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ANALYSIS OF PETROLEUM TANKER FIRE AND EXPLOSION ACCIDENTS IN NIGERIA

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ABSTRACT

The menace of petroleum tanker fire and explosion accidents in Nigeria continues to increase in recent years with attendant consequences of loss of lives and properties. The present study performed a 16-year in-depth analysis of petroleum tanker fire and explosion accidents in Nigeria using secondary sources of data. It employed a mixed-method relating both qualitative and quantitative data collection and analysis techniques using 171 accident cases, 1822 deaths and 811 injuries. Year 2019 recorded the highest number of accidents of injuries as 29 and 178 respectively. However, the highest number of fatalities of 294 occurred in 2024. Also, the entire tanker accidents fall within "unacceptable" risk level in relation to societal risk curves. Five major aggravating factors namely mechanical, collision, impact, scooping and human were found to increase the severity of the accidents. Human factor accounted for both the highest number of accidents and injuries as 101 and 416 respectively, whereas, scooping of spilled petroleum products led to the peak number of fatalities of 730. Finally, an overview of the causes and aggravating factors of petroleum tanker accidents in Nigeria as well as the corresponding preventive/mitigative measures was given in Haddon Matrix. Regulatory agencies should strengthen tanker safety enforcement through rigorous vehicle inspection, driver training, and strict penalties for traffic violations. Public education campaigns must discourage fuel scooping. Investment in road infrastructure, emergency response systems, and pre-event preventive strategies, guided by the Haddon Matrix, is essential to reduce tanker fire and explosion risks.

Keywords: Petroleum tanker, Fire, Explosion, Accident

INTRODUCTION

Transportation and distribution of refined petroleum products in Nigeria is predominantly by road using tankers as it accounts for about 80 per cent of the entire movement (Adsuls et al., 2017). One of the major hazards associated with the use of petroleum tankers is their frequent fire and explosions when involved in road traffic accidents (Ewbank, 2019; Dare et al, 2009; and Odogun, 2021). The accident often leads to loss of lives and properties, injuries of persons and environmental degradation. Generally, the causes of the road tanker accidents are numerous and interlinked as evident in the studies of Oggero et al (2006), Al-Masaeid (1996) Ewbank (2019), Oluwatuyi and Ileri (2013) and Singh (2017). However, there are four contributing factors or characteristics that lead to the accidents. These are host or human; agent of energy or vehicle; physical environment and social environment. The accidents are prevalent in low and middle-income countries as they take into account about 85 per cent of global fatalities as reported by (Adsul et al., 2017).

In recent years, the petroleum tanker fire and explosions continue to increase in Nigeria as evident with at least 10 petroleum tanker fire and explosion accidents in just First Quarter of 2025 which led to at least 120 deaths (Na'inna et al., 2025). Despite these consequences, there is inadequate and non-systematic study of this menace which is a prerequisite for preventing or minimizing it to the barest minimum (Ewbank, 2018; Odogun, 2021; Dare, 2009; Hajizadeh et al., 2022). On this premise, Na'inna (2024) conducted a 16-year overview of petroleum tanker fire and explosion accidents in Nigeria from 2009 to 2024. A total of 171 accident cases corresponding to 1,822 deaths were reported in the study.

The present paper aims at conducting an in-depth analysis by thorough and detailed examination of petroleum tanker fire and explosion accidents in Nigeria from January 2009 to December 2024. This is to uncover underlying patterns, relationships and insights on variables attributed to the accidents. Findings from this study are geared towards assisting relevant stakeholders with deeper understanding of the complex issues, making informed decision-making, problem-solving and strategic planning in tackling the menace of petroleum tanker fire and explosions in Nigeria for enhanced human security.

MATERIALS AND METHODS

The Federal Republic of Nigeria is the study area for this research. Nigeria, situated in West Africa, has land borders with the Republic of Benin on its west, Chad and Cameroon on its east, and Niger to the north. Additionally, it is located on the Gulf of Guinea coastline in the south and shares a border with Lake Chad to the northeast. Nigeria with a total population estimated at 230 million and density of 252 pers/km is ranked as the most populous country in Africa (Georef, 2024). Petroleum is the main economic backbone in Nigeria and is ranked as the first and 16th producer in Africa and world respectively (Carpenter, 2024). The GDP value of Nigeria as of 2023 is 362.81 billion USD and represents 0.34 percent of the world economy (Trading Economics, 2023). Despite being Africa's largest economy, Nigeria according to World Bank Group (2025) is a lower-middle income country which faces significant socioeconomic challenges, including high poverty and illiteracy rates, income inequality, unemployment and inadequate means of transport.

The research method employed in this study was a mixed-approach relating both qualitative and quantitative data collection and analysis techniques in a single study in order to offer a more insight on petroleum tanker explosion accidents in Nigeria. This approach leads to an optimum and robust outcomes by integrating the advantage of each method while alleviating their shortcomings (Creswell, 2014). Quantitative data was used to ascertain extensive trends and patterns of the

tanker accidents, while qualitative data offered thorough descriptions and context for those findings.
The source of data employed in this study is secondary. A Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) criteria was adopted in the search of relevant information. The records returned from the search were examined for relevance and insertion standards. This research work is a typical analytical research where critical thinking skills and evaluation of facts were applied.

When discrepancies occur across reports for a particular accident case as regards number of fatalities or injuries; the highest number reported or documented by the latest source was adopted for this study. The data used in this study is obtained from Na'inna (2025); in addition, the data link is attached https://doi.org/10.5281/zenodo.15032760. Additionally, attention was devoted to formal statements made by stakeholders present at the scene of the accident in order to gain more confidence in each source used. The stakeholders include the National Emergency Management Agency, Federal Fire Service, Federal Road Safety Corps and government officials of the states concerned. Hence, the bulk of the sources referred to in this study have utilized primary data in their reportage. The study variables includes the following; fuel type, location of the petroleum tanker fire, number of fatalities, injuries, properties destroyed and aggravating factor for each accident, and explosion accidents. These variables were thus used to perform analysis of the petroleum tanker fire and explosion accidents in the present study. Comprehensive details of each accident case are contained in form of a data set by Na'inna (2025). The collected data were analysed both qualitatively using logical reasoning based on facts, and, quantitatively using SPSS statistical tool to conduct Chi-Square and ANOVA tests. Consequently, data were presented in descriptive forms using diagrams, graphs, tables, and charts to gain more insight on the menace of the tanker accidents. This would ultimately guide the relevant stakeholders in coming up with ways to curb the undesirable events.

RESULTS AND DISCUSSIONS

This section presents the results of analysis conducted and carried-out detailed discussion on the basis of the results obtained.

Analysis of the Frequency of Accidents and Associated Deaths and Injuries

The relationship between the number of accidents and accident severity in terms of the number of deaths and injuries for the 16 year review is presented in Figure 1. There were 171 accident cases between 2009 and 2024 and for each for the frequency of accidents. There was a fairly steady trend of number of accidents for the first 8 years (2009 to 2016), with a mean value of about 6 cases. Subsequently, a rise in number of accidents was discernible in 2017, 2018 and 2019 having a peak number of accident of 29. This is about 7 times higher than the least number of accidents recorded in 2009, 2012 and 2014. Afterwards, a decline in number of accidents was noticed in the successive years up to 2024 with the least been 13 in 2023.

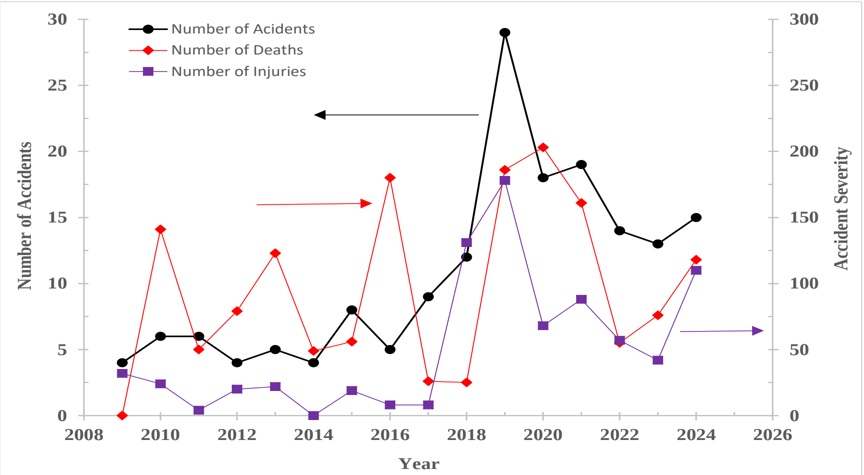

Figure 1: Relationship between Number of Petroleum Tanker Fire and Explosion Accidents and Associated Severity in Nigeria. (Source: Authors - (Na'inna et al. 2025)

There were 1822 deaths from the 171 accident occurrences in Nigeria from 2009 to 2024. The deaths pattern shows a zig-zag trend throughout the 16-year period with peak points having 141, 123, 180, 203 and 294 numbers of fatalities in 2009, 2012, 2015, 2019 and 2024 accordingly. However, year 2024 with the highest number of deaths of 294 did not match the year 2019 that had the highest number of accidents of 29. This suggests that there are factors responsible for the non-correlation between the frequency and number of fatalities associated with petroleum tanker fire and explosion accidents. Additionally, two categories have been established to clarify the accidents as a function of number of deaths: 11-100 and 101-1000. About 77 per cent of the fatalities are within 101-1000 death range whereas the remainder of 33 per cent falls within 11-100. This suggests that the accident severity for the bulk of the accidents are considered high. In relating the number of fatalities to frequency of accidents in the present study, a ratio of 10.7 is obtained. This high ratio implies that when an accident with domino effect occurs, often it involves large number of fatalities especially in developing countries like Nigeria. However, a ratio of 7.6 was found by Chanut (2015) in his study of domino effect accidents in hazardous materials transportation by road and rail.
A total of 811 various degrees of injuries were sustained during the 171 accidents which spanned between 2009 to 2024. The pattern of the number of injuries over time is similar to that of the number of accident cases. Pre-2017 number of injuries was small averaging 15 (137/9) before it subsequently spiked to 178 in 2019. The year 2019 corresponds with the highest number of accidents in this study. The number of injuries subsequently declined till 2023

having 42 and then began to rise in 2024 having 110 numbers of injuries.

Petroleum products commonly transported by road in Nigeria using tankers are petrol, kerosene, natural gas and kerosene. Figure 2 shows the number of accidents, deaths and injuries associated with each petroleum product involved in tanker fire and explosion accidents in Nigeria from 2009 to 2024. In terms of number of accidents, Premium Motor Spirit (PMS) popularly known as petrol accounts for about 87 per cent of the 171 total number of accident followed by diesel and gas fuels with 10 accident cases each. Kerosene and unknown fuels were involved in one and two accidents respectively. Additionally, accidents from PMS tanker recorded the highest number of fatalities of 1,573 followed by gas, other forms of inflammables and diesel having 178, 50 and 21 deaths in that order. Moreover, for number of injuries to persons, petrol fuel recorded a maximum number of 636 and thereafter gas and unknown fuel having 170 and 5 number of injured people. However, accidents from diesel and kerosene fuels recorded no injuries. Thus, it is imperative to note that the highest number of frequency and severity of accidents in terms of deaths and injuries from PMS in the present study could be attributed to its volatile nature of the product.

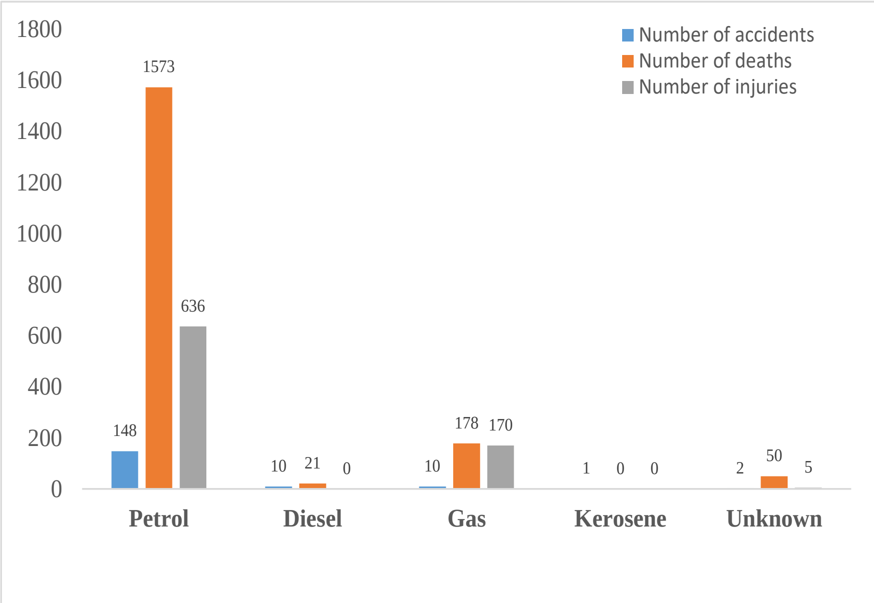

Figure 2: Number of Petroleum Tanker Fire and Explosion Accidents in Nigeria and Related Deaths and Injuries for Various Petroleum Products

The relationship between the frequency of accidents and number of deaths for the 16-year period (represented as the data points) is shown in Figure 3. Generally, the number of accidents is directly proportional to the number of fatalities and vice-versa as revealed by Chanut (2015). This trend is equally observed in the present study between the two variables with an R^2 value of 0.21 signifying a relatively weak relationship. However, there is a strong relationship between the number of accidents and number of injuries in the present study as depicted in Figure 4. This is evident with an R^2 value of 0.74 between the two variables.

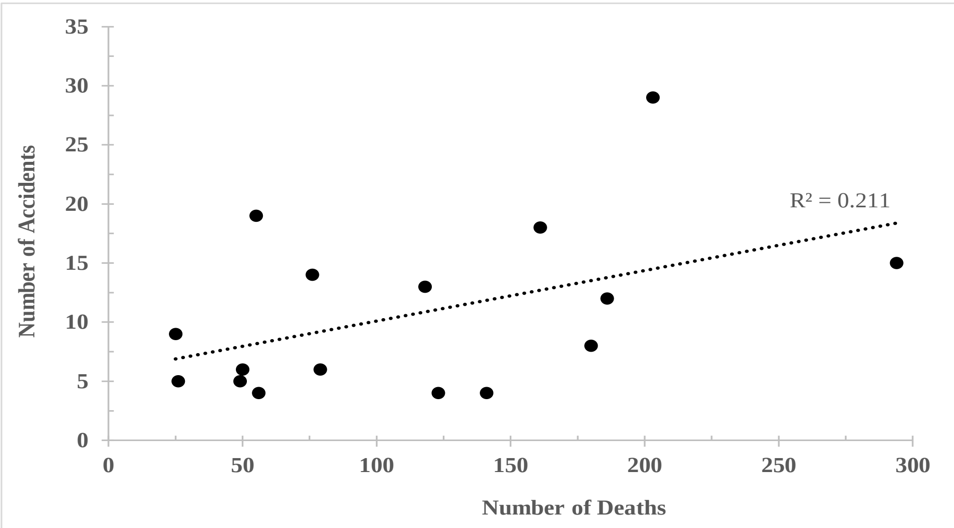

Figure 3: Linear Relationship Between Number of Petroleum Tanker Fire and Explosion Accidents in Nigeria and Number of Deaths

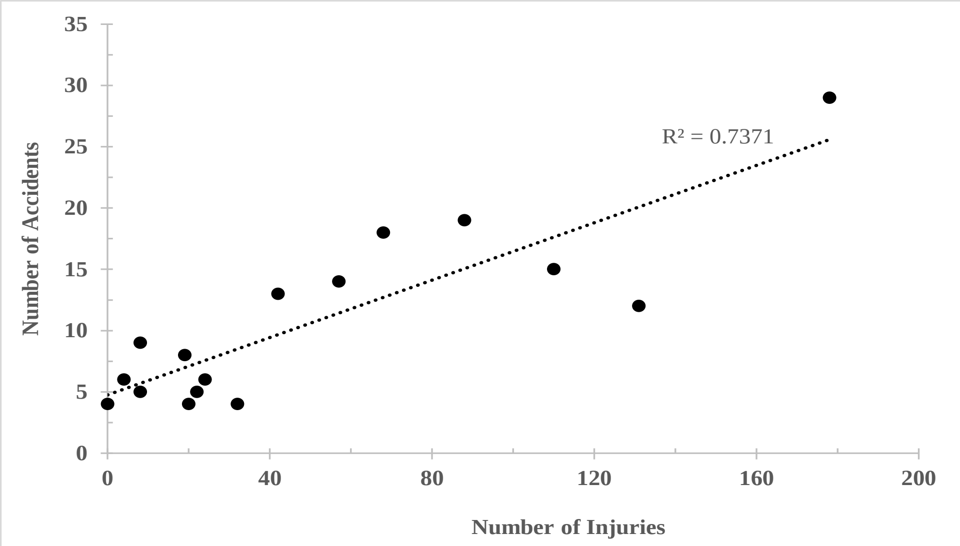

Figure 4: Linear Relationship Between Number of Petroleum Tanker Fire and Explosion Accidents in Nigeria and Number of Injuries

Petroleum tanker fire and explosion accidents pose inherent risk to the society. Risk curves are used to express societal risk criteria and to describe the safety levels of particular events/facilities. It is composed of acceptable, tolerable/ALARP, unacceptable and detailed study (Maselli et al 2021). To ascertain the risk level of the petroleum tanker accidents in Nigeria, the number of fatalities, N in the present study and their corresponding number of accidents are plotted on an adopted F-N risk curves as shown in Figure 5. The frequency of accident, F was obtained by dividing the number of accidents for the 16-year period. The entire data points fall within "UNACCEPTABLE" risk level. This implies that the level of risk is too high to be endured and thus necessitates more mitigation measures such as awareness creation with both primary and secondary stakeholders.

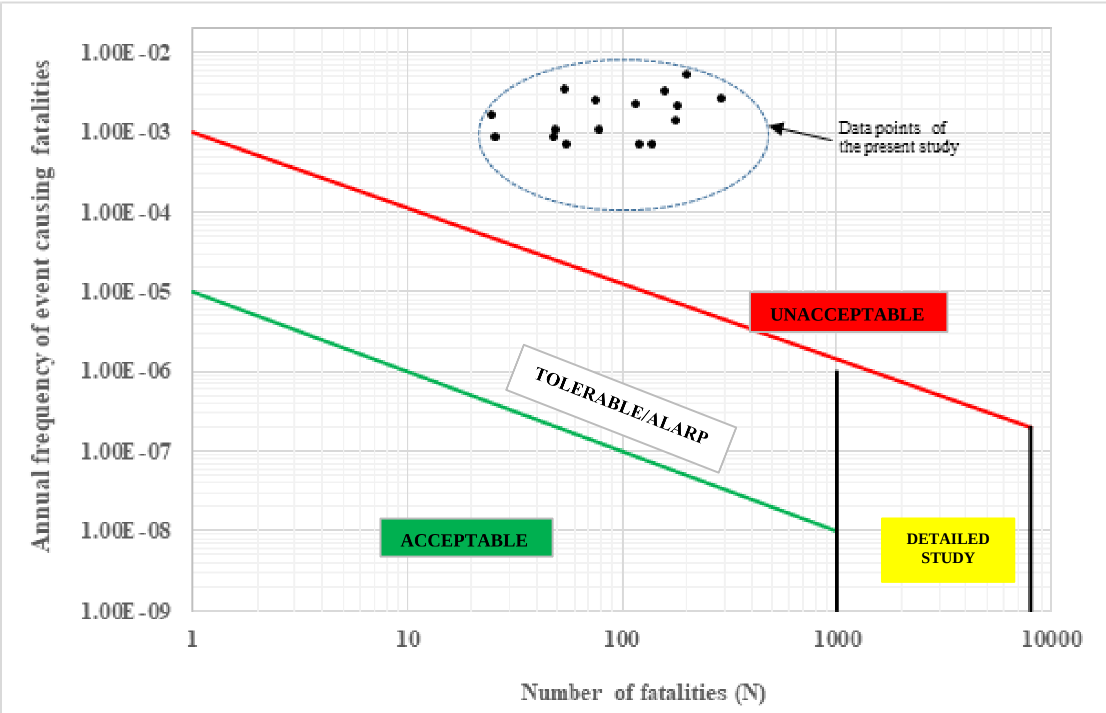

Figure 5: Risk Level of Petroleum Tanker Fire Explosion Accidents in Relation to Societal Risk Curves (Source: Maselli et al 2021).

Inbuilt Causes of Accidents and Aggravating Factors

Inherently, fire and explosion are caused by a combustion process denoted by fire triangle and explosion pentagon respectively as indicated in Figure 6.

Figure 6: Inherent Causes of Fire and Explosion Using Fire Triangle and Explosion Pentagon Hexagon Models. (Net, 2025)

The fire triangle starts with fuel substance inform of flammable solid, liquid or gases which generates heat and light when burnt or reacted. This is followed by an oxygen (oxidizer) substance which aids combustion and finally ignition source which avails the needed energy to start a chemical reaction between the fuel and oxygen. Common sources of ignition are hot surfaces, open flames, electrical energy and sparks. In the case of explosions, confined space and specific mixture ratio also play a role. Confinement either partial or total allows an increase in overpressure provided ignition of the fuel and air mixture occurs. This consequently allows a fast-burning flame to transit to an explosion. Additionally, the mixture of the fuel and oxygen must be within lower and upper flammability limits in order to be ignited at a particular pressure and temperature. Therefore, the aforementioned processes are responsible to the petroleum tanker fire and explosions in the present study.

Aside the inbuilt causes of fire and explosion as previously enunciated, there are aggravating factors responsible for the increase in the intensity of accidents in terms of number of deaths, injuries, environmental pollution and overall spread. In the present study, five major aggravating factors namely mechanical, collision, impact, scooping and human were found to increase the severity of petroleum tanker fire and explosion accidents in Nigeria. These factors were equally identified by Chanut et al. (2017) and Odogun (2021). It is pertinent to note that most accidents have more than one factor hence the most prevalent one is adopted. In the present paper, accident by collision refers to two or more moving objects (vehicles) coming together whilst accident by impact occurs when a moving object (tanker vehicle) hits a stationary object in an accident.

Figure 7 shows an overview of the frequency, deaths and injuries caused by petroleum tanker fire and explosion in Nigeria based on aggravating factors. Also from some accident cases, the aggravating factors could not be ascertained hence classified as unknown. Table 1 gives a detailed breakdown of the aggravating factors in terms of percentage. For number of accidents, human factor accounts for the highest number of accidents with about 59.0 per cent of the total number of 171 followed by mechanical and unknown with 13.5 per cent and 12.3 per cent in that order. This reaffirms the findings from the studies of Dare et al. (2009), Masaeid (1996), Odogun (2021) and Singh (2017) where human factor is regarded as the most contributing factor for petroleum tanker fire and explosion accidents.

In terms of number of fatalities, scooping of spilled petroleum products led to 730 deaths and subsequently, human and impact factors had 602 and 193 mortalities, accordingly. The influence of scooping as a major contributing factor was highlighted by Ewbank (2019) and Odogun (2021). In Nigeria the highest number of mortalities based on scooping could be attributed to Nigeria been a lower-middle income nation with poor socio-economic indices such as poverty and illiteracy rate. However, in terms of number injuries, human factor contributes the most with 416 followed by scooping of spilled fuel which is about 1.6 percent lower than the human factor.

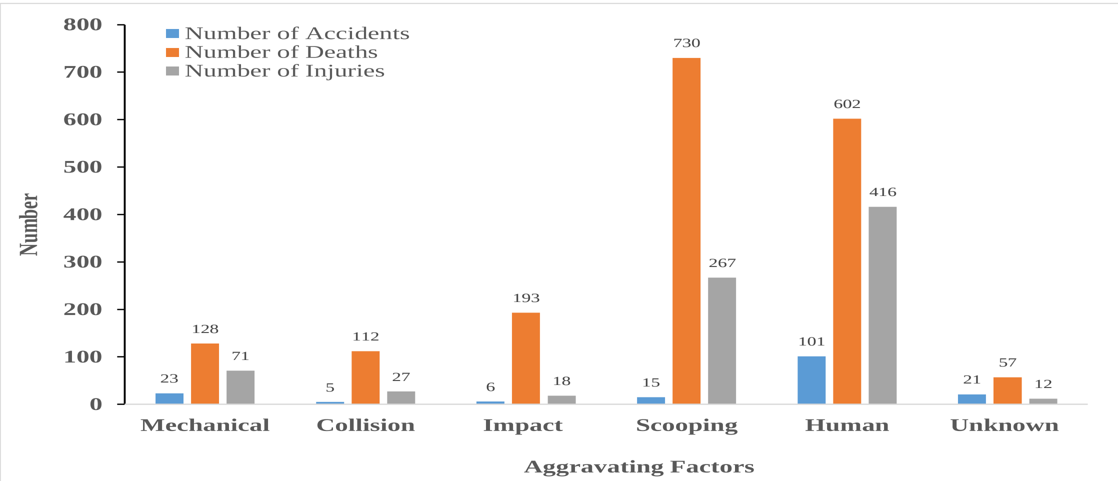

Figure 7: Analysis of Aggravating Factors on Petroleum Tanker Fire and Explosion Accidents in Nigeria for Number of Accidents, Deaths and Injuries

Table 1: Contribution of Aggravating Factors on Frequency, Number of Deaths and Injuries from Petroleum Tanker Fire and Explosion Accidents in Nigeria

Aggravating factors	Number of accidents	Percentage	Number of Deaths	Percentage	Number of Injuries	Percentage
Mechanical	23	13.5	128	7.0	71	8.8
Collision	5	2.9	112	6.2	27	3.3
Impact	6	3.5	193	10.6	18	2.2
Scooping	15	8.8	730	40.1	267	32.9
Human	101	59.0	602	33.0	416	51.3
Unknown	21	12.3	57	3.1	12	1.5
Total	**171**	**100**	**1822**	**100**	**811**	**100**

Statistical Analysis of Aggravating Factors

Chi-Square Test of Independence

A Chi-Square test of independence was used to test if there is a statistically significant association between categorical variable (the type of aggravating factor) and categorical/count data (the frequency of accidents, deaths, or injuries). The data in the present study (Table 1) is in a contingency table hence, perfect for a Chi-square Test. The test was premised on three assumptions. Firstly, the data are counts or frequencies, not percentages or continuous measurements. Secondly, observations are independent of each other (no person, object, or event is counted in more than one cell) and finally the sample size is sufficiently large, and specifically, no more than 20% of the expected counts should be less than 5 and no expected count should be less than 1. Table 2 displays the data in a contingency table used while Table 3 shows the result of the Chi-square result test.

Table 2: Data in Contingency Table used for Chi-square Test

Aggravating factors	Number of accidents	Number of Deaths	Number of injuries	Total
Mechanical	23	128	71	222
Collision	5	112	27	144
Impact	6	193	18	217
Scooping	15	730	267	1012
Human	101	602	416	1119
Unknown	21	57	12	90
Total	**171**	**1822**	**811**	**2804**

Table 3: Result of Chi-Square Test for Categorical Variables and Categorical Counts

x- squared	Degree of Freedom	p-value
235.26	10	0.0000

The condition for interpretation of the Chi- Square Test from Table 3 is that if p-value < 0.05; then, there is a statistically significant association between the type of aggravating factors and the accident outcomes. But, if p-value ≥ 0.05; then there is no significant association. The Chi-Square value (X-squared) of 235.26 signifies how different observed numbers are from what would be expected if there was no relationship. And Degrees of Freedom (df) = 10 is gotten based on how many groups and outcomes available. Also, the P-value < 0.0000, is an extremely small number (practically zero) and this implies that there is a very strong evidence against the idea that there's no relationship.

Generally, Table 2 indicates a strong and significant relationship between the cause of an accident and the type of outcome. In other words, the type of aggravating factor (like mechanical or human error) matters as it affects whether the event ends up being more accidents, more deaths, or more injuries. The pattern is not random because certain causes lead to more severe outcomes than others. For instance, scooping incidents caused 730 deaths and this far above what would be expected if outcomes were spread evenly across causes. While collision had only 5 accidents but 112 deaths signifying a relatively high death count for a small number of accidents. This pattern is too uneven to be explained by chance alone and the Chi-Square test confirmed that statistically as evident in Table 3.

By associating the experimental values to the predictable ones, a substantial statistical difference designating a bond between the variables could be determined using an expected Chi-Square value in a chi-square test. The expected value for each cell is critical because it symbolises an expected value to an observed one in a cell provided no relationship between the tested variables existed. Table 4 shows the expected Chi-Square value for each of the cell in the present study.

Table 4: Expected Chi-Square Value for Number of Accidents, Deaths and Injuries

Aggravating factors	Number of accidents	Number deaths	Number of injuries
Mechanical	13.5385	144.2525	64.2090
Collision	8.7817	93.5692	41.6491
Impact	13.2336	141.0036	62.7628
Scooping	61.7161	657.5835	292.7004
Human	68.2414	727.1106	323.6480
Unknown	5.4886	58.4807	26.0307

The expected values of Chi-Square shown in Table 4, the Chi-Square expected counts are above 5. Therefore, the type of cause behind an accident clearly influences whether it results in a greater number of accidents, injuries, or deaths. Some causes lead to worse outcomes than others, and this pattern is not random but a strong and proven relationship.

Analysis of Variance (ANOVA)

An inferential statistical tool, ANOVA was used in the present study to compare the mean number of deaths or injuries across different aggravating factors (assuming there were sample data with means and not just totals). This fits the data because it tests for significant differences between group means, and hence it will help in observing the association between the two factors. The data used for the ANOVA is in Table 2. The aggravating factors are considered to be factor A (The Treatment) with 6 levels taken as Mechanical (M), Collision (C), Impact (I), Scooping (S), Human (H), and Unknown (U) causes. The accidents outcomes are considered as the subjects (Factor B) with 3 levels taken as Number of accidents (NOA), Number of deaths (NOD) and Number of injuries (NOI). Hence, each treatment is assigned to each object to see how deep the number of outcomes on each subject (accidents outcomes) is. ANOVA provides the difference between the means of each factor as well as the relationship between them. The corresponding result of the ANOVA test is indicating how the two factors interact to affect a response variable is shown in Figure 8.

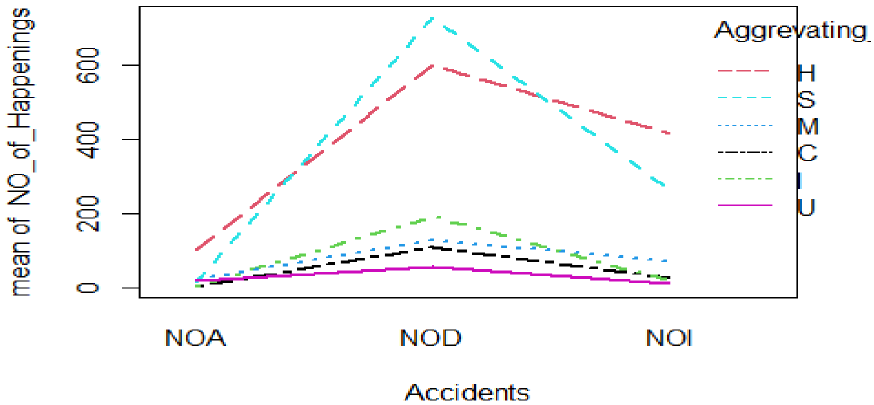

Figure 8: Relationship Between Mean Number of Happening and Outcome of Accidents (Source: Authors - (Na'inna et al. 2025)

Figure 8 shows that across all aggravating factors, the NOD is consistently higher than accidents NOA and NOI. Scooping (S) causes the highest number of deaths, peaking way above all other factors. Human (H) is the next highest contributor to deaths, but well below Scooping. Other factors like Mechanical (M), Collision (C), Impact (I), and Unknown (U) have much lower and relatively flat counts. Since the lines are not parallel, this suggests that the effect of an aggravating factor on the number of happenings depends on the accident type, which means there is interaction between the two factors.

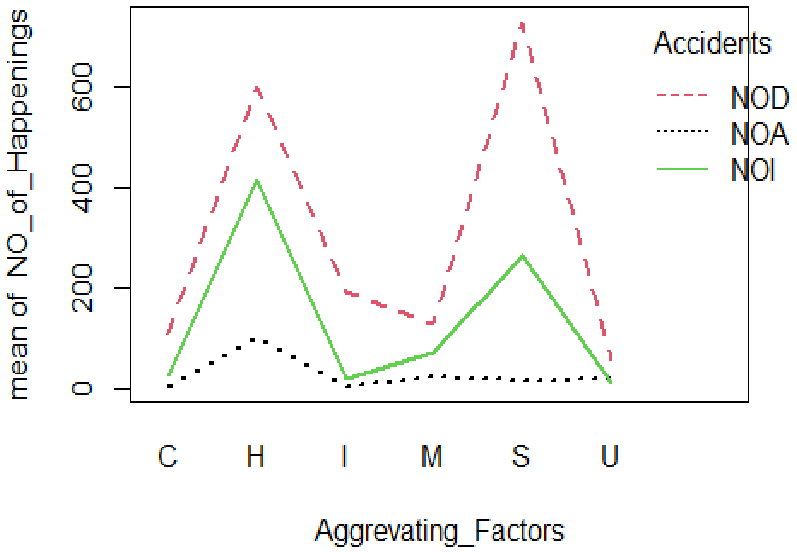

Figure 9: Relationship Between Mean Number of Happenings and Aggravating Factors (Source: Authors -(Na'inna et al. 2025)

Figure 9 displays connection between the mean number of happenings and aggravating factor for each accident type. It was revealed that the NOD is highest for Scooping (S) and Human (H) causes, NOI is notably high for Human (H) and Scooping (S) but much lower for others, and the NOA is relatively low and more evenly distributed, but still peaks for

Human (H) cause only. Again, the non-parallel lines confirm an interaction effect implying that the type of aggravating factor affects various accident outcomes differently.

In sum, the type of cause (aggravating factor) behind an accident outcome affects whether it results in more number of accidents, deaths, or injuries and this relationship changes depending on the type of accident cause. For example, scooping incidents lead to far more deaths than any other cause, while human-related incidents cause more injuries and deaths compared to others. The non-parallel line in the plots implies that the effect of one factor depends on the other, confirming a strong interaction between them.

Table 5 gives an overview of the ANOVA test with sources being accidents, aggravating factors and residuals.

Table 5. Result of Analysis of Variance (ANOVA) for the Petroleum Tanker Accidents

Source	Df	Sum Square	Mean Square	F value	Pr(>F)
Accidents	2	230,973	115,487	5.914	0.0202 *
Aggravating Factors	5	363,704	72,741	3.725	0.0365 *
Residuals	10	195,292	19,529		

The effect of accident type/outcome (accidents) shows that the p-value for accidents is 0.0202, which is less than 0.05, and this means there is a statistically significant difference in the mean number of happenings/outcomes (number of accidents, deaths and injuries) between different accident types. In other words, the type of accident has a significant effect on how many happenings/outcomes/observations occur. Also, the influence of aggravating factors shows that the p-value for aggravating factors is 0.0365, which is also less than 0.05. This also means that there is a statistically significant difference in the mean number of happenings based on different aggravating factors. Hence, the cause behind the accidents significantly affects how many happenings/outcome/observations occur. The Residual sum of squares and mean square gives a measure of unexplained variability. In the case of this study, there is still variability left (Residual SS = 195,292), meaning other factors not included in this model might also influence the number of happenings/outcomes/observations.

Therefore, both the type of accident and the cause (aggravating factor) have a significant impact on the number of happenings/outcomes/observations. This means that the number of accidents, deaths, and injuries vary significantly depending on what type of event it is and what caused it. So, to reduce these incidents, it is imperative to pay attention not only to what type of accidents occurs but also to the underlying causes.

Yearly Analysis of Aggravating Factors

A yearly analysis of the influence of aggravating factors on petroleum tanker fire and explosion accidents with respect to the number of accidents, deaths and injuries is presented in Figure 10, 11 and 12 respectively. The highest number of accidents, 18 occurred in 2019 and it is attributable to human factor (Fig 10). It followed a progressive pattern from 2009 up to the peak year of 2019 before it subsequently dwindled. Scooping and mechanical factors in 2019 and 2021 had their respective maximum number of accidents of about 3.6 and 4.5 folds lower than that obtained for human factor. On the number of deaths (Fig 11), scooping of spilled fuel had contributed to the highest number of fatalities of 209 in 2024. Relative spikes in ascending order were observed on the scooping profile in 2009, 2012 and 2019 which recorded 83, 112 and 142 deaths in that order. Based on the number of injuries (Fig 12), factor attributed to scooping led to the highest number of 199 injuries in 2019 followed by human with 109 victims in 2018 and mechanical having 50 persons injured in 2020. Details of the 16-year review of the aggravating factors and their influence on number of accidents, deaths and injuries are in Table 6.

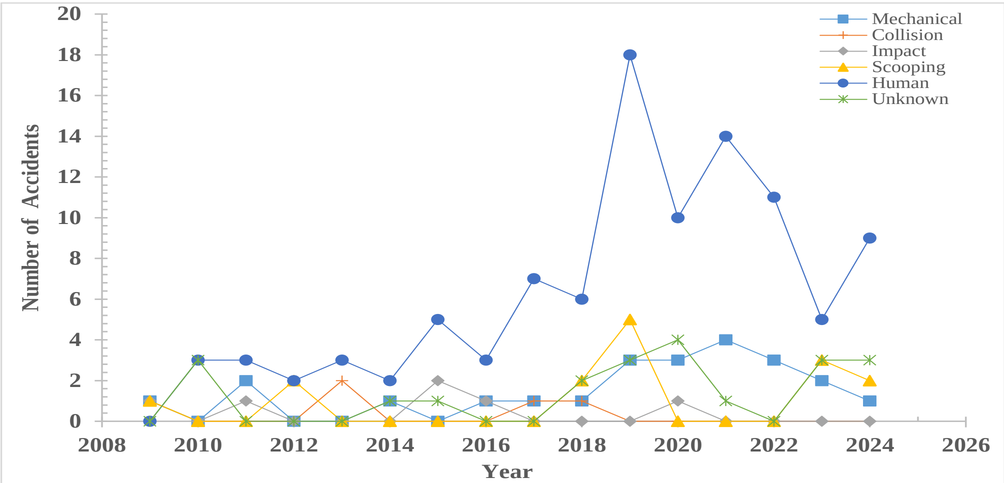

Figure 8: Yearly Analysis of Number of Accidents Based on Aggravating Factors of Petrol Tanker Fire and Explosions

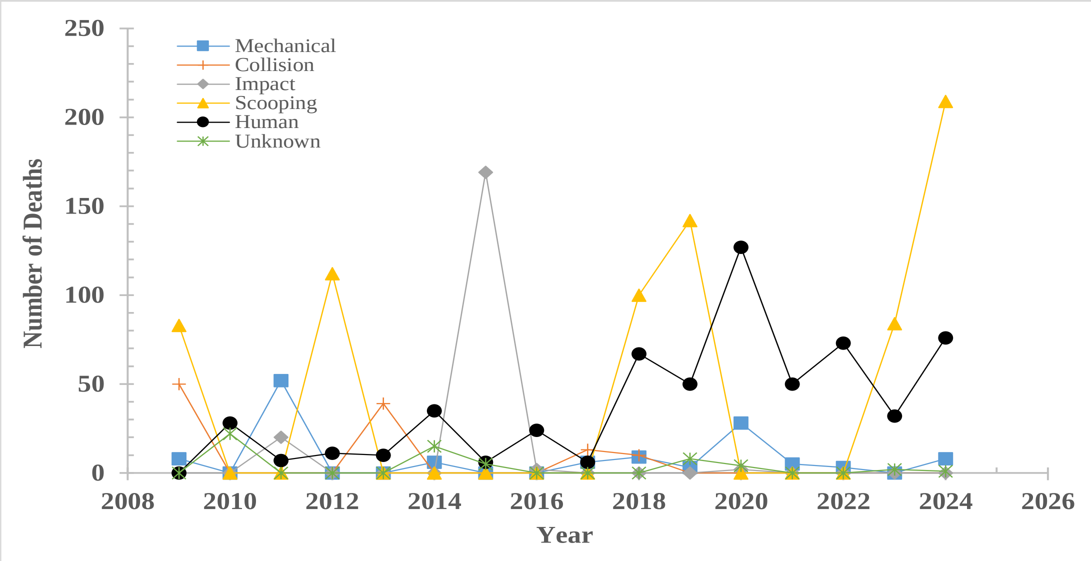

Figure 9: Yearly Analysis of Number of Deaths Based on Aggravating Factors of Petrol Tanker Fire and Explosions

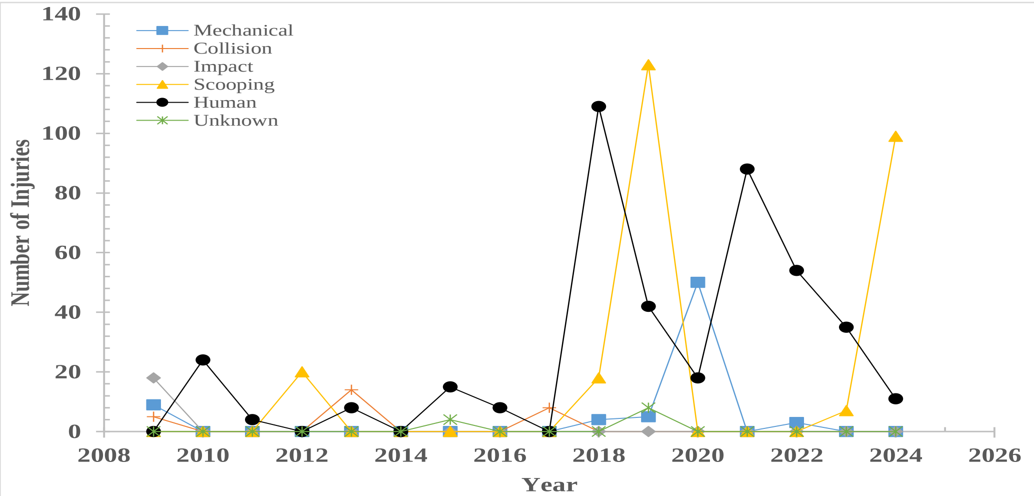

Figure 10: Yearly Analysis of Number of Injuries Based on Aggravating Factors of Petrol Tanker Fire and Explosions

Table 6. Annual Distribution of Aggravating Factors on Petroleum Tanker Fire and Explosions in Nigeria with Respect to Number of Accidents, Deaths and Injuries

				Number of Accidents			
Year	**Mechanical**	**Collision**	**Impact**	**Scooping**	**Human**	**Unknown**	**Total**
2009	1	1	1	1	0	0	4
2010	0	0	0	0	3	3	6
2011	2	0	1	0	3	0	6
2012	0	0	0	2	2	0	4
2013	0	2	0	0	3	0	5
2014	1	0	0	0	2	1	4
2015	0	0	2	0	5	1	8
2016	1	0	1	0	3	0	5
2017	1	1	0	0	7	0	9
2018	1	1	0	2	6	2	12
2019	3	0	0	5	18	3	29
2020	3	0	1	0	10	4	18
2021	4	0	0	0	14	1	19
2022	3	0	0	0	11	0	14
2023	2	0	0	3	5	3	13
2024	1	0	0	2	9	3	15
Sub total	23	5	6	15	101	21	**171**

Number of Accidents							
Year	**Mechanical**	**Collision**	**Impact**	**Scooping**	**Human**	**Unknown**	**Total**
Number of Deaths							
Year	**Mechanical**	**Collision**	**Impact**	**Scooping**	**Human**	**Unknown**	**Total**
2009	8	50	0	83	0	0	141
2010	0	0	0	0	28	22	50
2011	52	0	20	0	7	0	79
2012	0	0	0	112	11	0	123
2013	0	39	0	0	10	0	49
2014	6	0	0	0	35	15	56
2015	0	0	169	0	6	5	180
2016	0	0	2	0	24	0	26
2017	6	13	0	0	6	0	25
2018	9	10	0	100	67	0	186
2019	3	0	0	142	50	8	203
2020	28	0	2	0	127	4	161
2021	5	0	0	0	50	0	55
2022	3	0	0	0	73	0	76
2023	0	0	0	84	32	2	118
2024	8	0	0	209	76	1	294
Sub total	128	112	193	730	602	57	**1822**
Number of Injuries							
Year	**Mechanical**	**Collision**	**Impact**	**Scooping**	**Human**	**Unknown**	**Total**
2009	9	5	18	0	0	0	32
2010	0	0	0	0	24	0	24
2011	0	0	0	0	4	0	4
2012	0	0	0	20	0	0	20
2013	0	14	0	0	8	0	22
2014	0	0	0	0	0	0	0
2015	0	0	0	0	15	4	19
2016	0	0	0	0	8	0	8
2017	0	8	0	0	0	0	8
2018	4	0	0	18	109	0	131
2019	5	0	0	123	42	8	178
2020	50	0	0	0	18	0	68
2021	0	0	0	0	88	0	88
2022	3	0	0	0	54	0	57
2023	0	0	0	7	35	0	42
2024	0	0	0	99	11	0	110
Sub total	71	27	18	267	416	12	**811**

Overview of Causes of Accident and Preventive Measures

To gain more insights into the causes and aggravating factors on petroleum tanker fire and explosion accidents in Nigeria, a Haddon matrix is applied. The matrix is a framework used in accident/or injury prevention by systematically analysing events and developing prevention strategies (Haddon, 1968). It considers three phases as pre-vent, event and post-event in relation to various influencing factors namely host and agent as well as physical and social environments. Table 7 gives a summary of comprehensive overview of the causes and aggravating factors of petroleum tanker fire and explosion accidents in Nigeria.

Table 7: Analysis of Causes and Aggravating Factors in Petroleum Tanker Fire and Explosions in Nigeria using Haddon Matrix

Phase	Host	Agent	Physical Environment	Social Environment
Pre-event	•Driver ✓ Medical condition ✓ Sudden illness ✓ Heart attack ✓ Fatigue ✓ Under age ✓ Overtaking impulsiveness ✓ Not wearing seat belt/helmet ✓ Drunken driving	• Speeding truck • Wrong number of axle • Momentum of vehicle • Surrounding buildings • Welding torch • Vehicle carrying both passengers and fuel • Poor lighting • Poor safety features • Brake failure	• Poor roads • Absence of traffic system • Traffic congestion • Security checkpoints • Crowded buildings • Ravines • Bridges • Bad weather • Lightning	• Poverty provoking scooping • Lack of regulatory framework • Illegal fuel market • Corruption

	✓ Non-familiarity with terrain ✓ Inadequate training ✓ Operational Error • Maintenance Crew ✓ Poor design ✓ Poor construction ✓ Poor maintenance and monitoring	• Problem with head or tail light • Overloaded vehicles • Absence of assistive technologies in tankers • Spillage due to tank leakage • Tank material failure • Equipment Failure • Crack and Rupture • Leak and Line Rupture	• Lack of pedestrian footpath	
Event	• Bystanders • Other motorists • Bus passengers • Unrestrained passengers	• Impact of moving tanker with stationary objects • Collision of moving vehicle with tanker in motion • Rollover	• Nearby hospitals • Traffic control • Emergency medical services	• Opportunity to scoop fuel • Lack of corporate responsibility
Post-event	• Victim recovery • Post injury care received • Psychological coping of individual	• Smoking around spilled fuel • Severity of injuries • Post event psychological impact	• Rehabilitation facility • Transportation to hospitals	• Health insurance • Poor response time by relevant agencies • Family and social support • Access to rehabilitation services

(Source: Authors - (Na'inna et al. 2025)

A comprehensive overview of preventive and/or mitigative measures on petroleum tanker fire and explosion accidents in Nigeria is presented in Table 8 using Haddon Matrix. Preventive measures are regarded more important than mitigative measures because the former inhibits an accident from occurring while the later reduces the impact of an accident if it occurs. It is evident in Table 8 that pre-event phase is the most critical one where the bulk of the measures are found to be preventive. Both measures of preventing/mitigating the tanker accidents are to be taken by relevant stakeholders in Nigeria where applicable.

Table 8. Suggested Preventive and Mitigative Measures on Petroleum Tanker Fire and Explosion Accidents in Nigeria using Haddon Matrix

Phase	Host	Agent	Physical Environment	Social Environment
Pre-event	• Ensuring medical fitness to drive • Random checks on drivers and maintenance crew for alcohol consumption, drugs intake and substance abuse. • Regular safety and emergency response training for drivers and handlers • Routine maintenance and inspections of fuel tankers to ensure meeting safety standards • Adequate provision and appropriate usage of PPE by drivers • Changing road user behaviour on speed reduction, drunk/drug-driving, and distracted driving and the likes • Producing safer tanker trucks in line with UN minimum safety standards, protections for pedestrians/cyclists/motorcyclists • Provide drivers with necessary equipment to communicate with bystanders, blockade the area until additional assistance arrives	• Reduce the risks of mechanical failure by maintaining tankers to high safety standards • Equip vehicles with necessary emergency response tools • Development and use of explosion-resistant fuel containers equipped with passive protection modules. • Incorporation of hi-tech components such as anti-roll technology, stability braking system, speed limiter system	• Development of infrastructure such as roads, bridges and modern traffic system. • Provision of functional railway and pipeline transport systems as alternate to fuel tanker vehicles • Early warning signs of obstacles or danger ahead to drivers such as roadblocks, security checkpoints, sharp bents, hill climbing and the likes. • Set up of dedicated parking bays for tanker drivers to prevent accidents attributed to stress. • Ensure no naked flames or any source of ignition is	• Strengthen regulatory oversight to ensure only roadworthy tankers are operated by well-trained drivers. • Educate the public on the dangers of fuel scooping, risks of explosions and health issues. • Advocate for public emergency response education on how to act safely when witnessing fuel spills. • Regulatory agencies to ensure safety compliance through regular inspections, licensing and penalties for non-compliance. • Investing in research and development on the petroleum tanker

Phase	Host	Agent	Physical Environment	Social Environment
	• Train lay civilians to provide more extensive pre-hospital care	and anti-spill lock in fuel tankers. Others are vehicle location monitoring system, vehicle condition monitoring system, route planning systems, driver behaviour monitoring systems and crash preventing systems.	available around any parked or moving fuel • Construct mini fire service stations along major routes in the country regularly plied by fuel tankers • Provision of fire-fighting helicopters	accidents and related fields • Regulate the movement of fuel tankers to preferably between 8pm and 6am. • Layperson training in local wound care with simple open dressings and improved nutrition • Bar tankers carrying 60,000 litres of fuel and above on Nigerian roads. • Ensure strict regulations for driving test and issuance of driving licenses • Create and implement standardized emergency procedures for clearing the scene of fuel tanker accidents.
Event	• Care by Emergency Services at the scene before the arrival of medical staff. • Bystanders calling for ambulance, securing scene and applying first aid to victims		• Cordon of place by security personnel on crash site. • Provision of alternative routes for vehicles and persons within the vicinity of the accident.	
Post-event			• Provision of care before reaching a hospital. • Improving hospital care especially trauma treatment • Improving rehabilitation of victims • Develop and equip additional burn specialty units in Nigerian hospitals • Optimize hospital infrastructure to accommodate victims of fuel tanker accidents.	• Fuel companies and the haulage companies to bear consequences for accidents, environmental harm, injuries and deaths. • Improving post-crash care (e.g. universal emergency numbers, centralized emergency dispatch, lay pre-hospital provider training, emergency specialists at healthcare facilities, trauma care quality improvement programs

(Source: Authors - (Na'inna et al. 2025)

CONCLUSION

This study presents a comprehensive analysis of petroleum tanker fire and explosion accidents in Nigeria over a 16-year period from January 2009 to December 2024. Using data from 171 reported accident cases, the study recorded a total of 1,822 deaths and 811 injuries. Petrol-related tanker accidents accounted for approximately 80% of all incidents, fatalities, and injuries, followed by gas and diesel tanker accidents. Temporal analysis revealed that 2019 recorded the highest number of injuries (29 deaths and 178 injuries), while 2024 experienced the highest fatalities, with 294 deaths. The findings indicate a proportional relationship between accident frequency and accident severity, with injuries showing a stronger association than fatalities. All accident data points fell within the "unacceptable" societal risk zone, suggesting an excessively high risk level and underscoring the urgent need for enhanced mitigation strategies. Fire and explosion incidents were attributed to combustion processes involving fuel, oxygen, ignition sources, and confinement, alongside several aggravating factors. Five major aggravating factors mechanical failure, collision, impact, scooping of spilled fuel, and human factors were identified as contributors to accident severity. Human factors accounted for the highest number of accidents and injuries (101 and 416, respectively), while fuel scooping resulted in the highest fatalities (730 deaths). Statistical analysis using the Chi-square test confirmed a strong and significant association between accident causes and outcomes, indicating non-random patterns of severity. ANOVA results further demonstrated statistically significant differences in accident outcomes across different accident types and aggravating factors. Although the model explained much of the variability, residual analysis suggested the influence of additional unobserved factors. The Haddon Matrix was applied to categorize accidents into pre-event, event, and post-event phases, highlighting the pre-event phase as the most critical for preventive interventions. Overall, the study emphasizes prioritizing preventive measures over mitigative actions and calls for coordinated stakeholder efforts to reduce petroleum tanker accident risks in Nigeria.

Data Availability Statement

Data set associated with the paper is available via: https://doi.org/10.5281/zenodo.15032760

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