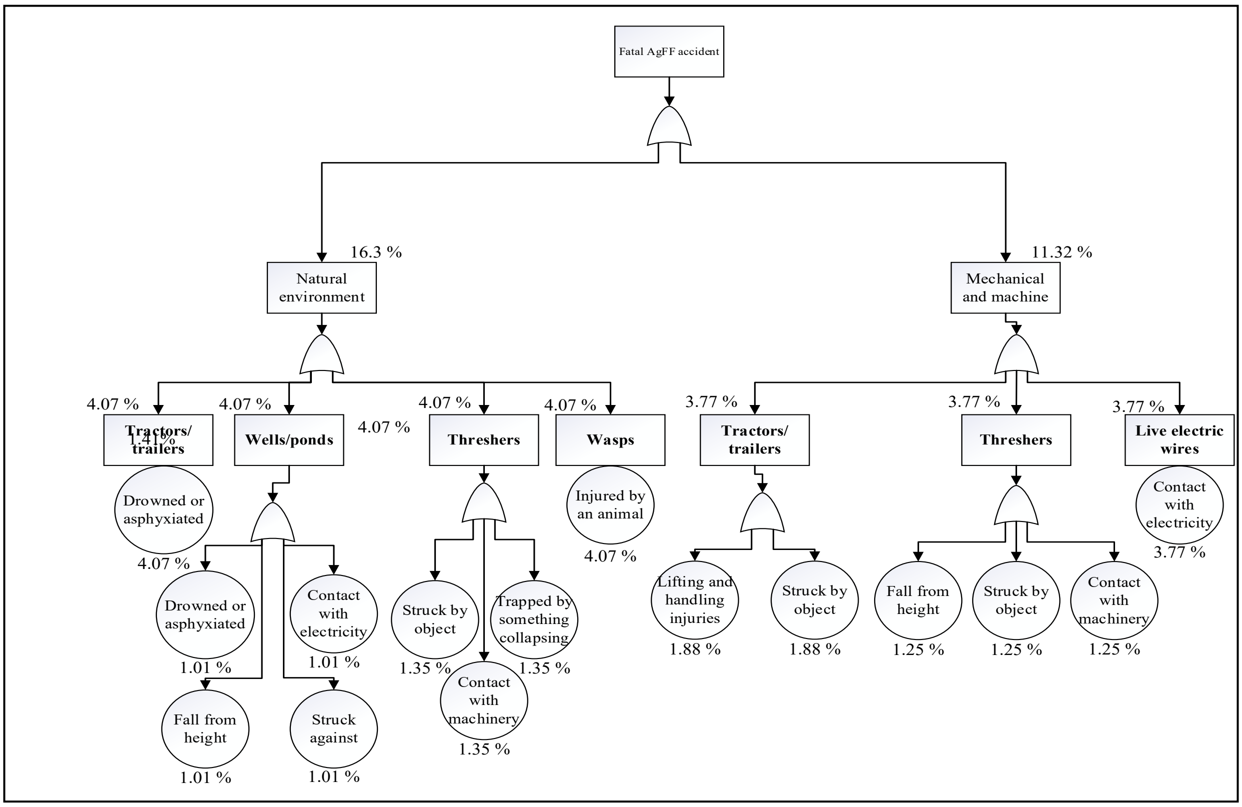

Figure 5 FTA of the Natural environment and mechanical and machine exposure sets

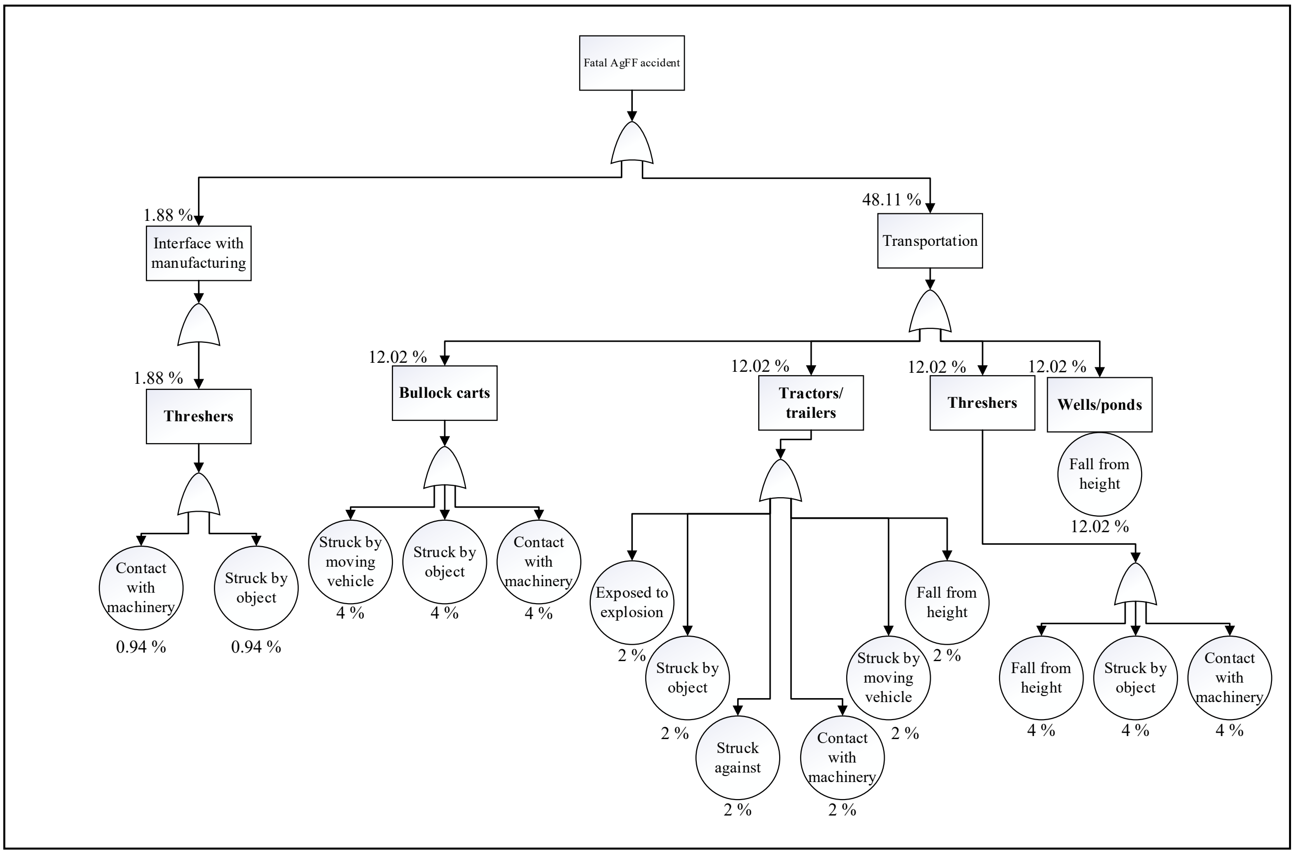

Figure 6 FTA of the interface with manufacturing and transportation exposure sets

4.0 DISCUSSION

Understanding fatal injuries in the AgFF sector can help decrease the probability of a fatal to a severe injury occurring at work. The results of this study revealed patterns related to fatalities in AgFF using a different set of statistical tools and regression models.

Employers in the AgFF Industry commonly provide short-term contracts to workers. Precarious employment, often known as temporary work, contract work, or temporary staffing, poses hazards to workers' health that are not faced by those with more stable, long-term jobs [44]. Many employments in the AgFF Sector are located in physically isolated and rural areas that may be quite far from cities, hospitals, and other services- and housing-rich localities where health and safety inspectors are stationed [41]. Furthermore, due to technological advancements, the AgFF sector has adopted new methods detrimental to workers' health. For example, throughout the growing season, farm workers are consistently exposed to several pesticides [30]. Furthermore, most of the individual pesticide metabolites were discovered more than once, and the total number of pesticide metabolites detected was positively correlated with the type of housing in which the farm workers lived [30]. Workers in these industries face increased transportation-related health and safety concerns due to the workers' tendency to move from one work location to another [41].

Unlike fatalities in the forestry industry, most sawmill worker deaths result from enormous trauma that could not have been prevented even with immediate medical assistance [45]. For example, working in sawmills in the forestry industry can lead to the unintentional release of a great deal of kinetic energy. Therefore, well-maintained and properly-guarded equipment and safe working habits must form the backbone of every mill's safety policy [45]. Most injuries in the agriculture sector in central India were inflicted by hand tools, such as cuts from hand tools, which are considered minor injuries and are, therefore, often overlooked [35]. Contrary to UK research finding that manual handling was a major cause of nonfatal injuries among agricultural workers, this statement is false [46].

Furthermore, of most plantation workers in the Philippines, 94% had either worked with or used pesticides at some point in their lives, and 16.4% had used pesticides at home [47], [48]. Acute health impacts, such as nausea or headaches, were reported by over 40% of plantation workers who were exposed to pesticides [49], [50]. However, in this study, there was little mention of pesticide-related injuries in the DOSH reports.

Malaysia is still a relatively new country regarding reporting and non-reporting accident occurrences. Although there is evidence that accidental cases were not reported, reported research on the subject is limited. Therefore, there needs to be more knowledgeable on the subject. However, according to estimates based on ILO, 1,301,816 instances in all industries had yet to be reported to DOSH [10]. When an accident, dangerous event, occupational poisoning, or occupational disease occurs, an employer is obligated to report it to the local Department of Occupational Safety and Health office per the Occupational Safety and Health Act of 1994 (Act 514). Furthermore, any doctor or medical officer who treats or is called to treat a patient he suspects suffering from an occupational sickness or poisoning must notify the incident to Director General.

As for workers who are often still employed in labour-intensive jobs, the introduction of mechanization has brought about substantial changes in the way work is done in agriculture, forestry, and fisheries, modifying exposures but not constantly increasing worker safety and health [41]. The increased pace and repetitiveness of professional duties caused by technological advancements and changes in how work is organized have led to an increase in the incidence of musculoskeletal illnesses incurred on the job [41]. The data in this study spans at least ten years. Mechanization has been incorporated into many facets of employment, most noticeably in the forestry industry. However, many of the duties and risks are still the same. A rise in mechanization should be expected to boost safety, but it also has the potential to introduce novel dangers and change the nature of existing risks [51].

A proper work method, followed by adequate training, is crucial to help prevent these types of accidents. In places where forestry work is being done, it would make sense to have reliable means of communication and a medical evacuation or retrieval team on standby. Despite the severity of an injury, research has shown that patients have a better chance of surviving if they receive care right away [45].

Several prevention methods were recommended in a report about AgFF accidents by Gorucu [52], such as Operators of all-terrain vehicles (ATVs) must comply with the following safety regulations: always wear a helmet and other protective gear, never ride on paved roads, and never operate an ATV while intoxicated. Before operating tractors or other agricultural vehicles on public roads, operators must ensure that all of their vehicle's lighting and marking features are operational. Employees must participate in heat stress and mental health awareness training. The dominance of tractors and trailers and threshers as sources of injury suggests prevention priorities focused on safe access, machine guarding, stability, and separation of people from moving plant. The high proportion of self-employed fatalities implies that interventions must be deliverable outside formal employer systems, including practical training, simplified guidance, and accessible inspection support. The predominance of transportation related exposure sets indicates that vehicle movement, loading, and travel within and between work sites represent a critical control point.

Because DOSH summaries are brief, future reporting that consistently records task, equipment involved, immediate mechanism, unsafe acts, unsafe conditions, and control failures would substantially improve causal modelling and enable more actionable prevention strategies.

5.0 CONCLUSION

This study aimed to investigate the fatal injury rates among agricultural, forestry and fishing workers in Malaysia. This study analysed 103 fatal accidents during the ten years from 2010 to 2020. Contrary to fatal accident research in Malaysia, fatal falls from heights were not the leading cause of fatalities in the AgFF sector but ranked second behind being hit by an object. Agricultural, fishery and related workers were the highest categories affected by fatalities compared to other categories, such as agricultural and other mobile plant operators. Machinery mechanics and fitters were the least affected category. Johor, Sarawak, and Sabah were the areas where the most fatalities occurred, with a total of 65 fatalities (66.2%) of all fatalities over ten years. There was no significant association between the relevant factors used in this study except for the employment status with the types of accidents and the activity 0.049) and 0.008, respectively. Finally, there was an effect size on the relevant factors and the day, week of the year or the year that ranged from large (accident type, year $\eta 2= 0.566$) to small (activity, day $\eta 2= 0.01$).

The range of the study is limited by the fact that data from the national OSH regulation were used to comprehend death patterns in Malaysian workplaces; fatalities recorded but not examined are available to the general public. In addition, DOSH has only looked at fatalities reported by employers, and just a few key details, such as "the date," "place," and a brief case summary, are available online. Although previous studies have focused on specific industries, this study looked at fatal incidents across various fields and periods (ten years). Furthermore, this information was gathered from a credible source representing the national entity responsible for the enforcement and regulation of OHS. Future research should focus on the human aspect of fatal AgFF accidents in Malaysia. Furthermore, (Ajis et al., 2014) highlighted that most agriculture workers were illegal immigrants, hence unregistered under the Ministry of Labor of Malaysia; future studies should focus on work-related injuries among foreign workers in the AgFF industry in Malaysia.

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