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Workplace accident analysis in the Algerian oil and gas industry

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Abstract

In Algeria, a total of 42.032 work accidents were reported in 2021 of which 38,225 accidents in the workplace and 3,807 others are traffic accidents, according to statistics released by the National Social Insurance Fund for Salaried Workers [1]. Most of these accidents were recorded in the building and construction field, followed by the oil and gas company exploration and drilling, which comes at the forefront of Sonatrach company. This study aims to analyze accidents in the workplace using quantitative and qualitative methods to determine the corresponding causes. Our study was carried out in collaboration with Sonatrach in south Algeria where information and reports on work accidents from years 2017 to 2021 were collected. After the acquisition process, data were classified and analyzed according to the location and time of the accident. Based on the results obtained, we found that the human factor was the main cause of most accidents due to non-respect of safety procedures and lack of concentration of workers. The results of the analysis suggest planning a rest time in the afternoon, avoiding long overtime hours, and suspending work outside stations at high temperatures in July and August and when sandstorms appear in winter should be implemented to reduce human errors that affect the workplace accident in oil and gas sector in Algeria.

Keywords: quantitative and qualitative accident analysis; work accidents; oil and gas industry; Ishikawa diagram; Causal tree; occupational health and safety.

1. Introduction

Work accidents have always greatly impacted various fields, especially in the economic and industrial fields, without forgetting the human aspect. The Algerian law of July 1983 provides in article 6 in particular: "it is considered as an accident at work any accident having caused a bodily injury, attributable to a sudden, external cause and occurring within the framework of the employment relationship" [2]. Recently, work accidents are witnessing frightening statistics, according to the International Labor Organization, every 15 seconds, a worker dies from a work-related accident or illness. Also, every 15 seconds 153 workers suffer a work-related accident and 321,000 people die each year from work-related accidents [3]. Despite all efforts to reduce these incidents, they still occur, especially in some industrial countries. In the past three decades, major industrial accidents have occurred, causing deaths and injuries to workers. Among these incidents;

- The Ocean Ranger tragedy in Newfoundland and Labrador, Canada occurred on 15 February 1982 and caused the death of 84 workers. The rig in Ocean Ranger was designed and built by Onshore Drilling and Exploration Company (ODECO) in 1976 [4].
- Sayano-Shushenskaya power station accident in Yenisei River, near Sayanogorsk in Khakassia, Russia. Occurred on 17 August 2009 at 08:13, 75 people were killed and billions of roubles have lost [5].
- Deep-water Horizon (the Macondo blowout) in the Gulf of Mexico, US, on 20 April 2010 with 11 workers dying, 17 were injured and millions of gallons of oil spilled in the Gulf [6].
- The Bhopal disaster in Bhopal, Madhya Pradesh, India. The tragedy happened on December 3, 1984, when a toxic methyl isocyanate (MIC) was released from a storage tank property of the Union Carbide India Limited (UCIL) pesticide plant in Bhopal causing the deaths of at least 3,787 people [7].

In Skikda, Algeria, on 19 January 2004. A very strong explosion occurred at 18:40 at the LNG (Liquefied Natural Gas) Liquefaction Complex GL1/K in Skikda, followed by a fire. Three of the six liquefying units in the Complex were severely damaged and subjected to intense fire. The losses include 23 deaths and 74 injured in addition to economic losses and environmental pollution. The causes of the accident and the lessons learned have been reviewed in detail by the authors in [8] and [9].

Globally, several laws and norms have been used to control and reduce the number of accidents for example the OHSAS 18001 standard whose performance was not perfect, according to a study of [10], and replaced in 2021 by ISO 45001. In Algeria, there is Law 88-07 of January 26, 1988, relating to health, safety, and occupational medicine designates the persons responsible (employer and its structures), the consultation bodies (Joint Health and Safety Committee, health and safety inter-company), as well as the implementation structure (Service of health and safety in the workplace). Also, Law 04-20 of 25 December 2004, relates to the prevention of major risks and the management of disasters within the framework of sustainable development. These norms and laws helped institutions to organize work and workers and reduce the number of accidents within these companies.

Accurate studies were carried out to analyze work accidents to avoid them from happening again in the future and benefit from the experiences gained. A. Palali and J. van Ours [11] present an empirical analysis of the determinants of workplace accidents based on an analysis of fatal and non-fatal workplace accidents and road accidents. Also, job safety analysis [12] which is an efficient proactive measure for safety risk assessment usually used in industrial manufacturing for planning the safest way to perform a task. Moreover, the authors in [13] used Bayesian networks to analyze workplace accidents that involve a high risk of falls from heights places.

These studies aimed to find the main causes of accidents without accusing any parties. Quantitative analyses were usually used to determine the number of accidents, how they occurred, when , and so on. Furthermore, some studies have used qualitative methods such as the cause-effect diagram and Ishikawa (fishbone) diagram to determine the root cause behind the accident. For example, Fishbone Diagrams and Root Cause Analysis were applied to the in-depth analysis of physical security- and cybersecurity-related events that affected the process industry [14]. A quantitative risk evaluation method that combined a risk matrix, fault tree and fishbone diagram model is proposed in [15] to define the risk level of a spherical tank.

M. Rodgers and R. Oppenheim [16] combine cause and- effect diagrams with Bayesian belief networks to establish a framework to estimate causal relationships in instances where formal data collection/analysis activities are too costly or impractical which helps to estimate the likelihood of risk scenarios using computer-based simulation.

Bayesian networks are widely used for dynamic safety and risk modeling, dynamic risk-based maintenance [17][18], risk assessment of process industries [19], envisaging potential accidents predicting the likelihood of accidents [20] [21].

A Combinaison of Failure Mode and Effect Analysis (FMEA), cause and effect analysis and Pareto diagram in conjunction with Hazard Analysis Critical Control Point (HACCP) are applied or the risk assessment of potato chips manufacturing plant in [22]. The same authors [23] made a comparison of ISO22000 analysis with HACCP in salmon processing and packaging where the Ishikawa diagram is used to identify the critical control points.

Root cause analysis based on Ishikawa diagram was applied in [24] to identify, rank, analysis and categorize the main sources of causes of delays in oil and gas projects. A. Verma and J. Maiti [25] develop a text clustering-based cause and effect analysis methodology based on experts' knowledge for incident data to unfold the root causes behind the incidents in steel plant.

The author in [26] developed a methodology to incorporate Lean Manufacturing tools in risk management, to reduce work accidents at service companies. They used Ishikawa diagram to analyze the main causes of accidents. Furthermore, A global propose a prevention approach in cement plants is proposed by [27] whose purpose is to improve working conditions by technical, organizational and human solutions to improve the health and safety of employees based on statistical analysis of work accident and cause-effect analysis based on Ishikawa diagram.

In the present paper, a combination of quantitative and qualitative approaches is used to analyse work accident in oil and gas company. A statistical analysis is firstly applied after gathering and classifying available data, thereafter, Ishikawa diagram and cause-effect diagram are both used to identify the root causes of different accidents. The two methods are very effective educational tools for training and raising awareness of safety because they did not need a specialist to read and understand the diagrams. Both methods are considered posterior analysis methods for preventive purposes that provide a realistic and dynamic map of the accident. The construction of these diagrams depends on group work and encourages dialogue and solidarity. The disadvantage of both methods is that they can only be built after the accident occurs.

After this introduction, the remainder of the paper is structured as follows. Section 2 introduces the work method where we explain our methodology in different steps and examples of Ishikawa and cause-effect diagram. Section 3 gives a description of Sonatrach company while sections 4 and 5 present and discuss the results obtained from the quantitative and the qualitative approaches of work accidents. Section 6 presents the conclusions and perspectives for future research.

2. Work methodology

The proposed methodology starts with the quantitative assessment obtained from collection of information from the available reports, classifying relevant information and the identification of the main causes of accident. Then, a qualitative analysis is performed by performing root cause analysis and finished with a set of recommendation to prevent and mitigate consequences of future accidents. Figure 1 shows the steps followed the perform the accidents analysis. This study is a posterior analysis since requires the accident to happen in order to analyze it. Knowing the main causes of past accidents is essential step for avoiding the repetition of the same or similar situations.

In the quantitative part, we rely on collecting and classifying information over a period of five years. In the second stage (qualitative part), two methods are used: Ishikawa diagram (fishbone diagram) and root cause analysis. These two methods are widely used to identify the possible causes of a specify event or in our case specify accident.

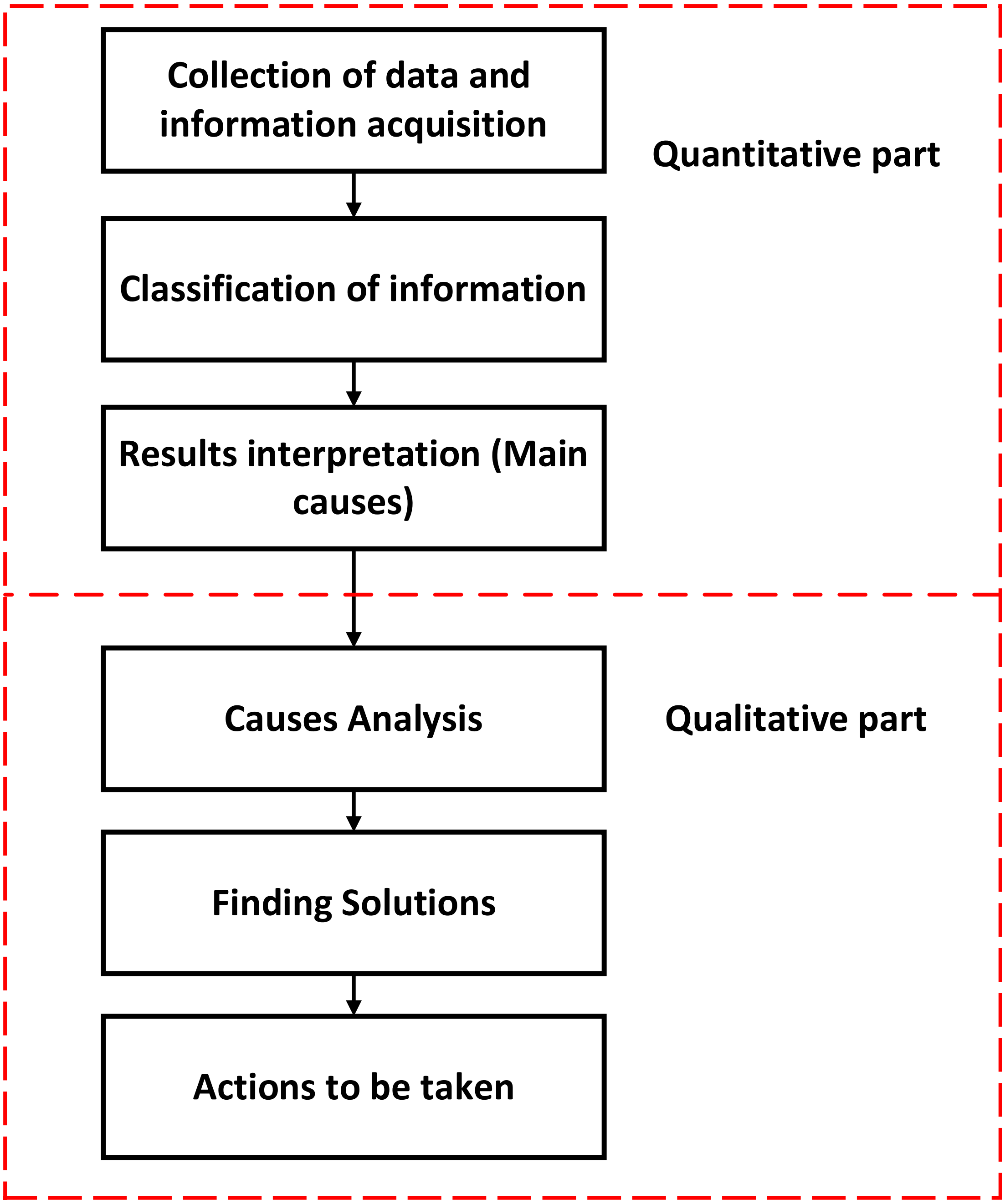

Figure 1. Methodology proposed for work accident analysis.

2.1. Cause-effect diagram

Several methods are often adopted to perform the cause-effect diagram such as Bow-tie, Bayesian network, and causal tree. The latter is a practical method of researching the facts that contributed to the occurrence of the accident. As a systemic approach, it considers the accident as the result (the symptom) of a dysfunction in the company. To understand the accident, it is therefore necessary to question all the components of the system (technical, organizational, human) and their interactions [28]. Figure 2 shows the different steps followed to construct the causal tree.

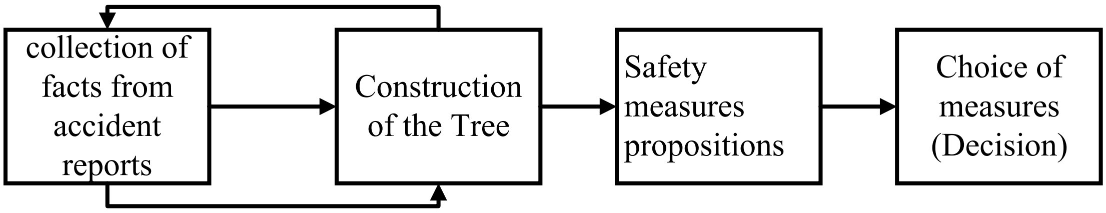

Figure 2. Causal tree construction method.

To better understand how to construct the causal tree base on the cause-effect diagram, an example of fire and explosion of Liquefied petroleum gas (LPG) spherical storage tank is presented in Figure 3. As we can see, there are two symbols based on the type of events: when the event is ordinary (usual), it is represented by a rectangle, and when an event is unusual, it is represented by oval or circle. Only the events in the circles need safety measures to avoid or eliminate them.

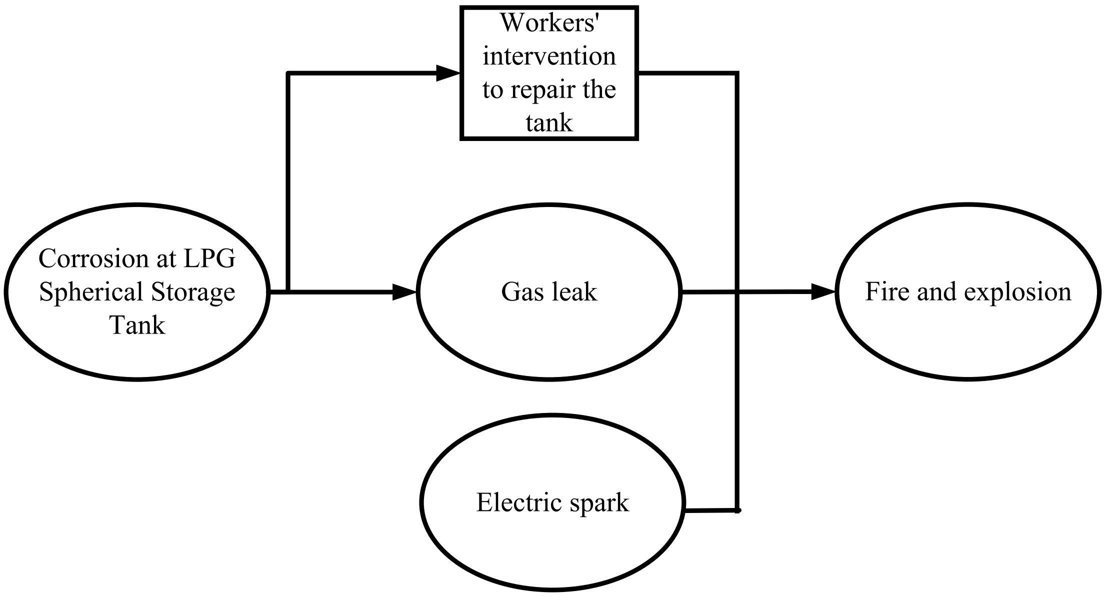

Figure 3. Example of LPG spherical storage tank with causal tree.

2.2. Ishikawa/fishbone diagram

The fishbone diagram, also known as Ishikawa diagram, is a cause-and-effect diagram, where starting from specific effect provides the root causes that led to its occurrence [22]. The diagram is used for quality management in manufacturing industries [29], food Industrial Processing [22][23], medical purposes [30], and also for accident analysis [27].

In terms of safety and accident analysis, these root causes usually divided into five main contributors:

- Environment: workstation, physical organization, …
- Methods: procedures, information flows, …
- Means (Machines): equipment, machines, tools, spare parts, …
- Working force (Labor): human resources, staff qualifications, …
- Material: the various consumables used, raw materials, …

The Ishikawa diagram starts by defining a problem (an accident in our case) written to the right of the diagram and drawing a horizontal arrow running to it. Thereafter, we choose major categories of causes of the problem (accident) such as methods, machines, and materials… and write the categories of causes as branches from the main arrow. In the next step, we gather all the possible causes of the problem by asking "Why does this happen?" and then write each cause as a branch from the appropriate category.

Figure 4 shows an example of a fishbone diagram with the five main causes. It is not necessary that all five causes are present in every incident but each cause can lead the accident. Depending on the accuracy of the incident report, the number of simultaneous causes presents may change.

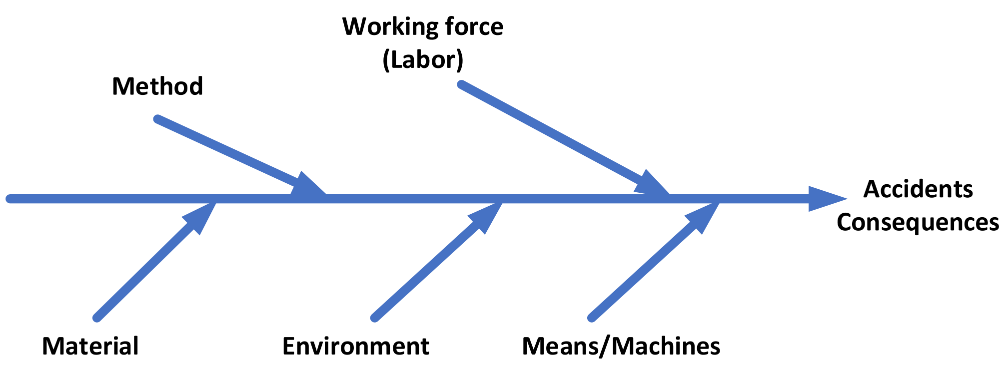

Figure 4. Exemple of Ishikawa diagram.

3. Case study

For confidentiality reasons, the name of the region company is not mentioned and is instead termed “group Sonatrach” throughout this paper. Group Sonatrach is an oil- and gas-producing company that has several oil and gas fields. The station located approximately 930 km directly south of the capital of Algeria. Our case study focuses on the accidents occurred in the gas company which contain several operations. These operations include drilling, processing and transporting operations, causing accident such as fall from high, vehicle crash, burn, and electric shocks.

3.1 Quantitative analysis of work accident

Quantitative data based on work accident reports from 2017 to early 2021 are used in this paper. During the last five years at group Sonatrach a total of 477 work accidents have been recorded and shown in Figure 5. It should be noted that the total number of employees of the enterprise is 1400 workers, where the latter are divided into two groups. The first group are the workers who work in the morning shift only from 7am in the morning until 7pm at night. The second group are the workers who work sometimes at night and sometimes during the day for 12 hours. It is also worth noting that the number of workers is always divided into two, as the worker, after working for four weeks, takes a four-week vacation to be compensated by another worker.

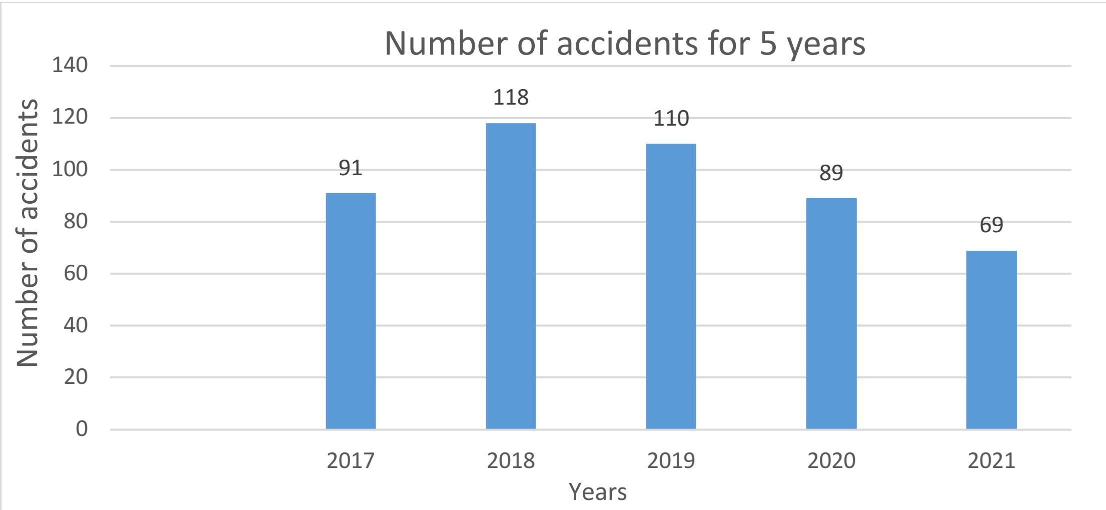

Figure 5. Number of work accidents during 5 years at group Sonatrach.

The number of accidents peaked in 2018 followed by a gradual decrease in the number of accidents and registering 69 accidents in 2021. This is a decrease of 37% compared to 2018. It is true that the company has made efforts to improve the means of safety and protection of workers. However, this significant drop in the number of accidents is mainly due to the following reasons:

- Strength of Health, Safety, and environment (HSE) team with new recruitments.
- Majority of procedures updated since 2018, with the target of implementing all HSE procedures by 2020.
- Requirement for the contractors to keep the experienced personals (there is problems with contractors when bring new staff that need trainings and take time to familiarize with the procedures of the company).
- Training program for all staff has been started in 2017 to identify the needs of every service such as maintenance, HSE, production, etc.
- Likewise, the actions from external Audits ISO 14001 and ISO 45001 which oblige the company to train and certify all team leaders and HSEs.
- The restrictions applied to the company and to workers due to the COVID-19 Pandemic and subsequent reduction in the number of workers .

The accidents are then classified depending on the information available to the following categories:

- Time of the accidents.
- The months in which the accidents occurred to identify the season with the huge number of accidents.
- Consequence of the accidents to identify which type of injuries are more likely to occur.

After analysing the work accidents reports, we will classify them into three categories such as part of body harmed, time and month of accident. We tried to classify these accidents according to the age and domains of the workers, but the registered reports do not contain the required details.

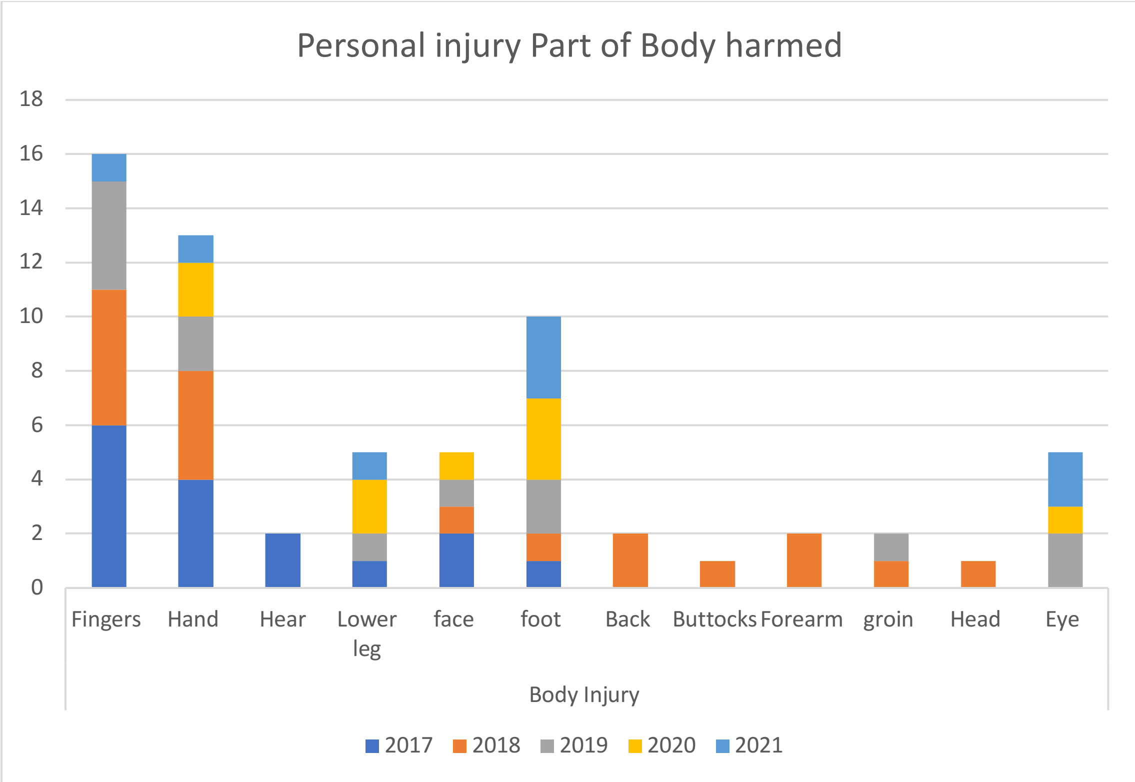

Figure 6. Accident distribution by part of body harmed.

Figure 6 indicates that the most frequently affected part of the body is fingers, with 17 accidents in the last 5 years representing the 37% of the total accidents. This number is followed by hand injuries, with 13 accidents and 25% of total accidents. It is worth noting that the number of accidents reported in Figure 6 is less than the number recorded in the Figure 5. This is because some reports are not detailed and not all the exact details are mentioned. Therefore, these statistics only address what was mentioned in these reports without examining their accuracy due to the large number of recorded accidents.

In Figure 6, we also can note that 67% injuries are centered on the hand, this is a very high rate compared to injuries in other body parts. This is usually due to not using personal protection equipment (specially gloves) because most of workers can't do some specialized work such as opening small screws with gloves.

However, even when protective gloves are used accidents continue to occur. The problem is that the gloves do not protect against shocks such as a hammer blow, nor against injuries such as cuts on the skin or amputation of fingers by an angle grinder.

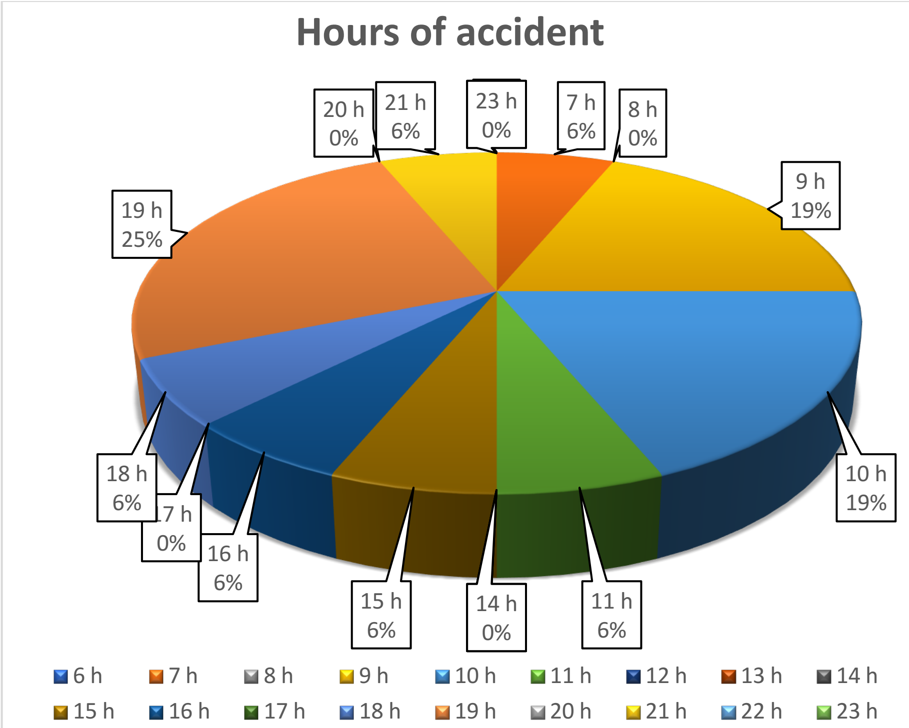

Figure 7. distribution according to the time of accident.

The work regime in Sonatrach company is four weeks work and four weeks off. In the weeks of work, they work 13 nights with 12 hours shift each. Then, they take a rest day then they work 14 days with 12 hours shift each. In Figure 7, a distribution of accidents per time of the day is presented. From Figure 7, we noted that there are two periods in which the number of accidents are significant higher. The first time period is from 8 until 10 (morning time) with 38% of the accidents, the second period is from 18 until 19 with 25% of the accident. The former time period is associated with the presence of a large number of workers (around 1000) compared to other periods (INCLUDE RANGE). Furthermore, most of the most challenging works beginning in the morning, such as maintenance, cleaning, and operating machinery. This requires a frequent movement of workers from one location to another. In summary, this period represents the busy period of work and the period of maximum production.

The latter period from 18:00-19:00 has an average the number of workers around 300. The reduced number of workers is due to the fact that the majority of maintenance workers, electricians and mechanics leave before 18:00. This time period corresponds to the departure of the morning-shift workers and the entry of the night-shift workers, i.e., it is the end of daytime working hours. This period is characterized by a lack of worker concentration, errors and mistakes that may increase towards the end of a 12 hours shift [31]. In addition, it is found that older workers fare less well on 12 hours shifts (particularly at night) [32], whereas the number of workers over 50 years of age represents 30% of the total number of workers. When the release period approaches, the worker begins to make mistakes such as making hasty decisions, as they start feeling sleepy and tired. Also, the delay of the second group workers who come to perform night work can cause anxiety and dissatisfaction to day workers [33].

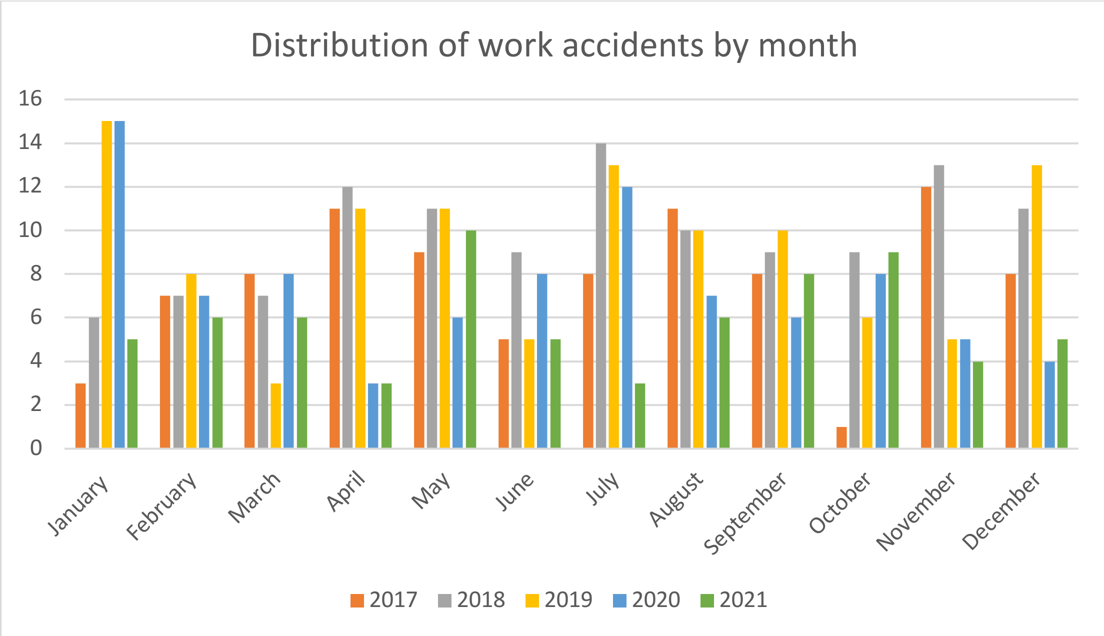

Figure 8. Distribution of work accidents by month.

It can be seen in Figure 8 that the number of accidents is high in winter, especially in January. This is due to the bad weather experienced during this period of rain and sandstorm. The desert of Algeria is characterized by a dry climate, hot in summer and cold in winter. In the latter, sandstorms are formed causing many problems such as lack of vision, especially on the roads. When rain falls, although it has little precipitation, can cause slip and fall accidents. When sandstorms occur, can cause poor visibility and confusion. All these harsh weather conditions can also increase road accidents and cause bad manipulation of different vehicles and machines.

There is also an increase in the number of accidents in the month of July as can be seen from Figure 8. In fact, Southern Algeria is characterized by high heat in summer, that can even exceed 50 C° under the shade. This extreme heat causes sunstrokes or heat stroke that can cause damage to the brain and other internal organs. In addition, the heat can cause ignition to gas or gasoline storage tanks, causing fires that lead to burns and fatalities among workers.

Furthermore, the analysis shows a significant decrease in the number of accidents in 2021. This is mainly due to the reduction in the number of workers due to the Corona pandemic and the suspension of most of the construction work outside the stations.

3.2. Qualitative approaches for work accident analysis

After the statistical analysis of the accidents, two incidents were selected for further investigation by the qualitative methods. The Ishikawa diagram and causal tree were adopted to find the causes of the accident of the proposed cases and gain information and formulate possible countermeasures.

In this section, we will expose one of the most catastrophic accidents in this establishment. We will start with the accident summary, followed by the root causes of the accident according to the accident report. We will use this information to build the Ishikawa diagram, which will help us to divide the causes of the accident and provide some recommendations to avoid similar accidents.

3.2.1. Explosion of oxyacetylene bottle

The 27th February 2019 at Sonatrach company, located in the south of Algeria, during oxyacetylene welding carried out by an air conditioning technician in the workshop of the accommodation camp, a bottle containing acetylene exploded, causing fatal injuries to two workers.

To facilitate the transportation of oxyacetylene welding equipment around the camp, the welding gas was transferred to lightweight refrigerant cylinders to perform the welding. There is no evidence of who modified this equipment. Acetylene, highly explosive when pressurized, is supplied as a solution of acetylene in acetone in low pressure cylinders. When pressurized, its explosive reaction does not require the presence of oxygen. No gauges, pressure regulators or flame arresters were fitted to the modified refrigerant cylinders and its operculum was modified to allow filling. The explosion of the container into multiple fragments was caused either by the influx of oxygen and a flashback on ignition, or by decomposition under the effect of pressure.

Based on the accident report, we built the fishbone diagram as shown in Figure 9 for the accident divided into the principle of 5 items (environment, methods, means, labor, material).

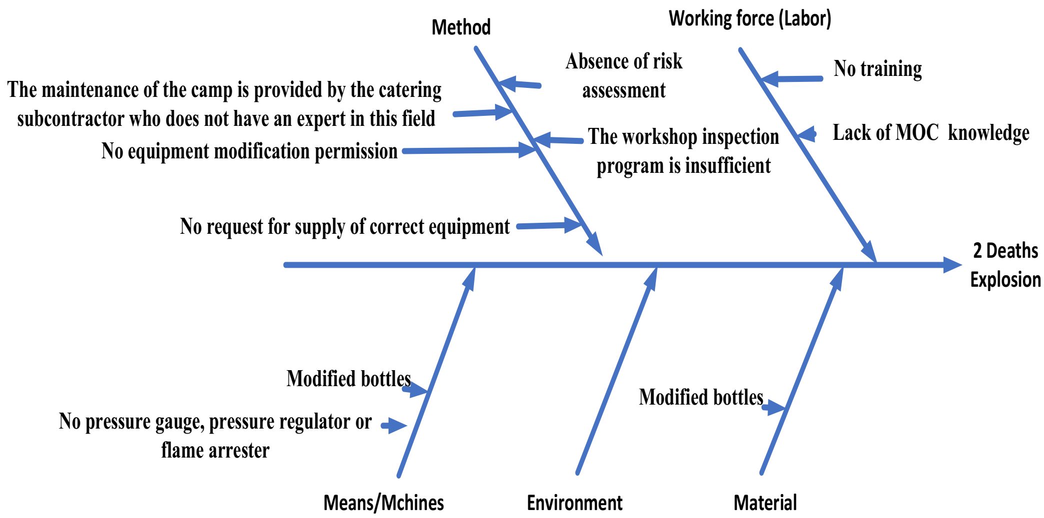

Figure 9. Ishikawa diagram for Explosion of oxyacetylene bottle.

Recommandations based on Ishikawa diagram

In Table 1 presents the identified actions that can improve the work conditions based on Ishikawa diagram in Figure 9. It is worth noting that there are no actions regarding the environment line. This is due to lack of information since we do not have a detailed report about the accident. Moreover, the available report did not provide details about time and environment of the accident.

Table 1. List of improvement measures based on Ishikawa diagram.

5M	**Mitigation Actions**
Materials	Use special pressure cylinders for acetylene and oxygen. Protect bottles from direct sunlight and heat sources.
Working force/Labor	Awareness of the danger presented by oxygen and acetylene is essential when we have gas welding. Integrated all workers in HSE Training.
Method	Make a precise risk analysis to identify all the dangers encountered. A risk assessment is needed to rank the risks.

	The MOC process is essential to ensure the transfer of training and evaluation files. Knowledge/skill of workers should be reevaluated.
Means/Machines	The use of manometer, pressure regulator and flame arrester are necessary.
Environment	Not enough information

3.2.2. Contamination with diesel fuel

Sonatrach has a diesel refueling station for the purpose of refueling vehicles site. This mainly comprises a retention tank and a pumping station. On the 27th November 2020 and 14:15 during the filling of the crude diesel fuel tank, the operator noticed that the tank was overflowing. Excess fuel flowed over the side of the tank and was contained in the dike; approximately 2.8 m^3 of crude diesel fuel was spilled.

During the COVID-19 period, the storage tank is refueled approximately twice a month. This because of the large number of cases of COVID-19 infections and the necessity of transporting workers to the hospital, as the nearest hospital is located about 230 km away. The working capacity of the tanks is approximately of 42 m^3.

While this system has a low-level sensor to shut down the diesel transfer pump from empty running, it does not have a high-high level sensor to shut down the diesel transfer pump if it overfills. Control measures of this operation require an operator to intervene when the high-level alarm goes off to physically stop the diesel transfer using the local stop button.

Based on the accident report which has been created after the occurrence of the accident, we construct the root cause analysis in Figure 10 to clarify the sequence that led to the soil contamination by diesel.

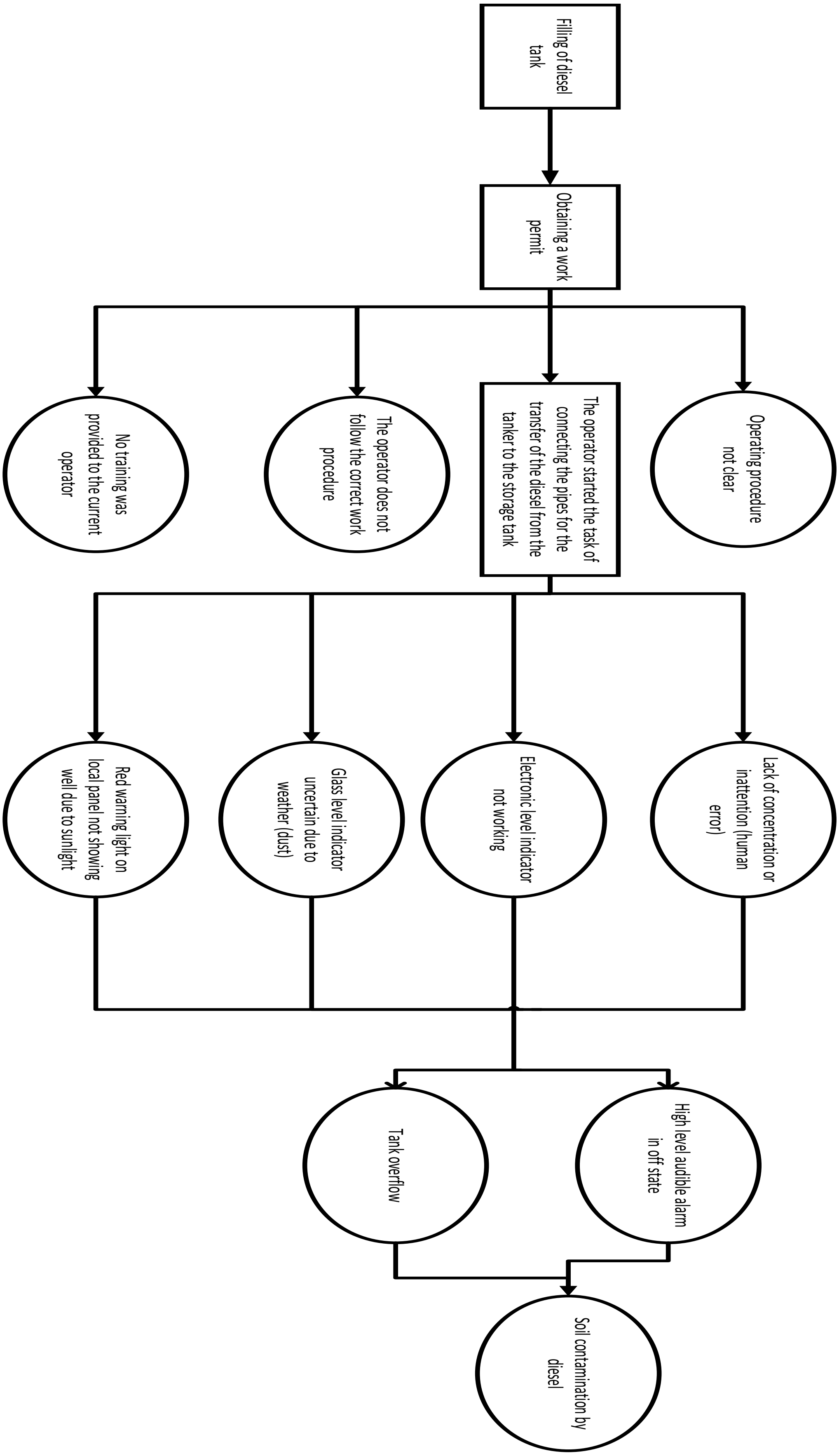

Figure 10. Root cause analysis of Soil pollution by diesel.

Recommandations based on causal tree analysis

The events in the circles in the section of root cause analysis are taken into consideration for improvement measures since these events represent unusual actions that led to the accident. These events are shown in Table 2.

Table 2. List of improvement measures based on root cause analysis.

Event	Recommended Measures
Operating procedure not clear. The operator does not follow the correct work procedure.	The operator and the supervisor, with the help of the site HSE engineer, create a workable procedure that considers not only how to perform the task, but also the risks associated with it.
No training was provided to the current operator.	Design, develop, and deliver training for this plant to all personnel who will operate it.
Lack of concentration or inattention (human error).	Providing amenities for the worker, especially with regards to reducing working hours.
Electronic level indicator not working.	Add an electronic level indicator (redundant).
Glass level indicator uncertain due to weather (dust).	Change the indication on the digital level gauge to a percentage indication so the operator can easily read levels in poor weather conditions.
Red warning light on local panel not showing well due to sunlight.	All the warning lights must be protected from harsh weather conditions (placed in special covers).
High level audible alarm in off state.	Verify alarms of the site periodically.
Tank overflow.	Install a pump shut-off system with very high-pressure detector.

6. Conclusions

This paper highlight the risk of occupational accidents in an oil and gas company. Statistical analysis was carried out by gathering and classifying accident reports during five years from 2017 until 2021. Thereafter, Ishikawa diagram and causal tree were used to determine the root causes of specific accidents.

Through this study using both quantitative and qualitative methods, it has been found that most workplace accidents were caused by the human error through omissions, lack of concentration and lack of compliance with safety work procedures. Quantitative methods are characterized by their ease of application, but they suffer from the need for precise reporting, which generally lacks precision in the data. As for qualitative methods, they require a lot of time. We only analyzed two incidents, but the accuracy was high because we were able to find the main causes of the accident.

This research also highlighted the importance of the working conditions and the importance of carefully consider the impact on safety of tiredness and fatigue in oil and gas industry due to the long hours shift per day, extended hours per week, night shifts work as well harsh environmental conditions due to extreme heat in summer and sandstorms and rain during winter. In the future, we will try to integrate credal network in the methodology. This method is considered one of the best for decision-making under uncertainty and when some information is missing.

References

1. Algeria Press Service. More than 42,000 work accidents declared to the CNAS in 2021.
2. *Official Journal of Algeria, Law No. 83-13 of July 2, 1983 Relating to Accidents at Work and Occupational Diseases*.
3. ILO. International Labour Organization, World Day for Safety and Health at Work 2013.
4. Collier K. The Loss of the Ocean Ranger, 15 February 1982. Newfoundland and Labrador Heritage.
5. Hamill FA. Sayano Shushenskaya 2009 Accident Update. *Hydraul Transients*. 2019;(2):50-53.
6. Summerhayes C. *Deep Water – The Gulf Oil Disaster and the Future of Offshore Drilling*. Vol 30.; 2011.
7. Labib A, Champaneri R. The Bhopal Disaster-learning from failures and evaluating risk. *Maint Eng*. 2012;27(3):41-47.
8. Chettouh S, Hamzi R, Benaroua K. Examination of fire and related accidents in Skikda Oil Refinery for the period 2002–2013. *J Loss Prev Process Ind*. 2016;41:186-193.

9. Samia C, Hamzi R, Chebila M. Contribution of the lessons learned from oil refining accidents to the industrial risks assessment. *Manag Environ Qual An Int J*. 2018;29(4):643-665.

10. Heras-Saizarbitoria I, Boiral O, Arana G, Allur E. OHSAS 18001 certification and work accidents: Shedding Light on the connection. *J Safety Res*. 2019;68:33-40.

11. Palali A, van Ours JC. Workplace Accidents and Workplace Safety: On Under-reporting and Temporary Jobs. *Labour*. 2017;31(1):1-14.

12. Rozenfeld O, Sacks R, Rosenfeld Y, Baum H. Construction Job Safety Analysis. *Saf Sci*. 2010;48(4):491-498.

13. Martín JE, Rivas T, Matías JM, Taboada J, Argüelles A. A Bayesian network analysis of workplace accidents caused by falls from a height. *Saf Sci*. 2009;47(2):206-214.

14. Iaiani M, Casson VM, Reniers G, Tugnoli A, Cozzani V. Analysis of events involving the intentional release of hazardous substances from industrial facilities. *Reliab Eng Syst Saf*. 2021;212.

15. Luo T, Wu C, Duan L. Fishbone diagram and risk matrix analysis method and its application in safety assessment of natural gas spherical tank. *J Clean Prod*. 2018;174:296-304.

16. Rodgers M, Oppenheim R, Yaghoubi K, et al. Ishikawa diagrams and Bayesian belief networks for continuous improvement applications. *TQM J*. 2021;31(January):291-303.

17. Bhandari J, Arzaghi E, Abbassi R, Garaniya V, Khan F. Dynamic risk-based maintenance for offshore processing facility. *Process Saf Prog*. 2016;35(4):399-406.

18. Hamza Z, Hacene S. Reliability and safety analysis using fault tree and Bayesian networks. *Int J Comput Aided Eng Technol*. 2019;11(1):73-86.

19. Zerrouki H. Risk assessment of a liquefied natural gas process facility using bow-tie and Bayesian networks. *Process Saf Prog*. 2022;41(2):1-12.

20. Baksh AA, Khan F, Gadag V, Ferdous R. Network based approach for predictive accident modelling. *Saf Sci*. 2015;80:274-287.

21. Tan Q, Chen G, Zhang L, Fu J, Li Z. Dynamic accident modeling for high-sulfur natural gas gathering station. *Process Saf Environ Prot*. 2014;92(6):565-576.

22. Arvanitoyannis IS, Varzakas TH. Application of failure mode and effect analysis (FMEA), cause and effect analysis and Pareto diagram in conjunction with HACCP to a potato chips manufacturing plant. *Int J Food Sci Technol*. 2007;42(12):1424-1442.

23. Arvanitoyannis IS, Varzakas TH. Application of ISO 22000 and Failure Mode and Effect Analysis (FMEA) for industrial processing of salmon: A case study. *Crit Rev Food Sci Nutr*. 2008;48(5):411-429.

24. Sweis R, Moarefi A, Amiri MH, Moarefi S, Saleh R. Causes of delay in Iranian oil and gas projects: a root cause analysis. *Int J Energy Sect Manag*. 2019;13(3):630-650.

25. Verma A, Maiti J. Text-document clustering-based cause and effect analysis methodology for steel plant incident data. *Int J Inj Contr Saf Promot*. 2018;25(4):416-426.

26. Tortorella G, Cómbita-Niño J, Monsalvo-Buelvas J, Vidal-Pacheco L, Herrera-Fontalvo Z. Design of a methodology to incorporate lean manufacturing tools in risk management, to reduce work accidents at service companies. *Procedia Comput Sci*. 2020;177:276-283.

27. Rachid C, Ion V, Irina C, Mohamed B. Preserving and improving the safety and health at work: Case of Hamma Bouziane cement plant (Algeria). *Saf Sci*. 2015;76:145-150.

28. INRS. *Analysis of the Accident at Work The Causal Tree Method*.; 2019.

29. Luca L, Minodora PASARE A, Alin STANCIOIU L. Study To Determine a New Model of the Ishikawa Diagram for Quality Improvement. *Acad Brâncuşi*. 2017;(1):6.

30. Wong KC. Using an Ishikawa diagram as a tool to assist memory and retrieval of relevant medical cases from the medical literature. *J Med Case Rep*. 2011;5(1):2-4.

31. J. Mitchell R, Williamson AM. Evaluation of an 8 hour versus a 12 hour shift roster on employees at a power station. *Appl Ergon*. 2000;31(1):83-93.

32. Barnes RG, Deacon SJ, Forbes MJ, Arendt J. Adaptation of the 6-sulphatoxymelatonin rhythm in shiftworkers on offshore oil installations during a 2-week 12-h night shift. *Neurosci Lett*. 1998;241(1):9-12.

33. Parkes K. Human factors , health and safety in the offshore oil / gas industry. 2017;(December 2013):1-10.

Collier K. The Loss of the Ocean Ranger, 15 February 1982. (2016). Newfoundland and Labrador Heritage. Accessed September 01, 2022.

2. Summerhayes C. Deep Water – The Gulf Oil Disaster and the Future of Offshore Drilling. Report to the President (BP Oil Spill Commission Report); 2011.