DISCOVERY

58(320), August 2022

Fault Tree Analysis for Mitigation of Equipment Failure during Covid-19 in Nigeria: A Case Study

IGBERE, Ndukam Billy[1], Ukpaka CP[2], Nkoi B[3]

To Cite:
Igbere NB, Ukpaka CP, Nkoi B. Fault Tree Analysis for Mitigation of Equipment Failure during Covid-19 in Nigeria: A Case Study. *Discovery*, 2022, 58(320), 839-856

Author Affiliation:
[1,3]Department of Mechanical Engineering, Rivers State University Port Harcourt, Rivers State, Nigeria.
[2]Department of Chemical/Petrochemical Engineering, Rivers State University Port Harcourt, Rivers State, Nigeria.
Email:chukwuemeka24@yahoo.com

Peer-Review History
Received: 24 May 2022
Reviewed & Revised: 26/May/2022 to 29/June/2022
Accepted: 02 July 2022
Published: August 2022

Peer-Review Model
External peer-review was done through double-blind method.

ABSTRACT

Accidental events in manufacturing industries can be caused by several factors, including poor risk management that leads to damage to assets, high maintenance cost, environmental damage, reduced production output, facilities and injuries. This research seeks to assess the implementation of Fault Tree Analysis for Mitigation of Equipment Failure in Nigeria. The various risk management techniques applied in Nigeria Liquefied Natural Gas (NLNG) Company at the event of the pandemic (Covid-19). The fault tree analysis (FTA) risk management technique as well as the extent to which it is implemented during the Pandemic and the challenges militating against the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of the pandemic transmission was assessed. Measures to mitigate the challenges faced by NLNG Company in effective implementation of FTA risk management technique against the events of the Pandemic transmission were provided. Descriptive survey and quantitative research method were employed to analyze the data of the responses generated from the structured questionnaires completed by employees in NLNG Company in Rivers State. Broad based for identification of various risk management techniques applied in NLNG Company against the event of corona virus transmission revealed about 57 percent of respondents believe the what-if method is the most reliable method of identifying risk in NLNG, while 39 percent believe Hazop is the most reliable method because it is a more detailed review technique used by the chemical and gas industries, and about 35 percent and 27 percent believe risk is identified through safety and other visualization. The result from the study for assessing the extent, to which fault tree analysis (FTA) risk management technique is implemented in NLNG Company against the event of corona virus transmission, revealed that RCA is often used and easy to use methods for more complete risk analysis, according to 80 percent to 100 percent of those polled. The next easiest and most commonly used tool is WHATIF analysis, which has been shown to have a 60 percent to 80 percent score test, followed by HAZOP, and FMEA, FMECA, FTA, and FISHBONE, which scored low on the aspect of "ease of use" tool in the NLNG Company based on the results of the survey collected. In the study, ten challenges militating against the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus

transmission were investigated. Lack of expertise in techniques in oil and gas industry achieved the highest RII mean index (4.08). Lack of familiarity with techniques and nonexistence or not followed management of change procedures accounting for RII mean index of 4.02 is the second most important barrier, followed by lack of information and knowledge, flawed communication and reporting systems and lack of joint risk management mechanisms by parties representing mean index of 3.94 and 3.88 respectively. The result shows that experts still don't have adequate information in FTA risk management and techniques then training are necessary for FTA risk managing implementation. Conclusion and recommendation were made that, since those experts still don't have adequate information in FTA risk management technique then training and education of contractors and employees in oil and gas companies on using FTA risk management technique can be a useful way and best practice to improve the productivity of the industry.

Key words: Fault tree, analysis, mitigation, equipment, failure, Nigeria:

1. INTRODUCTION

Fault-Tree (FT) can be introduced to handle unpleasant consequence of event [1-2]. As the Top-Event, the most serious result (such as hazardous discharge, explosion, infection, pollution, and so on) is chosen. This method can link hardware faults to human errors as well component failure, is used to start the event-tree. An increase in temperature/pressure, the release of a hazardous material, or a combination of these events could serve as initiating events, manual contact, or air borne droplets [3-4]. The possibility of airborne transmission of Corona virus was recently announced by the WHO and is expected to be responsible for the acceleration of the epidemic worldwide [5-6]. The search for causes is pushed to reach the root cause (RCA). This method is at the origin of the design and strategic implementation of Prevention barriers. When it comes to analysing the effects of a failure or unfavourable incident, ET is invaluable. The event's repercussions are traced through a succession of different paths, each with its own probability of occurrence, allowing the likelihood of many possible outcomes to be determined [7].

Protective and/or preventative measures, which are parts of risk control, must be undertaken to monitor, combat, and manage the danger of epidemic. Implementing strategies to prevent Covid-19 pathology from happening minimizes the chance of contamination [8]. In terms of protection, it lessens the severity by minimizing the potential impact of a biological hazard in the event of proliferation. Human, organizational (procedures, training, communication), or technology risk reduction or control measures are all possible [9]. The actions must be conducted at the correct time, in the right place, and with the proper rigor and response time. The Global risk security GHS Index identifies serious flaws in Nigeria's oil and gas production industries policies and other factors that have militated the firms against adopting health risk analytical and prevention technique such as fault tree analysis.

In this research, the various risk management techniques applied in the operations of Nigeria Liquefied Natural Gas (NLNG) Company against the event of corona virus transmission were identified and the level at which the gas firm incorporate fault tree analysis (FTA) risk management technique in their strategic prevention plan was evaluated [10-13]. The challenges the firm faces in the implementation of the fault tree analysis (FTA) risk management were also identified. This study described some of the main challenges fault tree analysis method of preventing the risk of Corona virus infection targeted at enhancing the decision-making process in the gas business [14-16].

The current world financial crisis, along with the fierce competition among companies to obtain business, is prompting organizations to look for solutions to lower the costs of accidents and health incidents on their equipment and human resources [17-18]. Reduced expenditures on equipment failures is a popular way to cut operating costs, loss of human life and environmental catastrophe caused due to mismanagement of risk and inabilities to detect, prevent, and respond to health hazards [19-20].

Hazards can be categorised, which can help identify and prioritize their elimination. Marginal, critical, and catastrophic hazards are the four types of hazards. In the case of minor dangers, the damage will not be severe enough to cause system failure or injury to service employees. System failures that result in personal injury or material damage are known as critical hazards. This is the result of an unacceptable threat that necessitates prompt response. As a result of the catastrophic danger, the system is severely harmed, and people are killed or injured [22]. Technical, human factors (human errors), and environmental risks can all be classified as threats depending on the source of the danger. Aside from the usual technical risks posed by machines, equipment, and instruments, the human aspect is frequently involved.

The aim of this study is the use of Fault Tree Analysis for Mitigation of Equipment Failure as it relate to Corona Virus Monitoring and Control strategy in Nigeria Liquefied Natural Gas (NLNG) Company.

2. MATERIALS AND METHODS

Materials

Primary data was obtained via structured questionnaires, and secondary data was generated using extant literatures on assessing the implementation of Fault Tree Analysis for Mitigation of Equipment Failure as it relate to Corona Virus Monitoring and Control strategy in Nigeria Liquefied Natural Gas (NLNG) Company.

For quantitative and qualitative analysis, the necessary data were gathered through a survey questionnaire and interviews. The content validity was utilized in this study to determine whether the structured questionnaire was valid for the study, and it was done with the help of workers and stakeholders in the Nigerian LNG business who are considered experts in the field. Due to the high literacy rates of the target demographic, the questionnaire was self-administered. Drop off, pick up later was the method used to administer the study instrument. The quantitative and qualitative data collected using questionnaires and interviews were analyzed using the SPSS statistical software which also constituted part of the materials used for this research work.

Research Questions

i. What are the various risk management techniques applied in NLNG Company against the event of corona virus transmission?
ii. What is the level at which NLNG industry implement fault tree analysis (FTA) risk management technique in their strategic plan against the event of corona virus transmission?
iii. What are the challenges faced by NLNG industry in the implementation of fault tree analysis (FTA) risk management technique against the event of corona virus transmission?

Research Approach

A convergent parallel mixed method with the relevant replies from structured survey questionnaires and interviews with employees of the Nigeria Liquefied Natural Gas (NLNG) Company in Rivers State were analyzed using a statistical approach. Quantitative research methods were used to acquire primary data due to the breadth of the study and the nature of the research aims. In order to use a quantitative research approach, in this case surveys, the research was conceptualized using qualitative research methodologies and interviews to get a picture of what needed to be examined. As a result, an exhaustive literature review was conducted first. On fault tree analysis (FTA) risk management technique and sources of the reviewed literatures and other relevant information. Indeed, theses were all used in the research.

The secondary data was derived from secondary sources through a systematic review of literature. Electronic searches of the following databases including; Scopus, Elsevier, Science direct and Google Scholar, was also conducted. The review provided information to the members of the conceptual framework that was used to create the research instrument for data collecting and analysis. A total of 55 people took part in the quantitative poll, including the company's senior executive, supervisors and stakeholders with relevant knowledge on fault tree analysis (FTA) risk management technique in In Rivers State, there is a company called Nigeria Liquefied Natural Gas (NLNG).

The respondents in the poll were carefully chosen based on predetermined criteria, and the nature of the respondents was underlined.

Research Methodology

For this study, a convergent parallel mixed method technique was used, which included both quantitative and qualitative methodologies in a single inquiry.

Research Design

Research aimed to examine, report, and give meaning to data on risk mitigation approaches of Nigerian oil and gas activity, which was the study's goal. This study used a convergent parallel mixed method technique, in which both quantitative and qualitative approaches were used in a single investigation. While data was only collected once, the goal was primarily for triangulation (cross-sectional). The study used a contemporaneous triangulation design, in which data was collected and analyzed at the same time, and the results were compared. Quantitative data was collected and analyzed using a survey questionnaire and descriptive statistics, whereas qualitative data was obtained and analyzed using semi-structured in-depth interviews and thematic analysis.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Study Area

The oil and gas business in Nigeria was chosen for this study because of its conventional nature of activities, both offshore and onshore, which are characterized by hazards of varied magnitudes. The research was conducted in the NLNG Company, Rivers State, Nigeria was chosen due to the fact that Rivers State hosts approximately 49 percent of Nigeria's oil and gas activities.

Research Characteristics

The participants in this study were staffs and management of NLNG Company. These target populations have requisite knowledge concerning risk management in oil and gas projects. 55 questionnaires were disseminated to the organisations and randomly administered to the stakeholders, face-to-face, at the refinery facility.

Data Collection

The study included both primary and secondary data, which was gathered via a structured questionnaire and semi-structured interviews to elicit specific responses for qualitative and quantitative analysis, respectively. Secondary data was gathered from public (books, journals) and unpublished (periodicals, conference proceedings, policies and guidelines relevant to risk management in oil and gas projects) sources. A total of 55 people took part in the quantitative survey, including employees (managers and supervisors) and stakeholders with relevant knowledge on risk management in NLNG Company in Rivers State. The responders were carefully chosen based on predetermined criteria and the nature of respondents sampled in the survey was highlighted.

Validity of Data

All data reported in this study is real, as evidenced by the nature of face-to-face pre-interviews and respondents' opinions expressed in preliminary pre-testing among a purposeful sample of organizations not necessarily included in the survey.

Data Collection Source

The instrument used in this study was a structured survey questionnaire, which was designed to assess the company with respect to the research questions. From the sample frame, 55 staff of NLNG Company in Rivers State, Nigeria was chosen. Different forms of sampling approaches may be acceptable for research purposes; however, for the purposes of this study, a simple random method was used from the study population of NLNG Company employees. Published materials (books and journals) and unpublished reports, such as magazines, conference proceedings, policies and guidelines linked to risk management in oil and gas projects, were used as secondary sources of data for this study.

Data Analysis

The scope of this research was limited to an NLNG industry in Port Harcourt, with the goal of determining risk management difficulties at oil and gas sites. In this project the relevant statistical method was employed to analyze the responses that were generated from structured survey questionnaires and semi structured interviews with managers and employees in NLNG in Rivers State. A total of 32 questions were included in the survey.

On a Likert scale, the variables were ranked. A five-point Likert scale was employed, with 1 indicating severe disagreement/never used, 2 indicating disagreement/rarely used, 3 indicating neutral/used in some projects, 4 indicating agreement/used in most projects, and 5 indicating strong agreement/used in all projects.

To address the first and second objectives in the analysis, the spearman's rank correlation analysis was used to identify the various risk management techniques applied in NLNG Company against the event of corona virus transmission and to assess the extent to which fault tree analysis (FTA) risk management technique is implemented in NLNG Company against the event of corona virus transmission, while the Relative Importance Index (RII) method was also used to access the factors challenging the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission in a bid to address the third objective. Measures to mitigate the identified challenges faced by NLNG Company in effective implementation of FTA risk management technique against the events of corona virus transmission were proffered to improve the operation of the industry.

i. Spearman's Rank Correlation

The spearman's rank correlation analysis, often known as the spearman's R test, is a statistical method for determining the strength of correlations between variables. The spearman's rank correlation analysis was used to identify the various risk management techniques applied in NLNG Company against the event of corona virus transmission and to assess the extent to which fault tree

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

analysis (FTA) risk management technique is implemented in NLNG Company against the event of corona virus transmission, to address the first and second objectives of this study.

ii. Relative Importance Index (RII)

The Relative Importance Index (RII) method was also used to access the factors challenging the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission in a bid to address the third objective. The RII is the ratio of the "summation of the weight value" (SWV) of the response ratings and the total number of people who voted in all of the polls. The closer the RII is to 5, the more important the grouped components are. The SWV is calculated by multiplying the product of the value assigned to each rating by the number of respondents, which is:

$$SWV = \Sigma x_i y_i \quad (1)$$

and

$$RII = \frac{SWV}{\Sigma x_i} \quad (2)$$

Where, x_i = number of responses to rating ij, and y_i = the value of rating i (i = 1 to 5).

iii. T-test

The significance of the partial slope parameters of the independent variables was determined using standard relevant t-tests. The t-test is a statistical hypothesis test that determines whether or not statistics have a normal distribution when the null hypothesis is true. When determining whether the population mean is equal to a given value, the null hypothesis is tested μ_0, the test is applied and it is given by:

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} \quad (3)$$

Where, $\bar{x}$ = sample mean value of the data, s = standard deviation of the sample data and n = sample size

The arithmetic mean of the values is given by:

$$\text{Arithmetic mean } (\bar{x}) = \frac{\sum_{i=1}^{n} x_i}{n} \quad (4)$$

Where, n = number of values and $\sum_{i=1}^{n} x_i$ = Sum of the individual values

And the standard deviation of the values is given by:

$$\text{Standard deviation (s)} = \sqrt{\frac{\sum\left(x - \bar{x}\right)^2}{n-1}} \quad (5)$$

Where, x = individual value and $\bar{x}$ = mean value

iv. Cronbach Alpha Reliability Coefficient

Cronbach alpha reliability coefficient was used to analyze the draw's dependability.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

For single administration, the Cronbach alpha, often known as the reliability coefficient alpha, is the most popular test score reliability coefficient. It is a measure of consistency, or how closely a group of elements are related to one another. It is regarded as a scale dependability indicator. Cronbach's alpha reliability coefficient is calculated as follows:

$$\rho_T = \frac{k^2 \sigma_{ij}}{\sigma_X^2} \quad (6)$$

Where, ϱ_T = Cronbach alpha or reliability coefficient alpha, k = number of items, σ_{ij} = covariance between Xi and Xj and σ_x = item variances and inter-item covariance's is presented in Table 1a.

Table 1a: Acceptable ranges for Cronbach Alpha [23]

8	Internal Consistency
$\alpha \geq 0.9$	Excellent
$0.9 \geq \alpha \geq 0.8$	Good
$0.8 \geq \alpha \geq 0.7$	Acceptable
$0.7 \geq \alpha \geq 0.6$	Questionable
$0.6 \geq \alpha \geq 0.5$	Poor
$0.5 > \alpha$	Unacceptable

In this study, the data and results from the responses that were generated from structured survey questionnaires and semi structured interviews with managers and employees in NLNG Company in Rivers State on risk management techniques implemented in their industrial operations were analyzed using the Statistical Package for Social Science (SPSS) package and presented categorically are presented in this research.

3. RESULTS AND DISCUSSION

The analysis of retrieved data and discussion of findings from the selected managers and employees in NLNG Company in Rivers State was covered in this chapter. The survey was conducted to assess the implementation of Fault Tree Analysis for Mitigation of Equipment Failure as it relate to Corona Virus Monitoring and Control strategy in Nigeria Liquefied Natural Gas (NLNG) Company. The findings were presented using descriptive statistics such as percentages, frequencies, mean, standard deviation, charts, tables, and graphs. A total of 55 questions were created with the help of sources such as Scopus, Web of Science, and Google Scholar, visits to distribution depots and filling stations and from interviews with the industry stakeholders, were disseminated and 51 completely filled and returned. Presenting a response rate of 92.7%, therefore, the data available was satisfactory for the study.

Socio-Demographic Profile and General Information of Respondents

The overall statistics considered during the study was the gender of the respondent, age, marital status, educational background, and years of work experience, job category and department/position of respondents in the organization.

Gender Distribution of Respondents

Table 1 shows that 72.5% of respondents were male while 27.59% of respondent indicated they were female. The data presented a response rate of 92.7%; therefore, the data available was satisfactory for the study.

Table 1: Gender Distribution of Respondents

Gender	Frequency	Percentage	Cumulative Percentage
Male	37	72.5	72.5
Female	14	27.5	100.0
Total	**51**	**100.0**	

The respondents were questioned about their gender. The outcome as shown in Figure 1 reveals that 72.5% of respondents were male while 27.59% of respondent indicated they were female. The data presented a response rate of 92.7%; therefore, the data available was satisfactory for the study.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

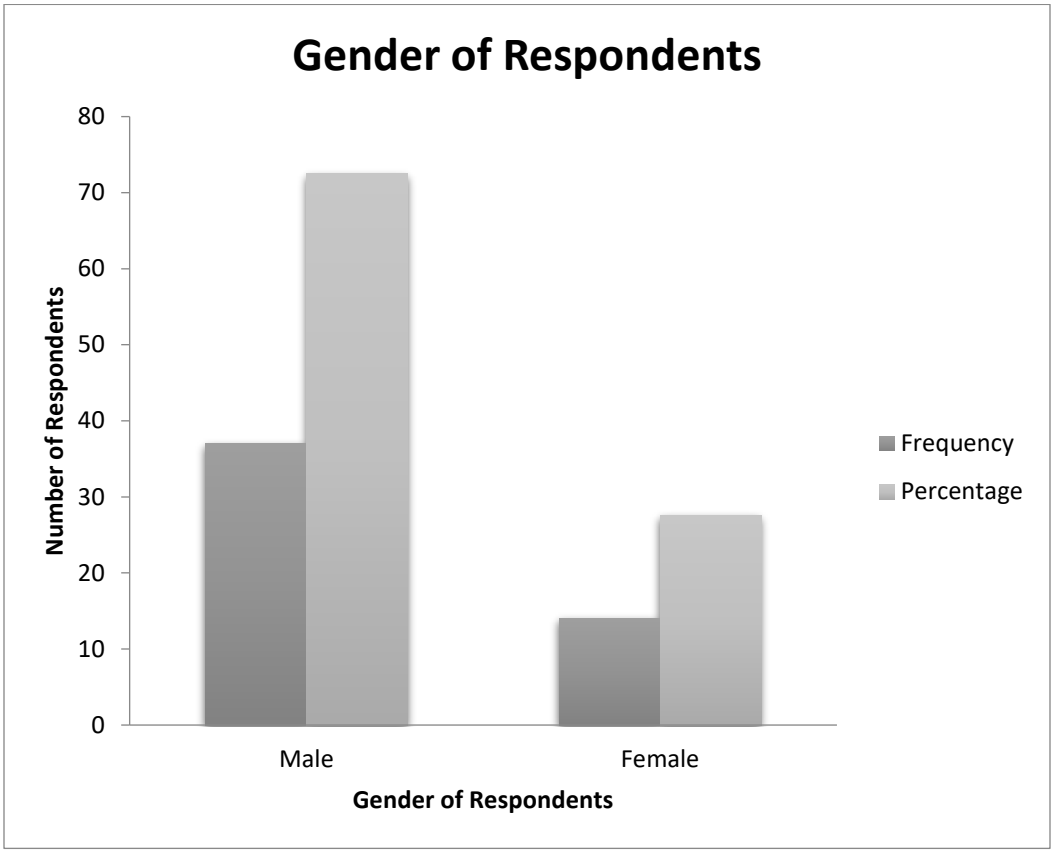


Figure 1: Gender Distribution of Respondents

Age Distribution of Respondents in the Organizations

Table 2 shows that 9.8% of respondents are under the age of 25, 25.5 percent are between the ages of 26 and 35, 35.3 percent are between the ages of 36 and 45, and 9.8% are between the ages of 46 and 50 29.4% indicated that they were 46years old and above. The results indicated that 90.2% of the respondents are above 25 years old.

Table 2: Age Distribution of Respondents in the Organizations

Age	Frequency	Percentage	Cumulative Percentage
Less than 25	5	9.8	9.8
26 – 35 years	13	25.5	35.3
36 – 45 years	18	35.3	70.6
46 years & above	15	29.4	100.0
Total	**51**	**100**	

The respondents were questioned about their ages. The outcome as shown in Figure 4.2 reveals that 9.8% of the respondents indicated that they were less than 25 years old, 25.5% 35.3 percent of respondents said they were between the ages of 26 and 35, and 35.3 percent said they were between the ages of 26 and 35 between 36-45 years old and 29.4% indicated that they were 46years old and above. The results indicated that 90.2% of the respondents are above 25 years old.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

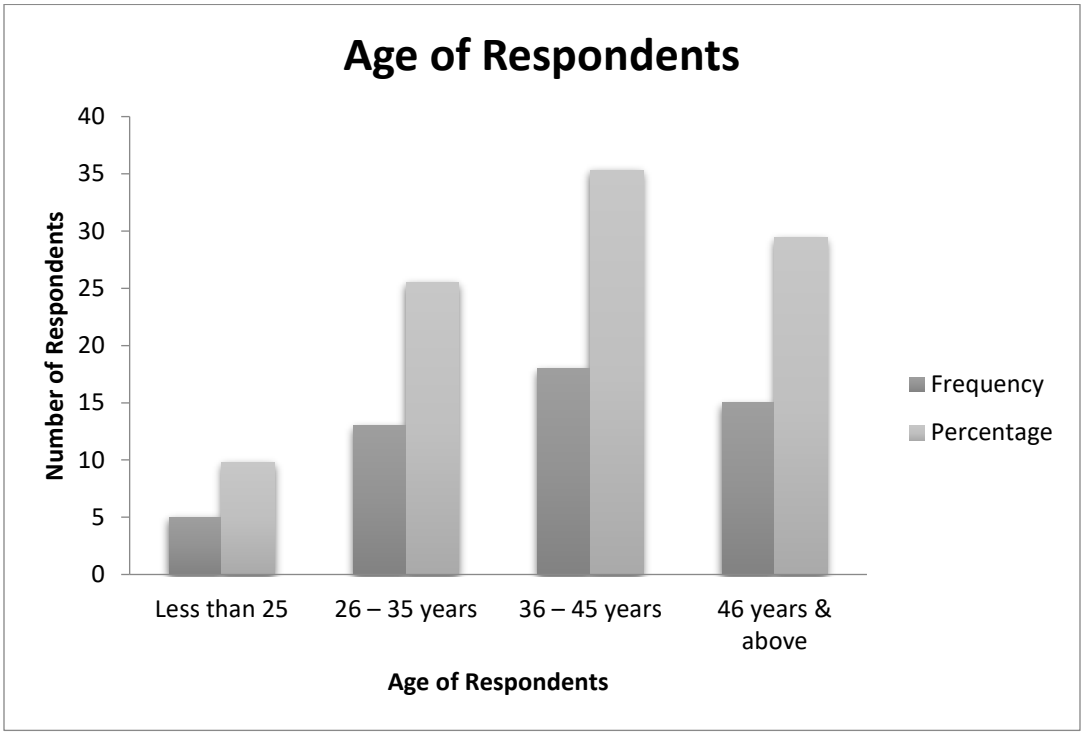


Figure 2: Age Distribution of Respondents

Marital Status of Respondents in the Organizations

Table 3 shows that 78.4% of the respondent indicated that they are married while 21.6% of the respondent indicated that they are not married. The data presented a response rate of 92.7%; therefore, the data available was satisfactory for the study.

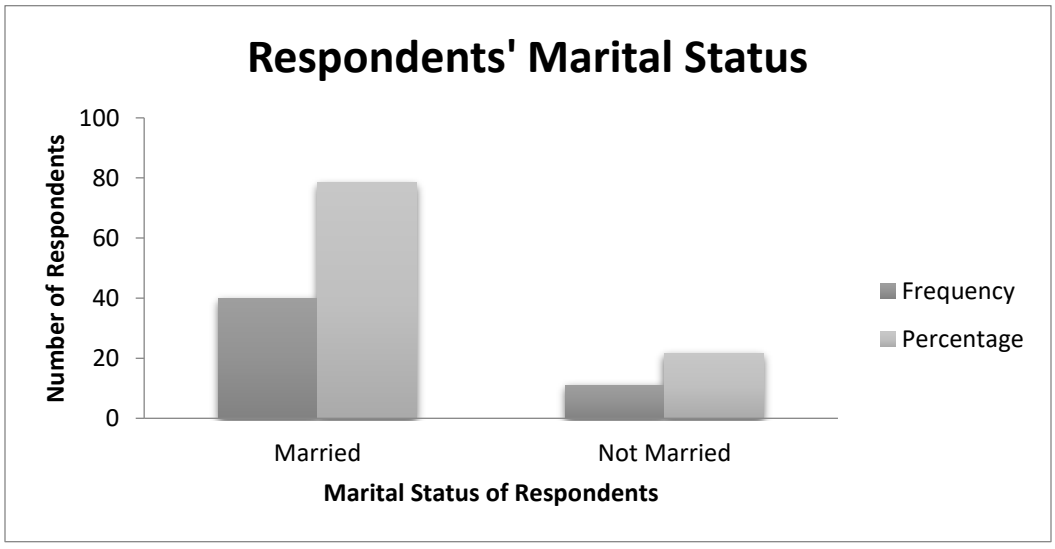


Figure 3: Marital Status of Respondents

Table 3: Marital Status of Respondents in the Organizations

Marital Status	Frequency	Percentage	Cumulative Percentage
Married	40	78.4	78.4
Not Married	11	21.6	100.0
Total	**51**	**100.0**	

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

The respondents were questioned about their marital status. The outcome as shown in Figure 3 reveals that 78.4% of the respondent indicated that they are married while 21.6% of the respondent indicated that they are not married. The data presented a response rate of 92.7%; therefore, the data available was satisfactory for the study

Educational Background of Respondents

Table 4 shows that 5.9% of 13.7 percent of respondents said their education background was primary schooling, and 13.7 percent said their education background was O' Level, 23.5% of the respondent indicated that they have a Diploma (OND/HND), 33.4% of the respondent indicated that they have a Bachelor's Degree, 15.7% of the respondent indicated that they have a Master's Degree and 7.8% of the respondent indicated that they have a PhD.

Table 4: Educational Background of Respondents

Educational Background	Frequency	Percentage	Cumulative Percentage
Primary Education	3	5.9	5.9
SSCE (O' Level)	7	13.7	19.6
OND/HND	12	23.5	43.1
Bachelor's Degree	17	33.4	76.5
Master's Degree	8	15.7	92.2
PhD	4	7.8	100.0
Total	**51**	**100.0**	

The respondents were questioned about their educational background. The outcome as shown in Figure 4 reveals that 5.9% of the respondent indicated that their education background is primary education, 13.7% of the respondent indicated that their education background is O' Level, 23.5% of the respondent indicated that they have a Diploma (OND/HND), 33.4% of the respondent indicated that they have a Bachelor's Degree, 15.7% of the respondent indicated that they have a Master's Degree and 7.8% of the respondent indicated that they have a PhD.

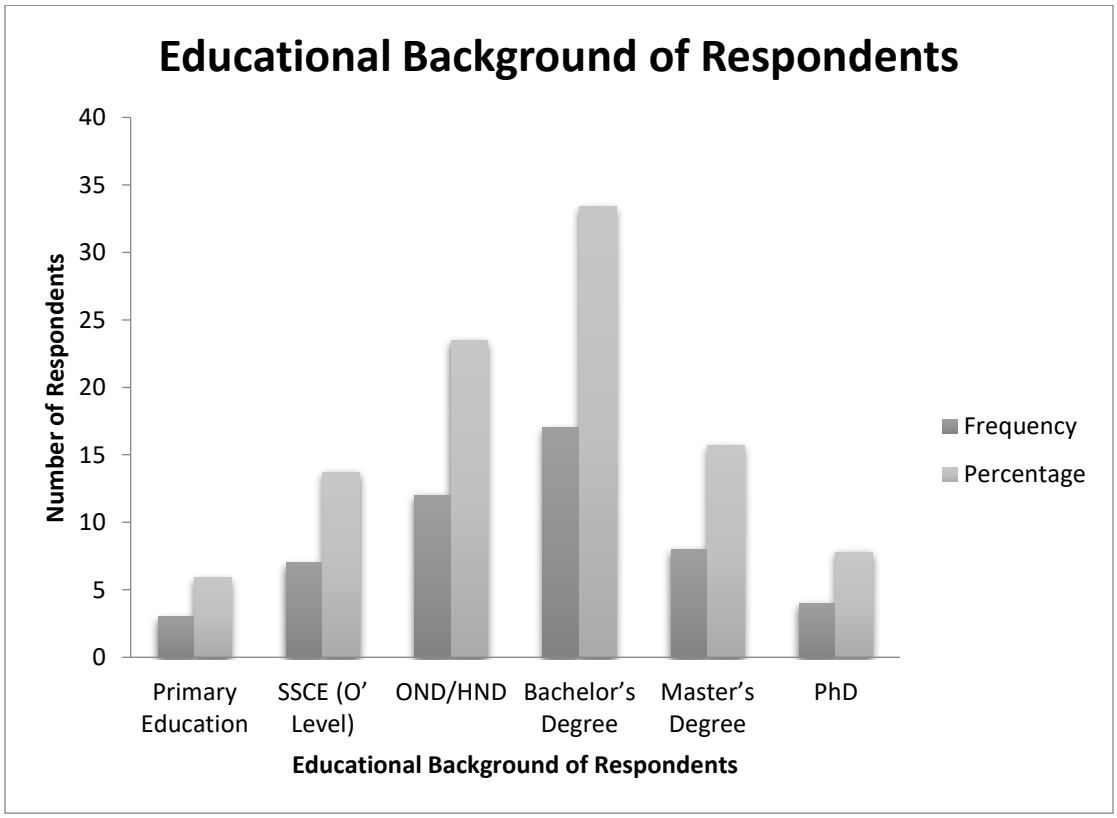


Figure 4: Educational Background of Respondents

Respondents' Years of Working Experience

Table 5 show that 5.9% of the respondents indicated that their years of working experience is less than 3 years, 16.7% of the respondents indicated that their years of working experience is between 3 – 6 years, 44.1% of the respondents indicated that their years of working experience is between 7 – 10 years and 33.3% of the respondents indicated that their years of working experience is 11 years and above.

Table 5: Respondents' Years of Working Experience

Years of Working Experience	Frequency	Percentage	Cumulative Percentage
Less than 3 years	6	11.7	11.7
3 – 6 years	13	25.5	37.2
7 – 10 years	17	33.4	70.6
11 years or more	15	29.4	100.0
Total	**51**	**100.0**	

The respondents were questioned about their years of working experience. The outcome as shown in Figure 5 reveals that 3.7% of the respondents indicated that 5.9% of the respondents indicated that their years of working experience is less than 3 years, 16.7% of the respondents indicated that their years of working experience is between 3 – 6 years, 44.1% of the respondents indicated that their years of working experience is between 7 – 10 years and 33.3% of the respondents indicated that their years of working experience is 11 years and above.

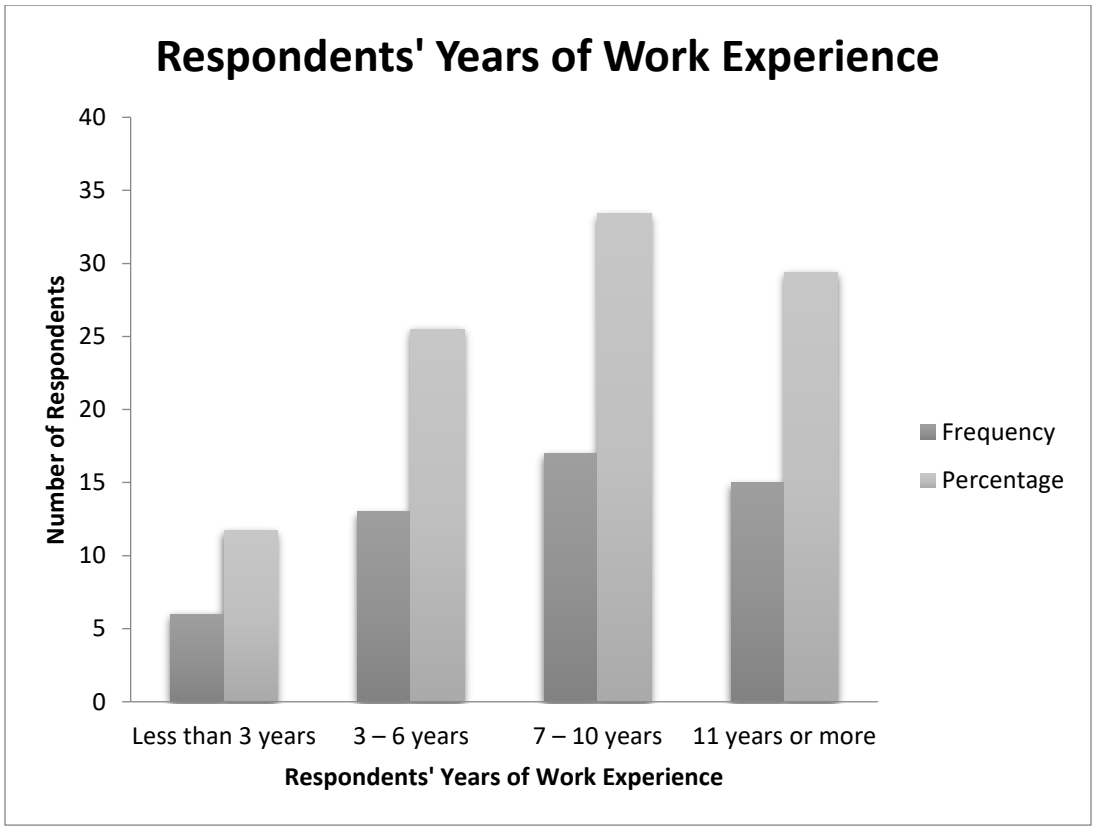


Figure 5: Respondents' Years of Working Experience

Respondents' Department in Group/Organization

Table 6 show that 25.55% of the respondents indicated that they were in the safety department, 7.8% of the respondents indicated that they were in the security department, 13.7% of the respondents indicated that they were in maintenance department, 9.8% of the respondents indicated that they were in the operations & sales department, 5.9% of the respondents indicated that they were in the information & communication technology department, 21.6% of the respondents indicated that they were in the senior management department and 15.7% of the respondents indicated that they were in the executive officers department.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Table 6: Respondents' Department in Group/Organization

Department	Frequency	Percentage	Cumulative Percentage
Safety	13	25.5	25.5
Security	4	7.8	33.3
Maintenance	7	13.7	47.0
Operations and Sales	5	9.8	56.8
Information Technology	3	5.9	62.7
Senior Management	11	21.6	84.3
Executive officers	8	15.7	100.0
Total	**51**	**100.0**	

The respondents were questioned about their department in their respective group/organizations. The outcome as shown in Figure 4.6 reveals that 25.55% of the respondents indicated that they were in the safety department, 7.8% of the respondents indicated that they were in the security department, 13.7% of the respondents indicated that they were in maintenance department, 9.8% of the respondents indicated that they were in the operations & sales department, 5.9% of the respondents indicated that they were in the information & communication technology department, 21.6% of the respondents indicated that they were in the senior management department and 15.7% of the respondents indicated that they were in the executive officers department.

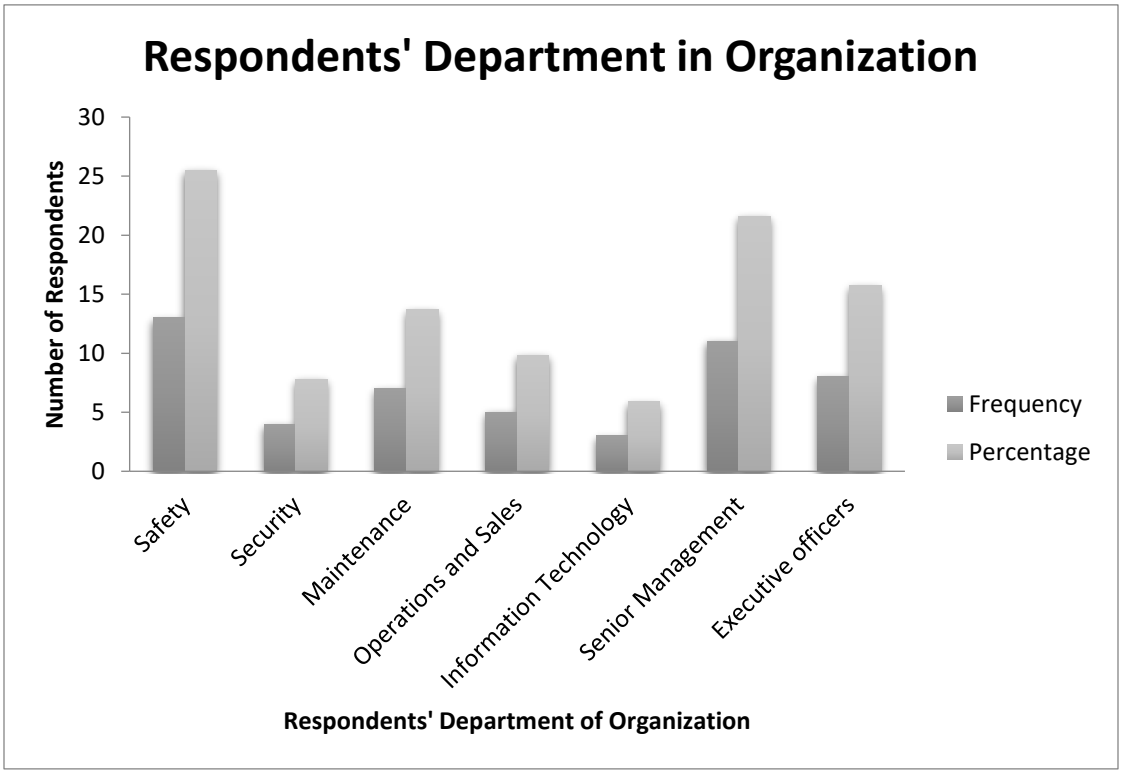


Figure 6: Respondents' Department in Organization

Identification of the Various Risk Management Techniques applied in NLNG Company against the Event of Corona Virus Transmission

Data bordering on the first objective of this study which was to identify the various risk management techniques applied in NLNG Company against the event of corona virus transmission was assessed. Risk identification is a constant event in risk management that identifies unfavorable influences on the workforce that impair efficiency or performance. Risk assessment can also be used to identify potentially hazardous workplace circumstances (internal and external). In the event of corona virus transmission, Figure 7 depicts the graph of multiple risk identification strategies used by NLNG Company.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

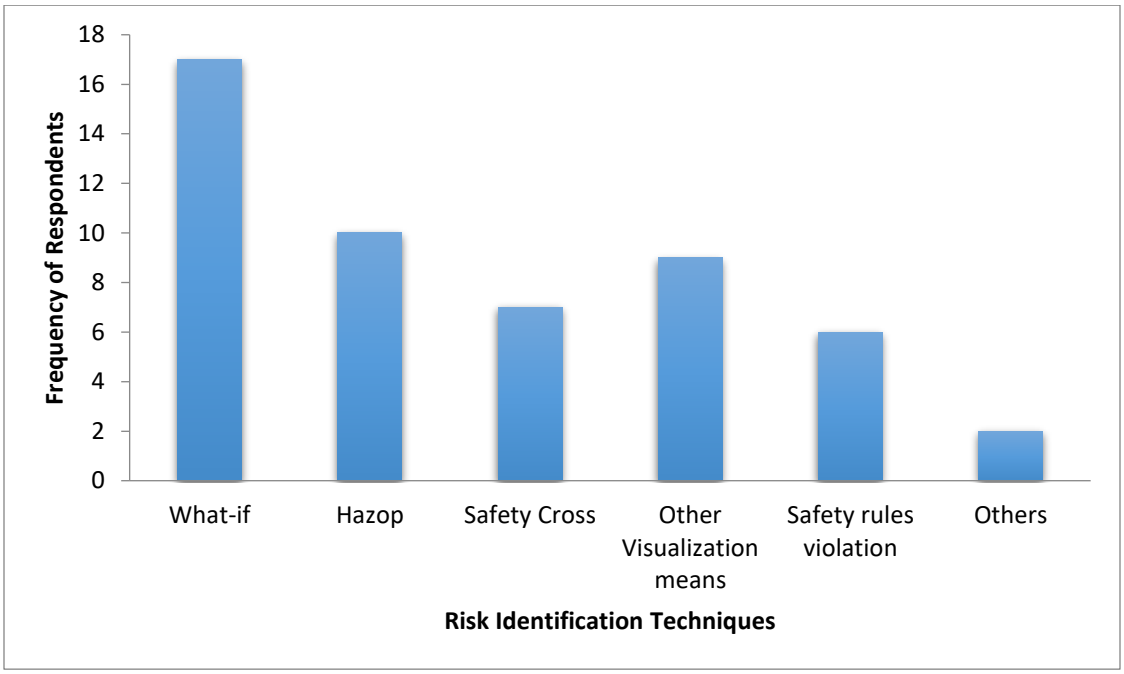


Figure 7:Risk Identification Techniques applied in NLNG Company against the Event of Corona Virus Transmission

In addition, the in risk management, risk analysis techniques are used to aid in the control of recognized risks in an organization. These tools can assist an organization in recognizing, assessing, reducing, or eliminating risk so that it does not have as large of an impact on the facility. As shown in Figure 8, root cause analysis (RCA) had a larger percentage of responses that were based on the questionnaire responses. RCA was seen as the most important instrument for risk analysis in the gas company; however, further comparisons need to be studied in other supporting study based on this result; however, this survey's result revealed that RCA is the most important tool employed in the NLNG Company.

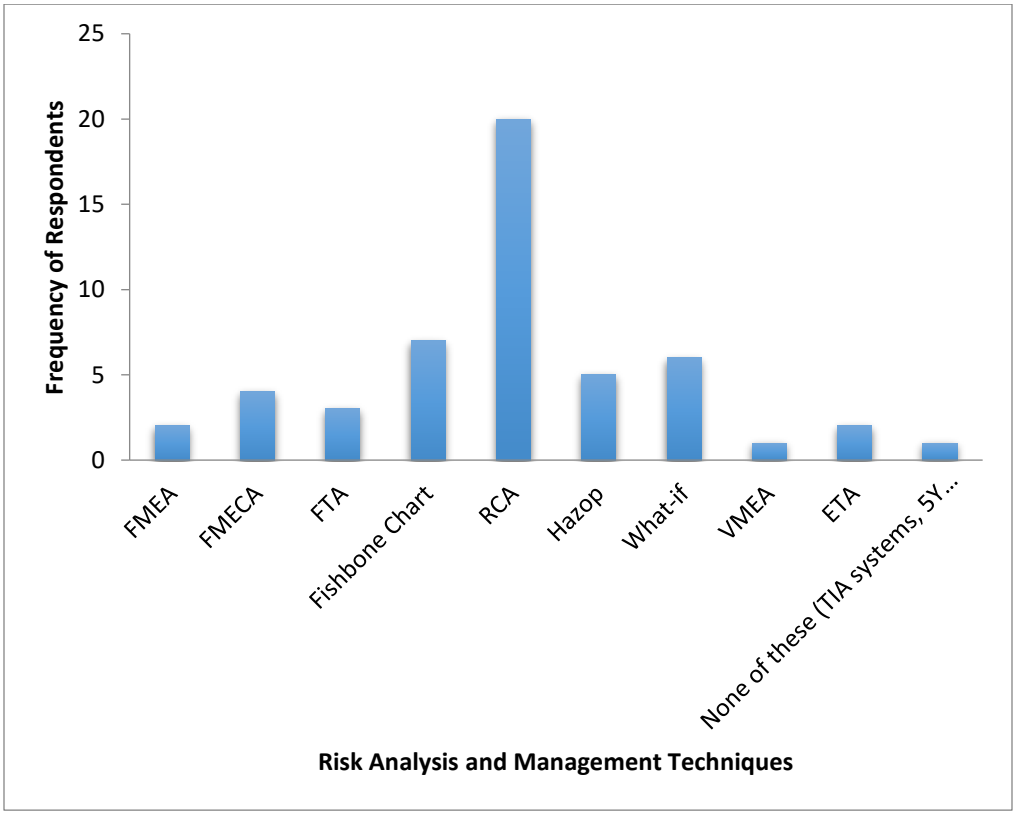


Figure 8: Risk Analysis Tools applied in NLNG Company against the Event of Corona Virus Transmission

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Assessment of the Extent to which Fault Tree Analysis (FTA) Risk Management Technique is Applied in NLNG Company against the event of Corona Virus Transmission

Based on the second objective of this study being to assess the extent to which fault tree analysis (FTA) risk management technique is implemented in NLNG Company against the event of corona virus transmission, the respondents were requested about the significance degree to which fault tree analysis (FTA) risk management technique is implemented in NLNG Company against the event of corona virus transmission and the results are represented with two combined chart in Figure 9.

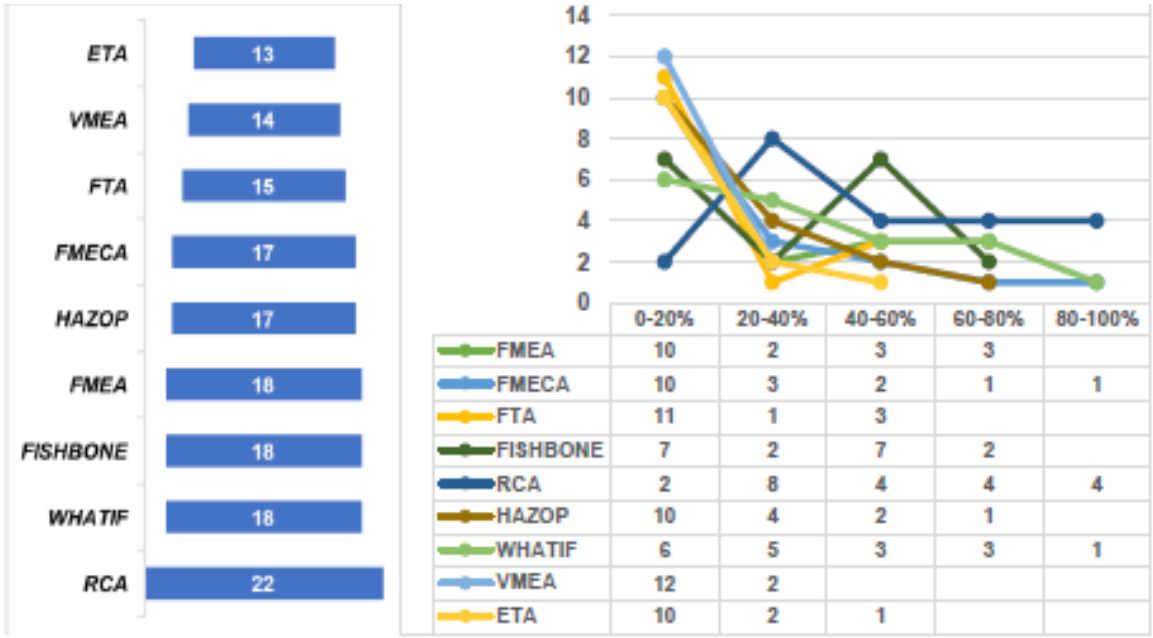


Figure 9: Extent at which Fault Tree Analysis (FTA) Risk Management Tools applied in NLNG Company against the Event of Corona Virus Transmission

Figure 9 reveals that about 80% to 100% of respondents rated RCA as frequently used and simple to use methods for more extensive risk analysis. The next most simple and widely used tool is WHATIF analysis, which has been shown to have a 60 percent to 80 percent score test, followed by HAZOP, and FMEA, FMECA, FTA, and FISHBONE, which scored low on the aspect of "ease of use" tool in the NLNG Company based on the results of the survey collected.

Challenges militating against the Implementation of Fault Tree Analysis (FTA) Risk Management Technique in NLNG Company against the event of Corona Virus Transmission

For the purpose of third objective of this study which was to assess the challenges militating against the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission, the importance of pre-identified impediments to FTA risk management implementation in the Nigerian gas industry was asked of the respondents. First and foremost, mean index analysis was used to assess the summary results from the questionnaire survey in this section in order to determine the most significant barrier impeding the adoption of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission.

Table 7 shows the responses of the respondents for each barrier as a mean index and frequency. Ten impediments have been identified, as shown in the table. According to the evaluations based on the mean index, Top management's lack of attention to safety, Different risk control measures are recognized differently, and hazard analysis and design for safety are poor. Lack of information and knowledge and flawed communication and reporting systems, a lack of technical skills, Lack of acquaintance with methodologies and the absence of or failure to follow change management processes, and Lack of joint risk management mechanisms by parties had their relative importance index (RII) mean index values between 3.5 and 4.5. However, four other barriers namely Low profit margin and insufficient learning from previous events, not cost-effective, and a mix-up between occupational and system safety

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

Lack of time and weaknesses in the organization's safety culture, as well as rivalry among minor oil and gas projects and the notion that process incidences/accidents are unlikely, have RII mean indexes between 2.5 and 3.5, indicating that these barriers are of moderate importance.

The RII mean index for lack of knowledge in procedures in the oil and gas business was the highest (4.08). The second most important barrier is a lack of familiarity with techniques and the lack of or failure to follow management of change procedures, which accounts for the RII mean index of 4.02. The third most important barrier is a lack of information and knowledge, as well as flawed communication and reporting systems. Joint deficiency representing mean index of 3.94 and 3.88 respectively. This shows that experts still don't have adequate information in FTA risk management and techniques then training are necessary for FTA risk managing implementation and research work by Osabutey *et al*. (2013).

Table 7: RII Mean Index, Sample T-test & Cronbach's Alpha test for the Challenges militating against the Implementation of Fault Tree Analysis (FTA) Risk Management Technique in NLNG Company against the event of Corona Virus Transmission

Challenges of Implementation of FTA Risk Management Technique	RII Mean Index	Rank	T-value	Significance Level	Cronbach's Alpha if Item Deleted
Lack of time and flaws in the safety culture of the organization	3.0000	8	.020	.978	.774
Lack of real commitment to safety by top management	3.8000	5	.003	.998	.772
Low profit margin and inadequate learning from prior events	3.1714	7	000	1.000	.756
Not economical and confusion between occupational and system safety	2.9714	9	.004	.097	.769
Different recognition of risk control strategies and inadequate hazard analysis and design for safety	3.6286	6	001	.995	.735
lack of information and knowledge, flawed communication and reporting systems	3.9429	3	.005	.989	.752
Lack of expertise in techniques	4.0857	1	000	1.000	.758
Lack of familiarity with techniques and nonexistence or not followed management of change procedures	4.0286	2	.002	.996	.722
Lack of joint risk management mechanisms by parties	3.8857	4	000	1.000	.759
Competition among small oil and gas projects and belief that process incidences/accidents are low probability	2.8286	10	008	.985	.779

Then training about FTA risk management and techniques for both position of client and contractors is a key factor in realizing risk and improving of implementation FTA risk management in oil and gas industry in Nigeria. Competition among oil and gas projects is the least important barrier with average importance. "Low profit margin and inadequate learning from prior events", "lack of time and flaws in the safety culture of the organization", and "not economical and confusion between occupational and system safety", which were all related to the expense of FTA risk management implementation, were ranked seventh, eighth and ninth barriers groups. This result implied that the experts in this part of Nigerian Industry did not believe FTA risk management

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

implementation is depend on expenses or waste money in project. The single sample t-test was used on each of the risk groups to see if the ratings among different respondents differed significantly.

Prior to doing the single sample t-test, a normality test was performed to ensure that the data had a normal distribution. Tables 7 demonstrate that all of the risk categories have significance values greater than 0.05, indicating that the evaluations of the respondents are not significantly different. It is worth reminding that statistically significant results are indicated by asymptotic significance values below 0.05 in this research.

Furthermore, to test reliability for our questionnaire, alpha Cronbach was calculated for all barriers. Table 7 shows that alpha Cronbach for all barriers is above 0.7. According to Hinton (2004), Alpha Cronbach above 0.7 shows that a questionnaire is reliable. Since the Alpha Cronbach is above 0.7, it can be inferred that the questionnaire is reliable. Results of Cronbach's Alpha if Item Deleted also show, that deletion of no item leads to higher Alpha Cronbach; therefore, no item must be deleted.

Covid-19 Risk Reduction to an Acceptable Level or its Elimination

The fourth objectives were to provide measures to mitigate the challenges faced by NLNG Company in effective implementation of FTA risk management technique against the events of corona virus transmission Safety measures (organizational or technical, prevention, limitation, protection, and/or intervention) must be implemented in the context of safety and public health research in order to control hazards, such as preventative and protection barriers See Fig.10. Barrier performances are evaluated according to the criteria of Effectiveness (capacity to fulfil the safety function assigned to them) and Response Time (time required to fulfil the function adapted to the kinetics of the epidemic propagation phenomenon). The rigour of application through the involvement of the government legal forces (police, military.) is necessary in the case where the recommended measures are not respected.

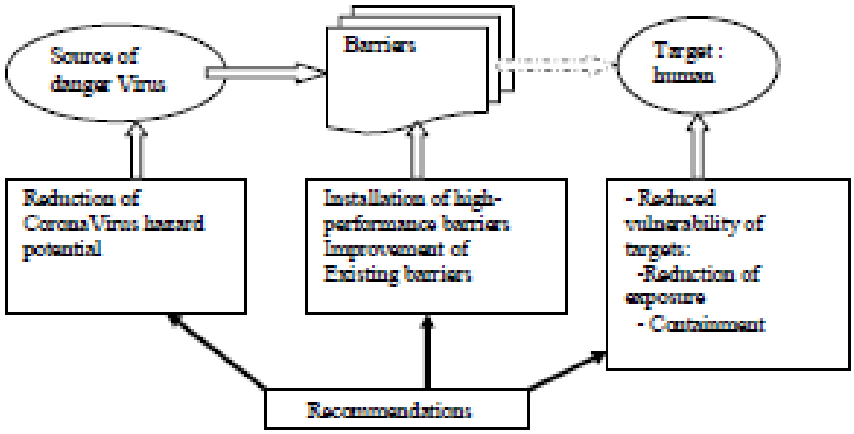


Figure 10 Barriers and Recommendations (Mahfoud *et al.*, 2020).

Covid-19 Prevention and Protection/Mitigation using FTA Risk Management Technique as Barrier

Protective and/or preventative actions, which are parts of risk control, must be performed to counteract the danger of epidemic. Implementing strategies to prevent Covid-19 pathology from happening minimizes the chance of contamination.

In terms of protection, it lessens the severity by minimizing the potential impact of a biological hazard in the event of proliferation. Human, organizational (procedures, training, communication), or technology risk reduction or control measures are all possible. The actions must be conducted at the correct time, in the right place, and with the proper rigor and response time. In the Figures 11 and 12, fault cause trees (with causal chain sequences) are presented as well as the implementation of barriers with a risk index or priority rating. Management of intensive care requiring artificial respiration and the adoption of a chloroquine-zythromycin treatment protocol reduce the degree of severity S.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

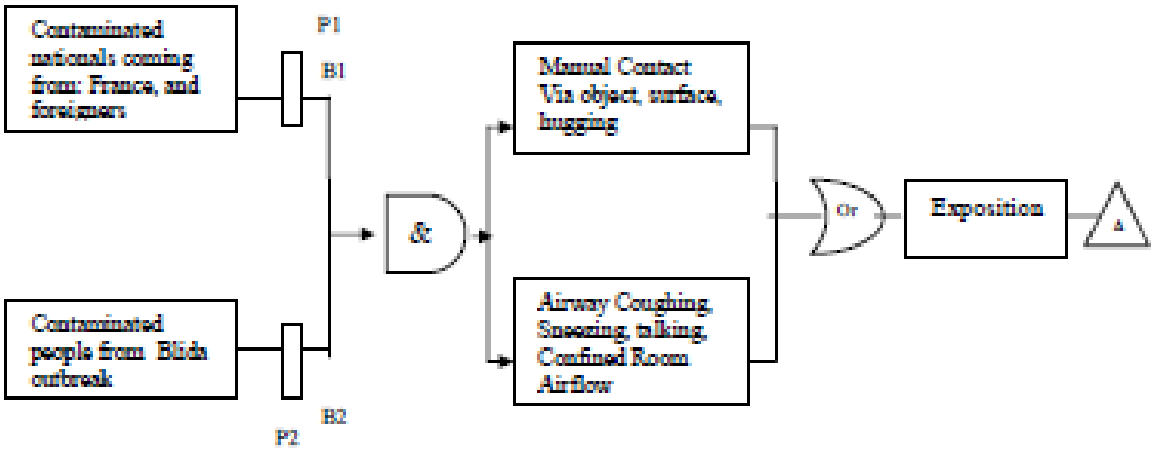
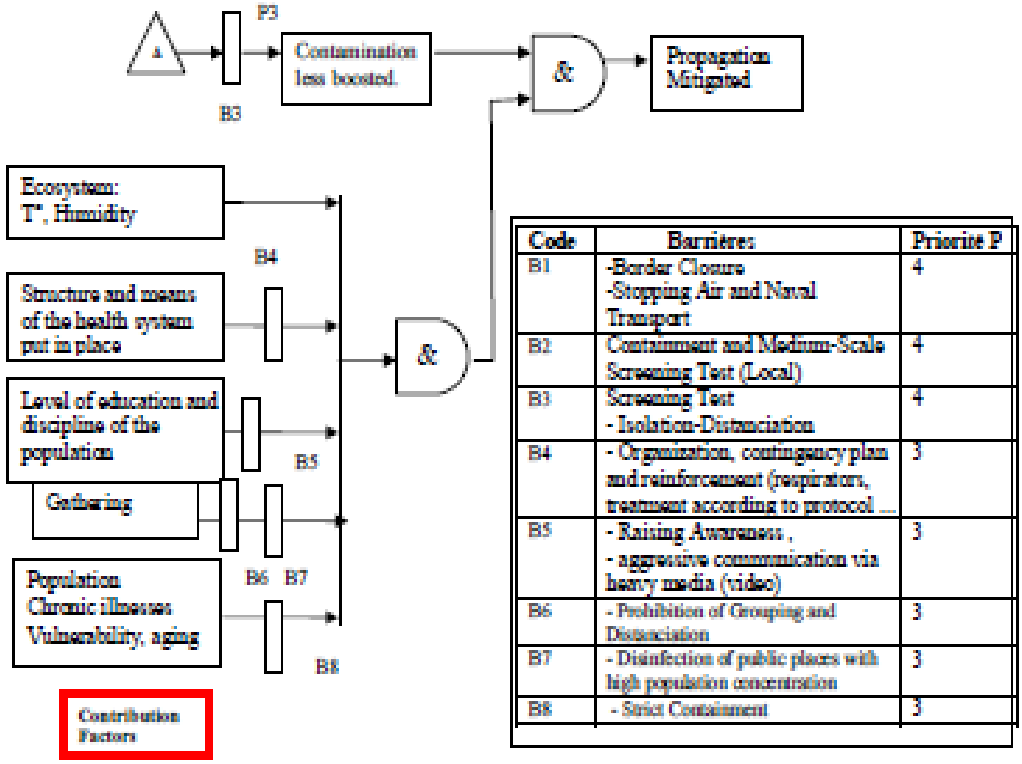


Figure 11: Casual Chain of the Undesirable Effect 'Exposure of People to Coronavirus



Code	Barrières	Priorité P
B1	-Border Closure -Stopping Air and Naval Transport	4
B2	Containment and Medium-Scale Screening Test (Local)	4
B3	Screening Test - Isolation-Distanciation	4
B4	- Organization, contingency plan and reinforcement (respirators, treatment according to protocol ...	3
B5	- Raising Awareness , - aggressive communication via heavy media (video)	3
B6	- Prohibition of Grouping and Distanciation	3
B7	- Disinfection of public places with high population concentration	3
B8	- Strict Containment	3

Figure 12: Contamination and Contribution Factors for the Acceleration of the Propagation

This study assessed the risk management techniques in Nigerian gas industry in order to identify the various risk management techniques applied in NLNG Company against the event of corona virus transmission, assess the extent to which fault tree analysis (FTA) risk management technique is implemented in NLNG Company against the event of corona virus transmission and to assess the challenges militating against the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission. In the first objective variety of risk identification techniques were presented in literature review and six risk groups were selected and ranked through questionnaire by experts as most probable risk identification techniques in NLNG. According to 57 percent of respondents, the most common method of identifying risk is what-if method. In the second objective of this study being to assess the extent to which fault tree analysis (FTA) risk management

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

technique is implemented in NLNG Company against the event of corona virus transmission, the survey result RCA is often utilized and easy to use methods for more complete risk analysis, according to 80 percent to 100 percent of respondents.

The next most simple and widely used tool is WHATIF analysis, which has been shown to have a 60 percent to 80 percent score test, followed by HAZOP, and FMEA, FMECA, FTA, and FISHBONE, which scored low on the aspect of "ease of use" tool in the NLNG Company based on the results of the survey collected. In the third objective, ten challenges militating against the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission were investigated. Lack of expertise in techniques in oil and gas industry achieved the highest RII mean index (4.08). Lack of familiarity with techniques and nonexistence or not followed management of change procedures the second most significant barrier, accounting for the RII mean index of 4.02, is a lack of information and understanding. Flawed communication and reporting systems and lack of joint risk management mechanisms by parties representing mean index of 3.94 and 3.88 respectively. This shows that experts still don't have adequate information in FTA risk management and techniques then training are necessary for FTA risk managing implementation.

Furthermore, the main challenges preventing The inability to apply FTA risk management techniques in the Nigerian oil and gas industry is attributed to a lack of knowledge in techniques, a lack of familiarity with techniques, and the lack of or failure to follow change management procedures as well as lack of information and knowledge, flawed communication and reporting systems. Training and education of employees and contractors in oil and gas companies on application of FTA risk management technique can be a useful way and best practice to improve oil and gas companies' productivity and profitability.

4. CONCLUSION

This study was aimed to assess the implementation of Fault Tree Analysis for Mitigation of Equipment Failure as it relate to Corona Virus Monitoring and Control strategy in Nigeria Liquefied Natural Gas (NLNG) Company. Relevant data bordering around the first objectives of the study which includes: to identify the various risk management techniques applied in NLNG Company against the event of corona virus transmission, was achieved using descriptive statistical models of SPSS as highlighted in this research. The second and third objectives which were to evaluate the fault tree analysis (FTA) risk management technique as well as the extent to which it is implemented in NLNG Company against the event of corona virus transmission and to access the challenges militating against the implementation of fault tree analysis (FTA) risk management technique in NLNG Company against the event of corona virus transmission were analyzed using descriptive statistical models, RII, spearman's rank correlation and t-test analysis of SPSS as presented in this research. While the fourth objective which was to provide measures to mitigate the challenges faced by NLNG Company in effective implementation of FTA risk management technique against the events of corona virus transmission was implemented using a conceptual framework and presented in research.

This research conclusion was based on the pool of existing knowledge in the following ways:

i. The research work was able to address the significance of fault tree analysis in monitoring, predicting and controlling Covid-19 risk management to prevent infection in operating plant system.
ii. The fault tree analysis (FTA) risk management technique, the extent to which fault tree analysis is implemented in NLNG Company against the event of corona virus transmission and the challenges militating against the implementation of same in NLNG Company against the event of corona virus transmission have been assessed.
iii. The quantitative statistical methods applied in the study were effective in assessing the risk management techniques applied in oil and gas industry against the event of corona virus transmission, the extent to which they are applied and the challenges faced by the oil and gas industry in Nigeria.

Funding

This study has not received any external funding.

Conflicts of interests

The authors declare that there are no conflicts of interests.

Data and materials availability

All data associated with this study are present in the paper.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS

REFERENCES AND NOTES

1. Aalok, K., Sunil, L. B., Sachin, K. M. C. & Yi ğit, K. G. (2020). COVID-19 Impact on Sustainable Production and Operations Management. *Sustainable Operations and Computers* 1(1), 1–7.
2. Ale, B. J. M. (2002). Risk Assessment Practices in the Netherlands. *Safety Science,* 40(1-4), 105–126.
3. Antioco, L. M., Richart, V. R. & Efraín, Q. P. (2019). A Methodology Based on Fault Tree Analysis to Assess the Domino Effect Frequency. *SYMPOSIUM SERIES*, 149.
4. Baker, S., Ponniah, D. & Smith, S. (1997). Risk Response Techniques Employed Currently for Major Projects. *Construction Management and Economics* 17(2), 205-213.
5. Beim, G. K., Hobbs, B. F. (1997). Event Tree Analysis of Lock Closure Risks. *Journal of Water Resources Planning and Management*, 123(3), 137–198.
6. Bruin, M. & Swuste, P. (2008). Analysis of Hazard Scenarios for a Research Environment in an Oil and Gas Exploration and Production Company. *Safety Science*, 46(2), 261–271.
7. Carrillo, C. J. A., Rubio-Romero, J. C., Guadix, J., & Onieva, L. (2014). Risk Assessment of Maintenance Operations: The Analysis of Performing Task and Accident Mechanism. *International Journal of Injury Control and Safety Promotion* 22 (3), 267-277.
8. Chevreau, F. R., Wybo, J. L. & Cauchois, D. (2006). Organizing Learning Processes on Risks by Using the Bow-Tie Representation. *Journal of Hazardous Materials*, 130(3), 276–283.
9. Dekker, S. (2006). *The Field Guide to Understanding Human Error*, Ashgate Publishing, 2-11, Farnham United Kingdom.
10. Devdatt, P. P., Siddiqui, N. A., Abhishek, N. & Bikarama, P. Y. (2018). Hazard Identification and Risk Assessment in Construction Industry. *International Journal of Applied Engineering Research*. 13(10), 7639-7667
11. Ebrahimnejad, S., Mousavi, S. M., & Mojtahedi, S. M. H. (2009). A fuzzy Decision-Making Model for Risk Ranking with Application to the Onshore Gas Refinery. *International Journal of Business Continuity and Risk Management* 1(1), 38 – 66.
12. Ebrahimnejad, S., Mousavi, S. M. & Seyrafianpour, H. (2010). Risk Identification and Assessment for Build-Operate-Transfer Projects: A Fuzzy Multi Attribute Decision Making Model. *Expert System. Application*. 37(16), 575–586.
13. Fan, C. & Chen, W. (2000). Accident Sequence Analysis of Human–Computer Interface Design. *Reliability Engineering and System Safety*, 67(1), 29–40.
14. Fauzilah, S., Salani, P., Ivy, L., Pooi, T., Huda, N. M., Helmi, A. A., Hamid, N. M., & Kassim, M. (2020). Review on Risk Management Implementation in the Construction Industry. *Journal of critical reviews,* 7 (11), 34-49.
15. Fayek, A. R., Revay, S. O., Rowan, D. & Mousseau, D. (2006). Assessing Performance Trends on Industrial Construction Mega Projects. *Cost Engineering,* 48(10), 16- 21.
16. Friday, A. O., Salihat, B., Cornelius, J. (2015). Environmental Risk Assessment of Petroleum Industry in Nigeria. *International Journal of Scientific Research and Innovative Technology*. 2(4), 60 -71.
17. Gholamreza, D., Rosli, M. Z., & Ali, K. (2015). Risk Classification and Barrier of Implementing Risk Management in Oil and Gas Construction Companies. *Jurnal Teknologi (Sciences & Engineering)* 77(16), 161–169
18. Haddon-Cave, C. (2009). *The Nimrod Review*, HC 1025, London: The Stationery Office Limited, Oct. 28, 2009.
19. Haimes, Y. Y. (2009). *Risk Modeling, Assessment and Management*, 3rd Edition, John Wiley and Sons, New York.
20. Harms-Ringdahl, L. (2001). *Safety Analysis, Principles and Practice in Occupational Safety*, 2nd Edition, CRC Press. New York.
21. Harms-Ringdahl, L. (2004). Relationships between Accident Investigations, Risk Analysis, and Safety Management. *Journal of Hazardous Materials, 111(1-3),* 13-19.
22. Hauptmanns, U., Marx M. & Knetsch, T. (2005). GAP—a Fault-Tree Based Methodology for Analyzing Occupational Hazards. *Journal of Loss Prevention in the Process Industries,* 18(2), 107-113.
23. Hillson, D. (2003). Risk Management: Best Practice and Future Developments. *In Proceedings of II Congreso Nacional de Gerencia de Proyectos,* 24-25, Peru.

ISSN 2278–5469 EISSN 2278–5450 I OPEN ACCESS