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Leveraging Social Network Analysis for Enhancing Safety Reporting in the Workplace: A Case Study of the IZAT Application

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Abstract: Unsafe condition reporting is an important source of information for companies to determine whether the reporting can be identified effectively as the key to reducing work accidents. The purpose of this study is to find out how the Social Network Analysis visualization network works when users report unsafe conditions in the IZAT app and sort the results of data processing. The findings revealed that the data collection process yielded 26,658 data items. The Unsafe Condition content comprised 79,667 words, with 2,388 unique words identified. The average number of occurrences per word was 33.36139. Certain network property calculations can be inferred from these results. Then, the word mapping with five related topics was carried out. The results of the categorization of the unsafe condition word mapping can be used as evaluation material for companies to prevent work accidents. In particular, the network visualization results can identify the most discussed topics and social network relationships for reporting in the IZAT application.

Keywords: Reporting, safety culture, unsafe condition, occupational health and safety, social network analysis.

Introduction

Companies are not resistant to workplace accidents that endanger both individuals and businesses. The accident occurred due to the organization's or company's failure to pay attention to implementing Occupational Health and Safety (OHS) [1]. Therefore, workers carry out their responsibilities without considering their well-being and physical condition. The implementation of the OSH program is crucial as it has the potential to effectively mitigate and diminish both accidents and occupational diseases [2]. Occupational accidents and diseases occur due to human, machine, and material factors involved in process stages with different hazard risk levels [3]. Each year, approximately two million workers die due to occupational hazards, despite the advancements and enhancements in occupational health and safety lately [4]. Millions of people were injured or deceased as a result of work accidents in various sectors, especially construction [5].

International Labor Organization reported that the highest level of protection for health and safety at work is a priority and one of their fundamental rights [6]. Workplace health difficulties have increased incapacitation and more frequent absences among afflicted workers [7]. History shows that near-miss incidents repeatedly trigger losses or work accidents. However, some companies may need a reporting culture in which employees are encouraged to report an imminent event. Furthermore, unsafe conditions and actions are the leading causes of workplace accidents [8].

Figure 1 shows the report of occupational accidents in the last six years (2017-2022) from the Employment Social Security Maintenance Agency, where the number of accidents at work has increased significantly yearly. According to the data, in 2017, there were 123.040 cases of work accidents, while in 2018, this number reached 173.415 cases. In 2019, the data continued to increase. The number of accidents at work reached 182.835 cases. It can be concluded that the total number of occupational accidents has increased by about

200,000 since the pandemic in 2020-2022. Many employees have not dared to facilitate openness about accidents at work, fear, and confidence that management facilitates justice in accidents, work accident reporting is still covered for the security of employment status, the rarity of reporting accidents because of fear of being a bad record and employee accidents rarely use common discussion material [9]. Unreported errors will affect companies by losing an opportunity to learn from their mistakes and build a safety culture, which will increase accidents and injuries.

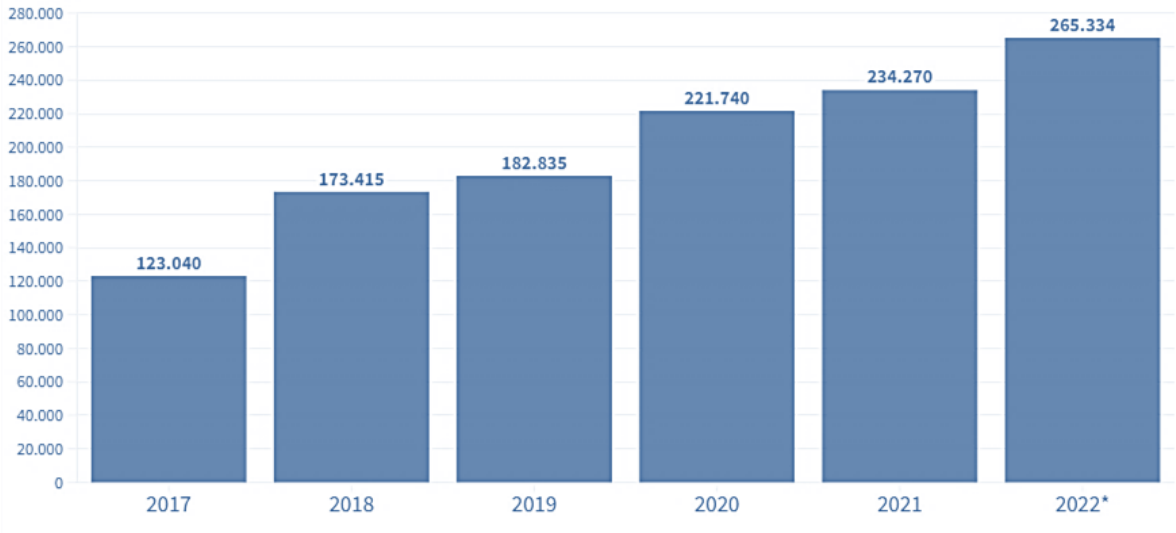

Figure 1. Graph of occupational accident annual report

Figure 2. Work accident pyramid

Figure 2 shows the theory of H.W Heinrich's domino effect, where accidents occur through a cause-and-effect chain relationship of several factors that cause work accidents that are interconnected to cause work accidents and several other losses. The most significant comes from human negligence factors, which is 88%, while the other 10% is from property/assets/goods ineligibility factors and 2% of other [10]. The prevention of occupational accidents and diseases is achievable in 98% of cases, and the key to achieving this is the development of a safety culture [11]. Therefore, companies must be responsible for protecting their jobs by implementing a safety culture in the workplace [12].

PT PLN Nusantara Power Company is an energy company engaged in power generation trusted by more than 40 generating units throughout Indonesia. PT PLN Nusantara Power faces significant occupational safety and health risks. The company has a history of work accidents from 2015 to 2020, resulting in losses exceeding 13 billion. The most recent incident involved work accidents and fires. From the problem of work accidents that occur, the OHS Development Division at the Head Office (PLN Nusantara Power) developed a strategy to create Zero Accident for all Generating Units, which creates a safe, healthy, and comfortable work environment for all employees, to support the company in achieving optimal performance. PLN Nusantara Power uses a safety reporting strategy to achieve the goal of zero accidents. The company strives to minimize

the immediate cause of work accidents, i.e., by implementing safety reporting, which is the inspection of health and accidents of work by reporting as many unsafe actions and unsafe conditions in the workplace as possible and taking action to mitigate work accident findings. PT PLN Nusantara Power strives to minimize the Direct Causes of Work Accidents, namely finding as many Unsafe Actions and Unsafe Conditions as possible in the workplace and taking mitigation actions by Closing OHS Nonconformity Findings quickly. IZAT (Zero Accident Assistant Application) is a mobile and web application-based application designed by PLN Nusantara Power to optimize all business processes in the OHS field. This application helps efficiently create, manage, implement, control, and evaluate OHS business processes. IZAT makes it easy for users to make structured and well-documented OHS plans. In addition, this application also facilitates the implementation of OHS activities by scheduling patrols, collecting findings reports, and follow-up actions that must be carried out.

Table 1. IZAT applications report 2020-2023

Years	Positive	Near miss	Unsafe condition	Unsafe action
14 Sept 2020 – 31 Des 2020	18.83%	2.20%	74.09%	4.88%
1 Jan 2021 – 31 Des 2021	36.12%	1.84%	58.12%	3.91%
1 Jan 2022 – 31 Des 2022	45.06%	0.64%	52.24%	2.07%
1 Jan 2023 – 31 May 2023	60.10%	0.53%	37.70%	1.66%

Table 1 shows a comparison of the last few years of patrols using IZAT. This data shows that from 14 September 2020 to 31 May 2023, the incidence of unsafe conditions decreased from 74,09% to 37.7%. This data also shows that positive or safe conditions continue to increase yearly from 18,83% to 60,1%. The findings in the IZAT application were immediately executed so as not to cause accidents at work. By using IZAT, the process of controlling and monitoring OHS can be carried out in real-time. The app allows users to monitor compliance with OHS policies and procedures and identify potential risks that need to be addressed. It can be seen that the IZAT application developed by PLN Nusantara Power to improve the occupational safety culture has shown its effectiveness in detecting potential hazards in the workplace. This app makes workers aware of the safety culture, and this awareness impacts the reduction in the incidence of work accidents. The data obtained from the application IZAT belonging to PT PLN Nusantara Power can be used as a reference in determining the topic of problems and research themes to be the object of the latest research.

The limitations of literature related to using SNA in analyzing unsafe conditions have become a gap in this research. Previous research mainly investigated the relationship between unsafe action and unsafe conditions [13], control efforts [14], and cause analysis [15], not in the case of reporting unsafe conditions. Even so far, SNA methods have not been used in the work's health and safety aspects. Thus, this research further fills up the literature shortfall related to using SNA in analyzing unsafe conditions. This research has two purposes: to categorize the results of unsafe condition findings on IZAT applications in PLN Nusantara Power units and to visualize the unsafe condition findings in IZAT applications. The results of this categorization and visualization can be a reference for companies to facilitate the prevention and handling of accidents at work.

Occupational Health Safety

Occupational Health Safety (OHS) is an integral part of company operations, inseparable from them. Companies should prioritize occupational safety and health to guarantee the safety and well-being of their employees. OHS is a deliberate and systematic approach to safeguarding workers' well-being and overall health and the quality of their work and the broader society to achieve fairness and prosperity [16]. Occupational health and safety is a specialized area that focuses on predicting, identifying, assessing, and managing environmental factors or stresses that originate from or occur in the workplace [17]. From some of the definitions above, it can be concluded that Occupational Health and Safety is the science and its application in preventing work accidents and occupational diseases.

Safety Culture

"Culture" pertains to the organizational environment, promoting well-being, and establishing a safe working environment. The safety culture frequently influences the attitudes and behaviors of employees toward ongoing health and safety performance [18]. The safety culture is shaped by multiple factors that impact on the safety. These factors include values, past experiences, and individual characteristics that contribute to

forming perceptions, expectations, and interpretations of appropriate behavior. Additionally, technical competence and the ability to recognize individual competencies influence the safety culture [19]. From some of the definitions above, it can be concluded that safety culture results from the values, attitudes, perceptions, competencies, and behavior patterns of individuals or groups, demonstrating their commitment to and implementation of Occupational Safety and Health.

Unsafe Condition

In general, human factors are usually responsible for work accidents. An unsafe condition refers to a hazardous or perilous situation that has the potential to result in accidents or close calls. Conversely, the definition of an unsafe condition is the opposite of this. An unsafe condition refers to substandard workplace conditions involving mechanical and physical hazards [20]. In all jobs, work accidents caused by unsafe conditions are inevitable. However, it is possible to manage and mitigate risks to an acceptable level by employing suitable measures. Safety awareness issues pertain to cases where workers possess the necessary knowledge and acknowledge the presence of unsafe conditions yet fail to take suitable action and continue with construction activities [21]. From some of the above definitions, it can be concluded that an Unsafe Condition is a bad workplace condition with a mechanical and physical danger that can cause an accident or near miss.

Social Network Analysis (SNA)

In recent years, researchers have shown significant interest in Social Network Analysis. Social Network Analysis involves the examination and interpretation of data that is contained within social networks. The information can be classified into two categories: structure-based information, which pertains to the topological structure of the network, and content-based information, which pertains to features associated with entities and their relationships [22]. Social Network Analysis is a structured way to investigate networks, map relationships, and explore the flow of knowledge among different entities [23]. According to some of the definitions above, social network analysis is a method that can aid in understanding interaction patterns on social media and in the work or business environment.

Table 2 shows the research focus on safety from several researchers. Reis *et al.* [29] did systematic research to analyze the dimensional characteristics of the Hospital Survey on Patient Safety Culture (HSOPSC), which is an innovation in the field of safety culture. Furthermore, an analysis conducted by Al-Bayati [22] examined the influence of a construction safety culture and a safety environment on safety behavior and motivation, focusing on the role of culture and safety climate in shaping safety outcomes in the construction industry. In addition, Mambwe *et al.* [31] did research to evaluate the factors contributing to the effectiveness of occupational health and safety management techniques among small-scale contractors in Zambia. The researchers presented a complete framework that integrated safety culture as a crucial component for attaining positive results. The works provide a substantial scholarly addition to the field of safety culture, encompassing many subjects such as patient safety, construction safety, and occupational health and safety management. These studies offer useful insights into the impact of safety culture on safety behavior, motivation, and the elements contributing to the effectiveness of safety solutions.

The references provided offer valuable insights into the advantages that can be obtained from using safety reporting. Reis *et al.* [29] thoroughly examined the dimensional characteristics of the Hospital Survey on Patient Safety Culture (HSOPSC). Their analysis yielded useful insights into the impact of safety culture on collaboration and safety in the medical domain. This assessment can yield advantages in enhancing collaboration and knowledge acquisition within the healthcare setting. Furthermore, research conducted by Al-Bayati [32] examined the influence of a construction safety culture and safety environment on safety behavior and motivation, focusing on the role of culture and safety climate in shaping safety outcomes in the construction industry. This research endeavor has the potential to provide valuable insights into the advantages linked to enhancing safety behavior and motivation inside construction sites. Tetzlaff *et al.* [19] did a retrospective analysis of mining occupational health and safety reports. This analysis has the potential to offer valuable insights into the advantages linked to safety culture in the mining industry. These referenced sources provide valuable insights into the advantages of safety reporting and safety culture in various industries and settings, such as healthcare, construction, and mining.

Table 2. Research focus of safety

Theme	Reference	Research focus	Method
Safety culture	Marshall [24]	Focuses on differences and similarities and uses risk perception and safety culture as management tools	Risk assessment and analysis
	Feng and Trinh [25]	Interactive effects of a safety culture on construction project safety performance	SEM PLS
	Tetzlaff *et al.* [26]	Analysis of occupational health and safety (OHS) reports in mining	Data analysis with Leximancer
	Zhang *et al.* [27]	Characteristics of safety culture deficiencies	Why Because Analysis (WBA)
	Jilcha and Kitaw [28]	Workplace safety and health innovations Pillars of sustainable development	Desk review
	Reis *et al.* [29]	Safety culture weaknesses and strengths Dimensions of safety culture	Systematic literature review (SLR)
	Petitta *et al.* [30]	The influence of organizational safety climate and safety culture	Quantitative research
	Mambwe *et al.* [31]	OHS improvement management strategy OHS success factors	Quantitative research
	Al-Bayati [32]	Construction safety culture and climate framework Construction safety culture measurement	Questionnaire with a numerical scale
Risk safety	Zhen *et al.* [33]	Development of offshore major hazard risk prevention	SPAR-H and Petro-HRA
	Ding *et al.* [34]	Generic bow tie framework model to prevent occupational accident risks	Case Research
	Jadidi and Bazdar [35]	Application of safety principles Applying case studies to risk identification	Case Research
	Jin *et al.* [36]	Use of Netica Bayesian simulation software and Bayesian network method for safety risk prevention	Bayesian network analysis
	Tran and Le [37]	Practical implications of risk theory in the covid-19 situation in Vietnam	CFA Model
	Kashmiri *et al.* [38]	Statistical analysis of perceived safety risks to construction workers	Statistical analysis
	Sunaryo and Hamka [39]	Risk cause analysis and safety risk assessment	HIRA and FTA
	Ilbahar *et al.* [40]	Construction risk analysis with risk assessment	PFPRA
	Wang and Chen [41]	Evaluate the project risk metro through the aspect of risk probability to assess the risk loss.	Fuzzy Bayesian network
Safety reporting	Kabul *et al.* [42]	Analyze the implementation of OHS by identifying potential environmental hazards	Qualitative, descriptive
	Tashia and Jamaluddin [43]	Analysis of OHSRS program in each unit Evaluation of routine reporting program	Qualitative and interviews
	Mayangkara *et al.* [44]	Implementation of a system for recording and reporting occupational accident incidents	Qualitative
	Soltanzadeh, *et al.* [45]	Analysis of Accident Severity in the Chemical Industry	Retrospective descriptive-analytic
	Hasanspahić *et al.* [46]	Analysis of crew willingness to report near-miss events	Qualitative research methods
	Park *et al.* [47]	Automated safety monitoring approach aids in potentially improving construction site safety.	Qualitative research methods
	Gnoni and Saleh [48]	The number of near misses reported each year in medium to large-sized organizations.	Near-miss report system
	Farokhzadian *et al.* [49]	Challenges weaknesses in feedback to report errors and weaknesses in organizational education and learning culture	Qualitative

Novelty safety risk research examines the impact of safety attitudes on safety risk perception and the identification of hazards [38]. This demonstrates how individual dispositions in the workplace might impact safety-related perceptions and the ability to identify hazards. This research provides an insightful viewpoint on managing safety risks in the production phase, specifically in the automotive supplier industry [35]. The research titled "A novel approach to risk assessment for occupational health and safety using Pythagorean

fuzzy AHP & fuzzy inference system" by iLbahar et al. presented a specialized technique for evaluating risks in the field of occupational health and safety, thereby adding to the innovation in risk management. This research utilizes the Pythagorean Fuzzy Analytic Hierarchy Process (AHP) and a fuzzy inference system as its methodology. This methodology enables a comprehensive and flexible assessment of risks by integrating the inherent uncertainty and ambiguity in the decision-making process. This research enhances the development of risk assessment methodologies in occupational health and safety by employing intricate procedures and introducing a novel risk management approach [40].

The studies in the table above incorporate innovative safety reporting and management approaches. Farokhzadian *et al.* [49] identified various obstacles to error reporting in their research on the challenges nurses encounter when establishing an effective patient safety culture. These barriers include the absence of a safety culture that focuses on assigning blame and reprimanding individuals, insufficient support from colleagues following an error, and inappropriate responses from management. This document offers comprehensive insights into the impact of organizational culture and human factors on safety reporting within healthcare settings. Hasanspahić *et al.* [46] conducted research that focused on near-miss management systems in the maritime industry. They highlighted the need for reporting as a crucial element for the effectiveness of such systems. This underscored the need to regularly report near-miss accidents and utilize them as learning opportunities to enhance safety in the maritime industry. In addition, Gnoni & Saleh [48] provide a comprehensive analysis of observation and near-miss management systems, specifically addressing safety events and accident precursors within the framework of safety principles. This exemplifies a proactive stance towards incident management and safety reporting that aligns with mitigating risks and striving for ongoing enhancement. The research on safety reporting is innovative because it covers all aspects of safety reporting, including the challenges in fostering a safety culture, the significance of reporting near-misses, and the proactive management of safety events and potential accidents.

Methods

The research employed a qualitative descriptive analysis approach, incorporating Social Network Analysis (SNA). This method represents users using symbols, dots, and interactions between users, represented by lines. These methods require analysis that can offer novel insights into the behavior of individuals or societies within their social interaction patterns. SNA can also utilize a network framework that includes organizations and individuals directly interacting with the surrounding environment [50]. The researchers' data source is secondary data from the IZAT application. This data collection technique is called data scrapping. The subjects of the research are all IZAT users who report during patrols for which information will be retrieved. The object of research is data containing comments in the condition column from IZAT application users who are categorized as unsafe conditions. The research location is the IZAT application.

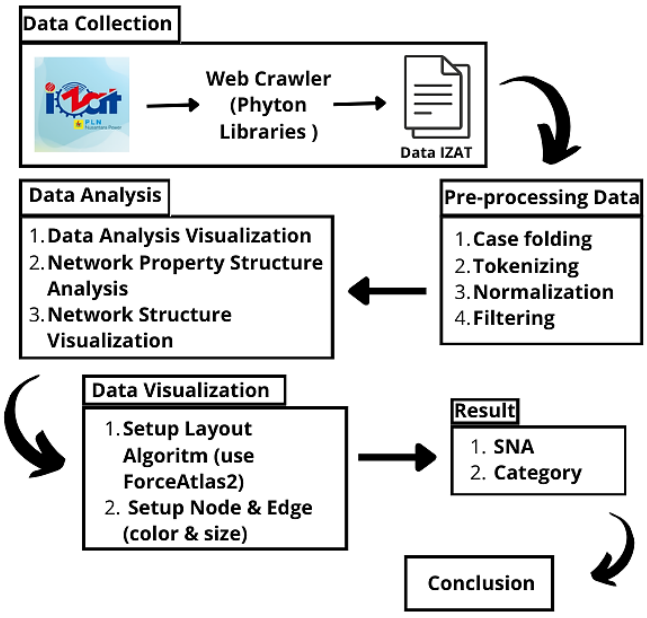

Figure 3. Research flow

The concept of this research is illustrated in Figure 3. The initial stage in the research process is a literature review of the phenomena that occur in the form of historical data through the IZAT (Zero Accident Assistant Application) application. The formulation of the problem in this study is the communication pattern of reporting through the IZAT application to the reporter's response to risk findings with the unsafe condition category and the relationship between actors from the graph analysis formed in the network structure. The data was then extracted (scraping) in Excel, covering the three contents: unsafe condition findings, title of findings, and generating units. Before entering the analysis and visualization stage, data preprocessing is required. The purpose of preprocessing in this study is to ensure that the data collected in text format only consists of terms that have relevance for analysis. This process involves four main stages: case folding, tokenizing, normalizing, and filtering. Tools used at this stage include anaconda, notepad++, and wordij. As an analysis tool to identify the structure of the property network formed and visualize it, Gephi 0.9.2 software was used. Gephi is an interactive visualization and examination or assessment tool for various types of simple and complex networks dynamic and hierarchical graphs [51].

Data Collection Method

The data obtained comes from the PT PLN Nusantara Power IZAT application. In 2020, the Head Office HSSE Division created the Zero Accident Assistant application (IZAT 2.0) with an OHS non-conformance findings report feature. The IZAT application will support scheduled patrol activities involving all workforce members at PLN Nusantara Power.

Preprocessing Data

Preprocessing is done to clean the data source, which contains unnecessary words[52]. Data preprocessing aims to eliminate noise in the reporting data, such as abbreviations and nonstandard words that are difficult to translate by computer. Preprocessing consists of several stages, namely:

1. Case folding is a stage that aims to convert all letters in the title into lowercase letters so that no capital letters are left in the title. This process aims to make the characters in the headline uniform [53].
2. Tokenizing can take the form of characters, words, or sub-words. Thus, the tokenization process can be broadly classified into three types, namely character-level, word-level, and sub-word-level tokenization [54].
3. Data Normalization is done to avoid repetition and standardize the documents.
4. Filtering can be called stopword removal, which removes words that are unimportant in the classification and reasoning process [55]. After that, the data is saved in CSV form.

After going through the filtering stage in the preprocessing process, the next step is to analyze thematic words by categorizing words into five topics: place, response, cause, tool, and condition. Place indicates the location of the incident, response refers to the action or actions taken, cause relates to the cause of the incident, tool indicates the related tool, and condition relates to the situation or state of the environment where the incident occurred.

Data Analysis and Visualization

The normalized information was processed using Wordij to extract the most important aspects of the dataset to be analyzed. After data preprocessing, social network modeling was performed using the social network analysis (SNA) method. Network visualization is done with the Gephi 0.9.2 application so that nodes representing users and edges representing relationships between actors in the social network can be seen [56]. This tool aims to help find patterns and distill dynamic, iterative visualizations in making hypotheses.

Results and Discussions

The data obtained comes from the PT PLN Nusantara Power IZAT application. In 2020, the Head Office HSSE Division created the Zero Accident Assistant application (IZAT 2.0) with an OHS non-conformance findings report feature. The IZAT application will support scheduled patrol activities involving all workforce members at PLN Nusantara Power. Based on data from September 2020 to July 2023, there were 26,658 words. The data collection process uses the Jupyter Notebook scrapping tool with the Python programming language, and the "title" content is formulated in a query. The successfully extracted data was saved in CSV format to enter the next processing stage.

Table 3. Wordij's data processing results

Focus	Year	The total number of words	Unique word	Average amount
Unsafe condition	21 September 2020 - 30 Juli 2023	79,667	2,388	33.36139

Source: Author-processed data (2023)

Table 3 presents the outcomes of Wordij data processing, encompassing the overall word count, the count of distinct words, and the mean number of all words per distinct word. The data indicates that the Unsafe Condition content consisted of 79,667 words, 2,388 unique words, and an average of 33.36139 words per instance.

Visualization results from changing text data into nodes and edges that have relationships to form a network [57]. The visualization in this research used word relationships from bigrams processed using Gephi. This visualization only brings up a ratio of about 99% of the total degree to eliminate node data that has no relationship with other nodes or only has an insignificant relationship. In this data, the ForceAltas2 algorithm is used so that the network connection can be drawn properly and there is no accumulation of data. ForceAtlas2 is a force-directed layout that acts like a real system to arrange a network's nodes [58]. Like charged particles, nodes push against each other, but edges pull their nodes toward them like springs. These forces create a movement that ends up in a state of balance. This final setup should make figuring out what the data means easier. The main idea behind the visualizing ForceAltas2 algorithm is that all nodes repel each other, whereas two connected nodes attract each other [59]. The larger the node and text that is visible, the more it shows that the word is the main focus of IZAT users in terms of unsafe conditions. The thicker an edge indicates the stronger the relationship between words. The visualization results for Unsafe Condition content are shown in Figure 4.

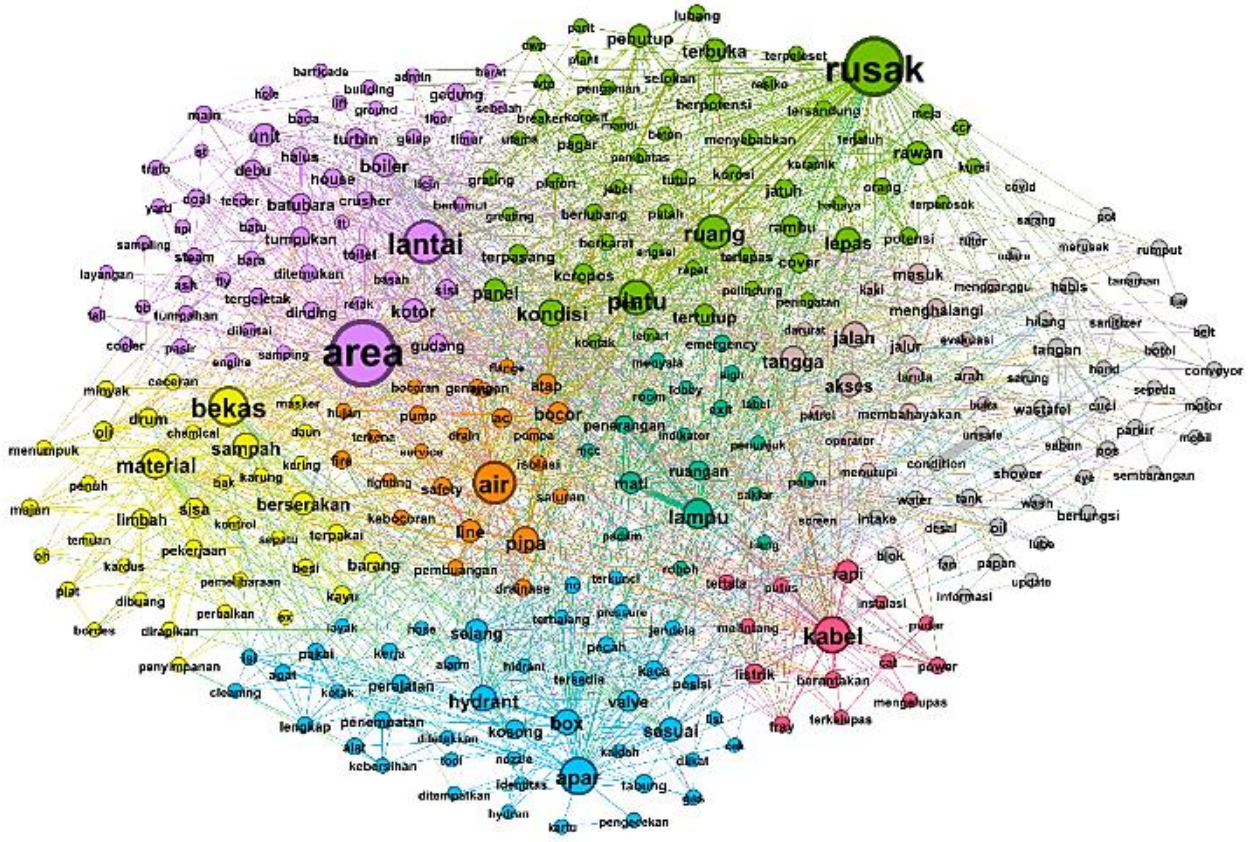

Figure 4. Network visualization image for Unsafe Condition at IZAT 2020-2023
Source: Author-processed data, 2023

The unsafe condition visualization results in Figure 4, which shows various colors distinguishing between the existing network of nodes and edges. From the visualization, there are eight different colors: light green, purple, yellow, blue, orange, pink, dark green, and grey. The light green colored network of nodes and edges shows the condition and response of the report findings. Reporters often use the word broken in reporting, where nodes related to broken are doors, panels, fences, cabinets, tables, chairs, porous, loose, potential, cause, and so on. Furthermore, the network of nodes and edges colored purple shows the place and cause of the

report findings. Reporters often use the word area in reporting, where nodes related to the area are floor, boiler, turbine, warehouse, unit, building, pile, coal, dust, and so on. Then, the network of nodes and edges colored yellow shows the causes and conditions of the report findings. Reporters often use the word used in reporting, where nodes related to used are material, garbage, goods, waste, oil, drums, wood, scattered, etc.

The blue-colored nodes and edges network shows the tools and conditions from the report findings. Reporters often use the word apar in reporting, where the nodes related to apar are box, hydrant, valve, hose, tube, empty, blocked, available, and so on. Then, the orange-colored nodes and edges network show the tools and conditions from the report findings. Reporters often use the word water in reporting, where nodes related to water are pipes, lines, ac, pumps, channels, leaks, puddles, and so on. Furthermore, the pink-colored network of nodes and edges shows the tools and conditions from the report findings. Reporters often use the word cable in reporting, where nodes related to cables are electricity, messy, peeling, crossing, breaking, neat, and so on. Then, the network of nodes and edges colored dark green shows the report findings' tools, conditions, and places. Reporters often use the word lamp in reporting, where nodes related to lamps are switches, poles, off, extinguished, collapsed rooms, lobbies, and so on. The grey network of nodes and edges is similar to the other colors, but no nodes are discussed in this color. It can be seen that the connected nodes are not only the same color but also connected nodes with different colors. This can happen when the word has a relationship even though it is different in the node; for example, the lamp node is connected to the broken node.

Based on the analyzed data, the researchers have determined the IZAT network properties for the Unsafe Condition content category from 2020 to 2023. The calculations are shown in Table 4.

Table 4. Results of unsafe condition network properties at IZAT 2020-2023

Network properties	Mark (unsafe condition)
Nodes	319
Edges	1897
Average Degree	11.893
Averages Weighted Degree	120.897
Network Diameters	4
Modularity	0.568

Source: Author-processed data (2023)

The Unsafe Condition content category had 319 nodes in the IZAT network in 2020-2023. The node is any word that has already been cleansed from preprocessing data. The larger the node and the more visible, it shows that the word is the main focus of IZAT users in unsafe condition content. These nodes are linked together through reporting between many users [60]. Nodes with more ties are considered central, important, and influential because they can play a key role in content [61]. The Edges network property refers to the connections or lines that link nodes and quantify the level of interaction between them. Edges can be directionless or directional and can also indicate relationship strength [62]. In 2020-2022, the Unsafe Condition content category has 1897 edges in the IZAT network. The more edges between nodes, the more connections between nodes, resulting in better data distribution. The Average Degree network property describes the average relationship between users in the network [63]. The higher the average degree, the faster and more accessible information is disseminated. In the IZAT network in 2020-2022, the Unsafe Condition content category has an average degree of 11,893. Network property Averages Weighted Degree is a network attribute that quantifies the average number of link weights that connect nodes in a graph within a network [64]. In the IZAT network in 2020-2022, the Unsafe Condition content category produced an average weighted degree of 120,897. A higher number of average degrees of weight is desirable as it signifies a more efficient rate of information dissemination.

The Network Diameters property refers to a network's maximum or longest distance [65]. For the Unsafe Condition category, the IZAT network has a network diameter of 4 in 2020-2022. The smaller or shorter the diameter, the more easily and quickly information about the content spreads. As a result of its small diameter, the information step takes little time. The Network Modularity property refers to the degree of strength exhibited by a group within a network [66]. In 2020-2022, the IZAT network had a modularity of 0.568 for the Unsafe Condition content category. A network with higher modularity exhibits a more robust relationship between the groups formed within the network.

Based on the data processed using Wordij, generate words related to unsafe conditions. The words are selected based on the same criteria and then grouped into their respective categories by analyzing their interrelationships.

The category is formulated and determined by expert judgment (from the safety expertise in PLN. The researchers have determined five categories of topics: place, response, cause, tools, and conditions. Five categories represent the general characteristics of the reporting sentence of the IZAT application. The mapping results for the top 10 words of each of these topics are shown in Table 5.

Table 5. Identify word relationship to topic

Topic 1: Place		Topic 2: Response		Topic 3: Cause		Topic 4: Tool		Topic 5: Condition	
area	0.06%	Sesuai (suited)	0.02%	air (water)	0.06%	lampu (lamp)	0.06%	rusak (broken)	0.09%
lantai (floor)	0.05%	Berpotensi (potential)	0.01%	material (material)	0.03%	pintu (door)	0.04%	mati (off)	0.05%
ruang (room)	0.03%	membahayakan (harm)	0.01%	batubara (coal)	0.02%	kabel (cable)	0.04%	bekas (scrap)	0.05%
jalan (street)	0.03%	Rawan (prone)	0.01%	lepas (loose)	0.03%	sampah (trash)	0.03%	kotor (dirty)	0.04%
parkir (park)	0.02%	menghalangi (blocking)	0.01%	licin (slick)	0.01%	apar	0.03%	bocor (leak)	0.04%
ccr	0.02%	menyebabkan (cause)	0.01%	limbah (waste)	0.01%	pipa (pipe)	0.03%	berserakan (scatter)	0.03%
atap (rooftop)	0.02%	Mengganggu (annoying)	0.01%	debu (dust)	0.01%	box	0.02%	rapi (neat)	0.03%
ruangan (room)	0.01%	Berfungsi (work)	0.01%	oli (oil)	0.01%	hydrant	0.02%	tumpukan (stack)	0.02%
gedung (building)	0.01%	Berbahaya (dangerous)	0.01%	hujan (rain)	0.01%	tangga (stairs)	0.02%	patah (broke)	0.02%
dinding (wall)	0.01%	Indikasi (indication)	0.01%	abu (ash)	0.01%	panel	0.02%	keropos (fragile)	0.02%

Source: Author-processed data (2023)

The calculation results shows that "Condition" (Topic 5) is the topic of most concern from IZAT users, with a special focus on damaged (0.09%), dead (0.05%), used (0.05%). Based on the results of the discussion, it can be concluded that users often talk about the topic of conditions, which can be an evaluation material for companies because it describes the state of unsafe conditions. Categories in unsafe condition reporting are made to facilitate grouping conditions that are unsafe and dangerous for workers. These categories can help companies identify the root causes of near misses and work accidents so that appropriate preventive measures can be taken. In addition, the categories can also help companies make near-miss reporting procedures as simple and easy as possible[46]. The “place category” in unsafe condition reporting refers to the location or place where the unsafe condition occurred. For example, the reporter will include information regarding the location of the near miss or unsafe event, such as a warehouse area, parking area, or room. Companies can implement targeted preventive actions by thoroughly understanding the precise area or environment where the hazardous situation occurred[67].

Additionally, this can aid in recognizing patterns of unsafe conditions and formulating tactics to mitigate the likelihood of workplace incidents. Furthermore, corporations can oversee and assess reports of unsafe conditions based on their specific site or location to identify the regions that are most susceptible to accidents. Subsequently, they can implement suitable measures to mitigate the risk of accidents in these identified places.

In reporting unsafe situations, the term "response category" pertains to the actions taken in response to unsafe conditions. The response category pertains to the company's actions and protocols while addressing hazardous situations, which involve coordinating incident response activities and reporting, as well as many parts of the response process. Effective communication and coordination among all parties managing the crisis is essential. Classifying responses is essential for establishing a comprehensive system for managing incidents, guaranteeing a timely, well-organized, and effective reaction to occupational health and safety issues. In reporting dangerous conditions, the “cause category” pertains to the causes of hazardous workplace conditions. The cause category in the safety reporting system might encompass information regarding the factors contributing to work accidents. Various things, including water, materials, waste, and others, can cause work accidents. By comprehending the underlying factors contributing to unsafe conditions, firms can implement suitable proactive measures to mitigate the likelihood of work-related incidents. Furthermore, by reporting unsafe circumstances according to their causes, firms can effectively identify recurring patterns of hazardous

occurrences and devise methods to mitigate the likelihood of workplace accidents.

The classification of unsafe condition reporting within the domain of tools encompasses the identification and origins of workplace incidents associated with equipment and personal protective equipment (PPE) that may not always be agreeable or unsafe for workers. The term "tool category" refers to the condition of equipment, machinery, or devices that can potentially cause workplace accidents. Knowledge of the classification of tools in unsafe condition reports can help companies identify potential risks associated with using tools and implement appropriate precautions. In the context of unsafe condition reporting, the term "condition category" pertains to hazardous workplace circumstances that can potentially result in accidents. Unsafe environments include deteriorated ceilings, compromised safety helmets, permeable panels, and dysfunctional ladders.

Furthermore, unsafe conditions can encompass unclean, disorderly, or chaotic work settings, along with other elements that may endanger the well-being and security of workers. Understanding the condition categories in unsafe condition reporting is crucial for firms to recognize potential workplace dangers and implement suitable preventive measures. Additional information regarding these categories might enhance comprehension of the influence of conditions on workplace accidents and the strategies that can be implemented to mitigate them. This Social Network Analysis (SNA) technique is used to show patterns of incident reporting in the workplace. This allows for the identification of many things that are frequently deemed unsafe by employees. These objects include doors, flooring, public amenities, lighting, and trash management. It gives the impression that these things regularly sustain damage or have the potential to cause mishaps on the job. The investigation results shed light on the efficiency of the event reporting system in identifying potential dangers by analyzing the patterns shown. In addition, the findings suggest that management should prioritize factors that should be addressed to enhance occupational safety standards while simultaneously making a beneficial contribution to the reduction of potential dangers that could affect the organization's entire workforce.

Conclusions

Research on reporting unsafe conditions at PT PLN Nusantara Power shows that dangerous circumstances and hazards cause most company work accidents. It shows the importance of raising employee awareness and compliance with safe working practices. The IZAT application developed by PLN Nusantara Power to enhance the culture of occupational safety has shown its effectiveness in detecting potential hazards in the workplace. However, further efforts are needed to increase the number of unsafe conditions and conduct more in-depth data analysis to identify potential risks that have yet to be detected. Based on an analysis of social networks (SNA) and text processing of data reports of unsafe conditions from the application IZAT PT PLN Nusantara Power, it is known that many employees are actively involved in reporting findings related to hazardous situations in the workplace. This high level of employee engagement reflects their commitment to the company's security reporting program. In addition, the theme of diversity, in particular, indicates employees' sensitivity and their caution for potentially unsafe conditions in the workplace. Overall, this data reflects a strong security culture in this company.

Based on the results of this research, the purpose of this study is to categorize the findings of unsafe conditions on IZAT applications in PLN Nusantara Power Unit and to visualize the findings of unsafe conditions that have been achieved on IZAT applications. The categorization results showed the words on the IZAT application related to unsafe conditions according to each topic: place, response, cause, tools, and conditions. SNA visualizes patterns of workplace incident reporting to identify several objects that are regularly unsafe by employees, including doors, floors, public facilities, lighting, and waste management. It suggests that these objects are often damaged or potentially cause workplace accidents. The findings provide insight into the effectiveness of the incident reporting system in detecting potential hazards based on the patterns displayed. In addition, the findings recommend priority aspects that management should address to improve occupational safety standards while contributing positively to reducing potential hazards to the company's entire workforce. There are some limitations to this research. First, the data collection period is only four years, which is not long enough to analyze the long-term trends of incidents of insecure conditions. Secondly, the number of incidents of unsafe conditions in the IZAT system still needs to be more extensive and more balanced for all work areas, which can affect the accuracy of the overall pattern analysis results. Third, there is no actual comparative data on the rate of work accidents in the field to be validated with the missing incident reporting pattern in the IZAT application. Comparison of data on the rate of work accidents in the field is an obstacle in validating and interpreting the failed reporting patterns resulting from social network analysis.

References

[1] M. Hoeft and C. Trask, "Safety built right in: Exploring the occupational health and safety potential of bim-based platforms throughout the building lifecycle," *Sustainability*, vol. 14, no. 10, 2022, doi: 10.3390/su14106104.

[2] J. M. Kim, K. Son, S. G. Yum, and S. Ahn, "Analyzing the risk of safety accidents: The relative risks of migrant workers in construction industry," *Sustainability*, vol. 12, no. 13, pp. 1–11, 2020, doi: 10.3390/su12135430.

[3] G. Baldissone, L. Comberti, S. Bosca, and S. Murè, "The analysis and management of unsafe acts and unsafe conditions. Data collection and analysis," *Safety Science*, vol. 119, no. September 2017, pp. 240–251, 2019, doi: 10.1016/j.ssci.2018.10.006.

[4] M. Rantala, M. Lindholm, and S. Tappura, "Supporting occupational health and safety risk assessment skills: A case study of five companies," *International Journal of Environmental Research and Public Health*, vol. 19, no. 3, 2022, doi: 10.3390/ijerph19031720.

[5] N. R. Nayak, S. Kumar, D. Gupta, A. Suri, M. Naved, and M. Soni, "Network mining techniques to analyze the risk of the occupational accident via bayesian network," *International Journal of System Assurance Engineering and Management*, vol. 13, no. January, pp. 633–641, 2022, doi: 10.1007/s13198-021-01574-1.

[6] G. Hrenov, "Conceptual model for the development of OHS management in SMEs," *Proceedings of the 32nd European Safety and Reliability Conference (ESREL 2022)*, pp. 2718–2725, 2023, doi: 10.3850/978-981-18-5183-4_s18-05-625-cd.

[7] R. N. Dewi, "Occupational health and safety risk analysis using AS/NZS standard 4360:2004 in a fish meatball industry," *Journal Teknik Industri*: *Jurnal Keilmuan dan Aplikasi Teknik Industri*, vol. 25, no. 1, pp. 31–42, 2023, doi: 10.9744/jti.25.1.31-42.

[8] M. K. Buniya, I. Othman, R. Y. Sunindijo, A. F. Kineber, E. Mussi, and H. Ahmad, "Barriers to safety program implementation in the construction industry," *Ain Shams Engineering Journal*, vol. 12, no. 1, pp. 65–72, 2021, doi: 10.1016/j.asej.2020.08.002.

[9] A. Asgarian, P. Mahjour, H. Heidari, N. Khademi, K. Ghassami, and A. Mohammadbeigi, "Barriers and facilities in reporting medical errors: A systematic review study," *Adv. Hum. Biol.*, vol. 11, no. 1, p. 17, 2021, doi: 10.4103/aihb.aihb_80_20.

[10] K. Najihah, C. S. Salmira, S. Ramadhani, N. Apriani, and S. S. Hasibuan, "Identify potential dangers of unsafe action and unsafe conditions with work accidents," *Journal of Asian Multicultural Research for Medical and Health Science Study*, vol. 1, no. 2, pp. 1–23, 2020, doi: https://doi.org/10.47616/jamrmhss.v1i2.39.

[11] Z. F. Olcay, S. Temur, and A. E. Sakalli, "A research on the knowledge level and safety culture of students taking occupational health and safety course," *Cypriot Journal of Educational Sciences*, vol. 16, no. 1, pp. 187–200, 2021, doi: 10.18844/cjes.v16i1.5519.

[12] M. Duryan, H. Smyth, A. Roberts, S. Rowlinson, and F. Sherratt, "Knowledge transfer for occupational health and safety: Cultivating health and safety learning culture in construction firms," *Accident Analysis & Prevention*, vol. 139, no. January, p. 105496, 2020, doi: 10.1016/j.aap.2020.105496.

[13] T. Diah and A. P. Pratiwi, "Hubungan unsafe action dan unsafe condition terhadap kecelakaan kerja pada perawat RSUD Haji Makassar," *Jurnal Dinamika Kesehatan Masyarakat*, pp. 1–8, 2023.

[14] A. S. Sinaga *et al.*, "Unsafe condition and unsafe action risk control efforts for medical equipment repair workers at the haji general hospital Medan," *Contagion Scientific Periodical Journal of Public Health and Coastal Health*, vol. 4, no. 2, pp. 205–212, 2022.

[15] A. Rafindadi *et al.*, "Analysis of the causes and preventive measures of fatal fall-related accidents in the construction industry," *Ain Shams Engineering Journal*, vol. 13, no. 4, 2022.

[16] P. K. Marhavilas and D. E. Koulouriotis, "Risk-acceptance criteria in occupational health and safety risk-assessment—the state-of-the-art through a systematic literature review," *Safety*, vol. 7, no. 4, 2021, doi: 10.3390/safety7040077.

[17] H. Mohammadi, H. Rabiei, and S. F. Dehghan, "Editorial: Emerging technologies in occupational health and safety," *Front. Public Health*, vol. 11, 2023, doi: 10.3389/fpubh.2023.1117396.

[18] M. Abeje and F. Luo, "The Influence of safety culture and climate on safety performance: Mediating role of employee engagement in manufacturing enterprises in Ethiopia," *Sustainability*, vol. 15, no. 14, 2023, doi: 10.3390/su151411274.

[19] E. J. Tetzlaff, K. A. Goggins, A. L. Pegoraro, S. C. Dorman, V. Pakalnis, and T. R. Eger, "Safety culture: A retrospective analysis of occupational health and safety mining reports," *Safety Health Work*, vol. 12, no. 2, pp. 201–208, 2021, doi: 10.1016/j.shaw.2020.12.001.

[20] L. Yuliana and D. Ardhyaksa, "Analysis of unsafe action and unsafe condition based on occupational health and safety reporting programs," *Journal of Global Research in Public Health*, vol. 4, no. 2, pp. 78–86, 2019.
[21] L. Hou, S. Wu, G. K. Zhang, Y. Tan, and X. Wang, "Literature review of digital twins applications in constructionworkforce safety," *Appled Sciences*, vol. 11, no. 1, pp. 1–21, 2021, doi: 10.3390/app11010339.
[22] A. Kumari, R. K. Behera, K. S. Sahoo, A. Nayyar, A. Kumar Luhach, and S. Prakash Sahoo, "Supervised link prediction using structured-based feature extraction in social network," *Concurrency and Computation: Practice and Experience*, vol. 34, no. 13, 2022, doi: 10.1002/cpe.5839.
[23] G. F. Khan, M. Sarstedt, W. L. Shiau, J. F. Hair, C. M. Ringle, and M. P. Fritze, "Methodological research on partial least squares structural equation modeling (PLS-SEM): An analysis based on social network approaches," *Internet Research*, vol. 29, no. 3, pp. 407–429, 2019, doi: 10.1108/IntR-12-2017-0509.
[24] T. M. Marshall, "Risk perception and safety culture: Tools for improving the implementation of disaster risk reduction strategies," *International Journal of Disaster Risk Reduction*, vol. 47, no. February, p. 101557, 2020, doi: 10.1016/j.ijdrr.2020.101557.
[25] Y. Feng and M. T. Trinh, "Developing resilient safety culture for construction projects," *Journal of Construction Engineering and Management*, vol. 145, no. 11, 2019, doi: 10.1061/(asce)co.1943-7862.0001720.
[26] E. J. Tetzlaff, K. A. Goggins, A. L. Pegoraro, S. C. Dorman, V. Pakalnis, and T. R. Eger, "Safety culture: A retrospective analysis of occupational health and safety mining reports," *Safety and Health at Work*, vol. 12, no. 2, pp. 201–208, 2021, doi: 10.1016/j.shaw.2020.12.001.
[27] J. Zhang, J. Fu, H. Hao, G. Fu, F. Nie, and W. Zhang, "Root causes of coal mine accidents: Characteristics of safety culture deficiencies based on accident statistics," *Process Safety and Environmental Protection*, vol. 136, pp. 78–91, 2020, doi: 10.1016/j.psep.2020.01.024.
[28] K. Jilcha and D. Kitaw, "Industrial occupational safety and health innovation for sustainable development," *Engineering Science and Technology an International Journal*, vol. 20, no. 1, pp. 372–380, 2017, doi: 10.1016/j.jestch.2016.10.011.
[29] C. Tartaglia Reis, S. G. Paiva, and P. Sousa, "The patient safety culture: A systematic review by characteristics of Hospital survey on patient safety culture dimensions," *International Journal for Quality in Health Care*, vol. 30, no. 9, pp. 660–677, 2018, doi: 10.1093/intqhc/mzy080.
[30] L. Petitta, T. M. Probst, C. Barbaranelli, and V. Ghezzi, "Disentangling the roles of safety climate and safety culture: Multi-level effects on the relationship between supervisor enforcement and safety compliance," *Accident Analysis & Prevention*, vol. 99, pp. 77–89, 2017, doi: 10.1016/j.aap.2016.11.012.
[31] M. Mambwe, E. M. Mwanaumo, W. D. Thwala, and C. O. Aigbavboa, "Evaluating occupational health and safety management strategy success factors for small-scale contractors in zambia," *Sustainability*, vol. 13, no. 9, 2021, doi: 10.3390/su13094696.
[32] A. J. Al-Bayati, "Impact of construction safety culture and construction safety climate on safety behavior and safety motivation," *Safety*, vol. 7, no. 2, 2021, doi: 10.3390/SAFETY7020041.
[33] X. Zhen, J. E. Vinnem, and S. Næss, "Building safety in the offshore petroleum industry: Development of risk-based major hazard risk indicators at a national level," *Process Safety and Environmental Protection*, vol. 128, pp. 295–306, 2019, doi: 10.1016/j.psep.2019.06.006.
[34] L. Ding, F. Khan, and J. Ji, "Risk-based safety measure allocation to prevent and mitigate storage fire hazards," *Process Safety and Environmental Protection*, vol. 135, pp. 282–293, 2020, doi: 10.1016/j.psep. 2020.01.008.
[35] N. Jadidi and A. A. Bazdar, "Safety risk management in production process: A case study in the automotive supplier industry," *International Journal of Reliability, Risk & Safety Theory and Application*, vol. 3, no. 1, pp. 85–95, 2020, doi: 10.30699/ijrrs.3.1.10.
[36] Y. Jin, J. Zhang, and L. Sun, "Safety risk assessment of prefabricated building construction based on bayesian network," *IOP Conference Series: Earth and Environmental Science,* vol. 371, no. 3, 2019, doi: 10.1088/1755-1315/371/3/032052.
[37] V. D. Tran and N. M. T. Le, "Impact of service quality and perceived value on customer satisfaction and behavioral intentions: Evidence from convenience stores in Vietnam," *The Journal of Asian Finance, Economics and Business*, vol. 7, no. 9, pp. 517–526, 2020, doi: 10.13106/JAFEB.2020.VOL7.NO9.517.
[38] D. Kashmiri, F. Taherpour, M. Namian, and E. Ghiasvand, "Construction research congress 2020 809," *Constr. Res. Congr.*, vol. 007, no. 1994, pp. 809–818, 2020.
[39] Sunaryo and M. A. Hamka, "Safety risks assessment on container terminal using hazard identification and risk assessment and fault tree analysis methods," *Procedia Engineering*, vol. 194, pp. 307–314, 2017, doi: 10.1016/j.proeng.2017.08.150.
[40] E. Ilbahar, A. Karaşan, S. Cebi, and C. Kahraman, "A novel approach to risk assessment for occupational health and safety using Pythagorean fuzzy AHP & fuzzy inference system," *Safety Science*, vol. 103, no.

October 2017, pp. 124–136, 2018, doi: 10.1016/j.ssci.2017.10.025.
[41] Z. Z. Wang and C. Chen, "Fuzzy comprehensive Bayesian network-based safety risk assessment for metro construction projects," *Tunnelling and Underground Space Technology*, vol. 70, no. August, pp. 330–342, 2017, doi: 10.1016/j.tust.2017.09.012.
[42] E. R. Kabul, S. N. Ramadhan, S. Sukiman, and H. Madiistriyatno, "Analysis of safety management system implementation and occupational health based on PP No 50 Year 2012," *Eduvest - Journal of Universal Studies*, vol. 2, no. 2, pp. 196–206, 2022, doi: 10.36418/edv.v2i2.359.
[43] O. S. Tashia and J. Jamaluddin, "Evaluation of occupational health and safety management system at haji hospital Medan," *Jurnal Perilaku Kesehatan Terpadu*, vol. 2, no. 1, pp. 62–68, 2023, doi: 10.61963/jpkt.v2i1.60.
[44] R. H. Mayangkara, A. A. Subiyanto, and D. G. Tamtomo, "Implementation of hospital occupational health and safety regulations to minimize occupational accidents at the Sultan Agung Islamic Hospital, Semarang," *Journal of Health Policy and Management*, vol. 6, no. 3, pp. 160–167, 2021, doi: 10.26911/thejhpm.2021.06.03.01.
[45] A. Soltanzadeh, H. Heidari, M. Mahdinia, H. Mohammadi, A. Mohammadbeigi, and I. Mohammadfam, "Path analysis of occupational injuries based on the structural equation modeling approach: A retrospective study in the construction industry," *Iran Occup. Heal.*, vol. 16, no. 3, pp. 47–57, 2019.
[46] N. Hasanspahić, V. Frančić, S. Vujičić, and L. Maglić, "Reporting as a key element of an effective near-miss management system in shipping," *Safety*, vol. 6, no. 4, pp. 1–15, 2020, doi: 10.3390/safety6040053.
[47] J. Park, K. Kim, and Y. K. Cho, "Framework of automated construction-safety monitoring using cloud-enabled BIM and BLE mobile tracking sensors," *Journal of Construction Engineering and Management*, vol. 143, no. 2, 2017, doi: 10.1061/(asce)co.1943-7862.0001223.
[48] M. G. Gnoni and J. H. Saleh, "Near-miss management systems and observability-in-depth: Handling safety incidents and accident precursors in light of safety principles," *Safety Science*, vol. 91, pp. 154–167, 2017, doi: 10.1016/j.ssci.2016.08.012.
[49] J. Farokhzadian, N. Dehghan Nayeri, and F. Borhani, "The long way ahead to achieve an effective patient safety culture: Challenges perceived by nurses," *BMC Health Services Research*, vol. 18, no. 1, pp. 1–13, 2018, doi: 10.1186/s12913-018-3467-1.
[50] A. S. Rachma, R. Ambarwati, and M. Yani, "Comparison of Twitter users' perception of content marketing effectiveness and service quality in two online transportation," *Almana Jurnal Manajemen dan Bisnis*, vol. 7, no. 1, pp. 134–146, 2023, doi: 10.36555/almana.v7i1.2132.
[51] A. Wajahat *et al.*, "Interactively visualize and analyze social network Gephi," *2020 3rd International Conference on Computing, Mathematics and Engineering Technologies iCoMET 2020*, no. January 2021, 2020, doi: 10.1109/iCoMET48670.2020.9073812.
[52] P. Svec, L. Benko, M. Kadlecik, J. Kratochvil, and M. Munk, "Web usage mining: Data pre-processing impact on found knowledge in predictive modelling," *Procedia Computer Science*, vol. 171, no. 2019, pp. 168–178, 2020, doi: 10.1016/j.procs.2020.04.018.
[53] G. Yunanda, D. Nurjanah, and S. Meliana, "Recommendation system from microsoft news data using tf-idf and cosine similarity methods," *Building of Informatics, Technology and Science*, vol. 4, no. 1, pp. 277–284, 2022, doi: 10.47065/bits.v4i1.1670.
[54] S. Sakthi Vel, "Pre-Processing techniques of text mining using computational linguistics and python libraries," *Proceedings International Conference on Artificial Intelligence Smart Systems ICAIS 2021*, no. March, pp. 879–884, 2021, doi: 10.1109/ICAIS50930.2021.9395924.
[55] N. Shelke, S. Chaudhury, S. Chakrabarti, S. L. Bangare, G. Yogapriya, and P. Pandey, "An efficient way of text-based emotion analysis from social media using LRA-DNN," *Neuroscience Informatics*, vol. 2, no. 3, p. 100048, 2022, doi: 10.1016/j.neuri.2022.100048.
[56] J. R. Saura, D. Palacios-Marqués, and D. Ribeiro-Soriano, "Using data mining techniques to explore security issues in smart living environments in Twitter," *Computer Communications*, vol. 179, no. July, pp. 285–295, 2021, doi: 10.1016/j.comcom.2021.08.021.
[57] Z. Hou, F. Cui, Y. Meng, T. Lian, and C. Yu, "Opinion mining from online travel reviews: A comparative analysis of Chinese major OTAs using semantic association analysis," *Tourism Management*, vol. 74, no. January, pp. 276–289, 2019, doi: 10.1016/j.tourman.2019.03.009.
[58] M. Jacomy, T. Venturini, S. Heymann, and M. Bastian, "ForceAtlas2, a continuous graph layout algorithm for handy network visualization designed for the Gephi software," *PLoS One*, vol. 9, no. 6, pp. 1–12, 2014, doi: 10.1371/journal.pone.0098679.
[59] H. S. Lee and W. S. Lee, "Network connectedness among Northeast Asian financial markets," *Emerging Markets Finance and Trade*, vol. 56, no. 13, pp. 2945–2962, 2020, doi: 10.1080/1540496X.2019.1668267.
[60] A. K. Shaikh, M. Al-Shamli, and A. Nazir, "Designing a relational model to identify relationships

between suspicious customers in anti-money laundering (AML) using social network analysis (SNA)," *Journal of Big Data*, vol. 8, no. 1, 2021, doi: 10.1186/s40537-021-00411-3.

[61] J. Vassey *et al.*, "E-cigarette brands and social media influencers on Instagram: a social network analysis," *Tobacco Control*, 2022, doi: 10.1136/tobaccocontrol-2021-057053.

[62] M. Valeri and R. Baggio, "Social network analysis: Organizational implications in tourism management," *International Journal of Organizational Analysis*, vol. 29, no. 2, pp. 342–353, 2021, doi: 10.1108/IJOA-12-2019-1971.

[63] X. Kong, Y. Shi, S. Yu, J. Liu, and F. Xia, "Academic social networks: Modeling, analysis, mining and applications," *Journal of Network and Computer Applications*, vol. 132, no. February, pp. 86–103, 2019, doi: 10.1016/j.jnca.2019.01.029.

[64] F. A. Nurjanah, R. Ambarwati, and H. M. K. Sari, "Analysis of cashback promotion in the fintech industry among user interaction," *Jurnal Fokus Manajemen Bisnis*, vol. 13, no. 2, pp. 152–163, 2023, doi: 10.12928/fokus.v13i2.8515.

[65] M. P. Ramadani, R. Ambarwati, and M. Hariasih, "Online travel agent marketing strategy through social interaction during the pandemic COVID-19," *Jurnal Sisfokom (Sistem Informasi dan Komputer)*, vol. 12, no. 2, pp. 169–177, 2023, doi: 10.32736/sisfokom.v12i2.1553.

[66] S. P. Anjania and R. Ambarwati, "Analysis of the credibility of utilizing brand ambassador to compete between shopee and Tokopedia using social network analysis on Twitter," *Jurnal Manajemen (Edisi Elektronik)*, vol. 14, no. 3, pp. 391–404, 2023, doi: 10.32832/jm-uika.v14i3.13777.

[67] A. Ghahramani and A. Amirbahmani, "A qualitative investigation to discover causes of occupational injuries and preventive countermeasures in manufacturing companies," *Heliyon*, vol. 8, no. 9, p. e10501, 2022, doi: 10.1016/j.heliyon.2022.e10501.