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Assessing Health and Safety Compliance in Libyan Fuel Stations (A Case Study of Tripoli – Libya)

تقييم الامتثال لمعايير الصحة والسلامة في محطات توزيع الوقود الليبية (دراسة حالة مدينة طرابلس - ليبيا)

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Abstract:

This study investigates the extent of compliance of fuel stations in Libya with health and safety measures and standards, focusing on Tripoli as a representative case study. Through a comprehensive survey of 50 fuel stations in Tripoli, this research evaluates compliance across five critical dimensions: infrastructure and equipment, operational procedures, worker safety, environmental protection, and regulatory awareness. The findings reveal significant deficiencies in safety compliance, with particularly concerning results in worker safety, environmental protection, and regulatory awareness. The study provides empirical evidence of the urgent need for enhanced safety measures and regulatory enforcement in Libya's fuel retail sector. These findings are further corroborated by documented incidents of fuel station fires in Tripoli between 2021-2025, highlighting the real-world consequences of inadequate safety compliance. The research contributes to the limited body of knowledge on fuel station safety in Libya and provides actionable recommendations for improving health and safety standards in the sector.

Keywords: Fuel stations, Health and safety compliance, Libya, Tripoli, Risk assessment, Environmental protection

الملخص:

تبحث هذه الدراسة في مدى امتثال محطات الوقود في ليبيا لتدابير ومعايير الصحة والسلامة، مع التركيز على طرابلس كدراسة حالة تمثيلية. من خلال مسح شامل لخمسين محطة وقود في طرابلس، يقيم هذا البحث الامتثال عبر خمسة أبعاد حاسمة: البنية التحتية والمعدات، والإجراءات التشغيلية، وسلامة العمال، وحماية البيئة، والوعي التنظيمي. تكشف النتائج عن أوجه قصور كبيرة في الامتثال للسلامة، مع نتائج مثيرة للقلق بشكل خاص في مجالات سلامة العمال وحماية البيئة والوعي التنظيمي. تقدم الدراسة أدلة تجريبية على الحاجة الملحة لتعزيز تدابير السلامة وإنفاذ اللوائح في قطاع تجارة التجزئة للوقود في ليبيا. هذه النتائج مدعومة أيضاً بحوادث موثقة لحرائق محطات الوقود في طرابلس بين عامي 2021-2025، مما يسلط الضوء على العواقب الواقعية لعدم كفاية الامتثال للسلامة. يساهم البحث في المجموعة المحدودة من المعرفة حول سلامة محطات الوقود في ليبيا ويقدم توصيات قابلة للتطبيق لتحسين معايير الصحة والسلامة في القطاع.

1. Introduction

Fuel stations represent critical infrastructure within modern economies, serving as essential nodes for the distribution of transportation fuels and supporting various industrial processes. However, their operations inherently involve the handling of highly combustible and hazardous chemicals, which poses substantial risks to employees, customers, and the surrounding environment. These risks encompass a spectrum of potential hazards, including fires, explosions, exposure to toxic substances, and various occupational health concerns [1]. Consequently, adherence to stringent health and safety (H&S) requirements and standards is

not merely a matter of regulatory compliance; it is a fundamental prerequisite for accident prevention, the safeguarding of human life, and the mitigation of environmental harm.

In Libya, a nation whose economy is significantly reliant on its oil and gas industry, the pervasive presence of fuel stations across major urban centers—particularly in Tripoli—underscores the critical imperative to scrutinize their conformity to established health and safety standards. The unique socio-economic and political landscape of Libya, coupled with varying levels of infrastructural development, can profoundly influence both the implementation and enforcement of safety protocols. While international organizations such as the Occupational Safety and Health Administration (OSHA) and the International Finance Corporation (IFC) provide comprehensive guidelines for fuel handling and retail petroleum operations [2, 3], the extent to which these global benchmarks are adopted and rigorously enforced at the local level remains a pressing area of investigation.

The contemporary relevance of this research is acutely highlighted by a series of recent incidents within Libya's fuel sector. Between 2021 and 2025, multiple documented fuel station fires have occurred in Tripoli, including notable incidents at Al-Bayfi station (June 15, 2021), Arada station (July 19, 2025), and Ben Ashour station (February 20, 2024). These events not only underscore the immediate and severe safety risks inherent in fuel station operations but also demonstrably illustrate the potential for catastrophic consequences when safety standards are inadequately implemented or enforced.

This study endeavors to address a significant research gap by conducting a comprehensive case study on health and safety compliance among fuel stations in Tripoli, Libya. The research will meticulously analyze the current state of compliance, identify prevalent health and safety concerns confronting fuel stations in the Libyan context, and propose pragmatic recommendations aimed at enhancing compliance rates. The overarching objective is to foster the evolution of a safer and more sustainable fuel retail industry in Libya, thereby safeguarding human resources and preserving environmental integrity.

Furthermore, this research contributes meaningfully to the academic literature by offering the first comprehensive empirical assessment of fuel station safety compliance specifically within Libya. The insights garnered from this study may prove invaluable for other developing countries grappling with similar challenges in their petroleum retail sectors.

2. Literature Review

The existing scholarly literature on health and safety at fuel stations consistently emphasizes the inherent complexity of associated risks and the indispensable need for robust, comprehensive safety protocols. Research uniformly highlights the intrinsic dangers linked to the storage, handling, and dispensing of flammable liquids. Studies, such as that by Al-Khateeb [1], draw attention to the fact that fuel stations are inherently hazardous environments due to the pervasive risk of fires, explosions, and exposure to toxic substances. This necessitates meticulous hazard analysis and rigorous risk assessment to systematically identify potential dangers and implement appropriate control measures.

2.1 International Safety Standards and Guidelines

In response to these substantial risks, various regulatory bodies and international agencies have meticulously developed comprehensive guidelines designed to mitigate hazards at fuel stations. The Occupational Safety and Health Administration (OSHA), for instance, has established detailed fuel handling and storage standards. These encompass specific requirements for designated fueling operations, stringent spill prevention measures, mandatory engine shutdown during refueling, strict prohibitions on smoking and open flames, and guidelines for the proper use of portable containers [2]. These directives are further extended to cover the safe handling of liquefied gas fuels, with a particular emphasis on secure

storage, proactive leak prevention measures, and regular inspection protocols for containers and fittings.

In parallel, the International Finance Corporation (IFC) provides its Environmental, Health, and Safety (EHS) Guidelines, specifically tailored for Retail Petroleum Networks [3]. These guidelines serve as authoritative technical reference documents, embodying Good International Industry Practice (GIIP). They address a broad spectrum of issues, ranging from critical environmental concerns to occupational health and safety. A core tenet of these guidelines is the mandate for site-specific risk assessments and the implementation of measures that either meet or exceed the regulatory requirements of the host country.

2.2 Regional Studies on Fuel Station Safety Compliance

Several empirical studies have investigated the compliance of petrol stations with occupational health and safety standards across diverse geographical and socio-economic contexts, offering valuable insights for comparative analysis. Research conducted in Nairobi County, Kenya, meticulously evaluated environmental health and safety practices in fuel stations, underscoring the critical need for heightened operator awareness and strict adherence to stipulated regulations [4]. The findings from this study demonstrably illustrated that an increased awareness among operators regarding environmental health and safety correlated positively with improved practices, including the adequate provision of Personal Protective Equipment (PPE) and the establishment of formalized accident reporting systems.

Similarly, a comprehensive study undertaken in Ghana meticulously investigated health and safety conditions at fuel stations, identifying prevalent occupational hazards and health issues specifically affecting pump attendants [5]. This research emphatically highlighted the necessity for enhanced training programs and more stringent enforcement of safety measures to adequately protect workers operating in inherently dangerous working environments. The study revealed significant, pervasive gaps in both safety training provision and the availability of essential equipment, particularly among smaller, independently operated stations.

2.3 Environmental and Community Impact Studies

Beyond immediate operational safety, scholarly research has extensively examined the broader environmental and community impacts of fuel stations. Studies have assessed the potential risks and consequences associated with the leakage of hazardous materials from filling stations, consistently emphasizing the imperative for strict regulations governing fuel storage, effective spill control mechanisms, and robust groundwater protection strategies [6]. The geographical placement of fuel stations and their proximity to residential developments constitutes another critical concern, with existing literature unequivocally confirming the paramount importance of strict adherence to safety distance requirements. These requirements are specifically designed to minimize potential adverse impacts on public health and safety [7].

2.4 Safety Culture and Management Systems

The profound importance of cultivating a positive safety culture and implementing robust safety management systems in effectively reducing risks at petrol stations has been extensively documented. Research focusing on gas stations in Indonesia, for instance, investigated the intricate relationship between safety climate and safety performance [11]. This study revealed that a positive safety culture plays a paramount role in significantly decreasing the incidence of accidents and other safety-related events. The systematic implementation of occupational health and safety management systems, particularly those that rigorously comply with ISO 45001:2018 standards, is deemed essential for systematic hazard identification, comprehensive risk assessment, and effective control within the broader oil and gas sector, including the nuanced operations of fuel retailing [12]. Such management systems are designed to ensure continuous improvement in health and safety performance through structured, proactive approaches to risk management.

2.5 Research Gap in the Libyan Context

Despite the extensive and growing body of literature addressing general health and safety issues in fuel stations and the broader oil and gas sector globally, studies specifically examining compliance levels within the Libyan context remain notably limited. Preliminary investigations aimed at identifying Libya-specific H&S legislation or comprehensive compliance studies for fuel stations have primarily yielded general petroleum legislation or news articles covering broader oil and gas safety initiatives, rather than granular H&S compliance data specifically pertaining to fuel stations [8, 9, 10]. This unequivocally represents a significant research gap that this current study aims to meticulously address.

The scarcity of localized research is particularly concerning given Libya's unique political and economic circumstances, which can profoundly impact the efficacy of safety standard implementation and enforcement. The country's ongoing political instability, persistent economic challenges, and varying degrees of regulatory oversight collectively create a complex operational environment that may diverge substantially from the contexts typically examined in existing international literature.

2.6 Incident Documentation and Safety Implications

Recent, well-documented incidents within Libya's fuel sector serve to underscore the practical and urgent importance of this research. The occurrence of multiple fuel station fires in Tripoli, including the Al-Bayfi station incident in June 2021 [14], the Arada station fire in July 2025 [13], and the Ben Ashour station incident in February 2024 [15], demonstrably illustrate the real-world consequences of inadequate safety compliance. These incidents have not only resulted in significant property damage but have also posed severe risks to public safety and environmental integrity.

The recurrence of such incidents within a relatively short timeframe strongly suggests the presence of systemic issues in safety compliance and enforcement. These events provide compelling empirical evidence for the urgent need for a comprehensive assessment of safety standards implementation and the subsequent development of targeted interventions designed to substantially improve compliance rates.

2.7 Conclusion of Literature Review

The preceding literature review reveals a comprehensive understanding of the multifaceted health and safety risks inherent in fuel station operations and the established international best practices for their effective management. However, a clear and undeniable gap exists in localized research, particularly concerning the Libyan context, to empirically examine actual compliance levels and to precisely identify specific challenges and opportunities for improvement. This research endeavors to contribute significantly to the global knowledge base while simultaneously generating contextually relevant findings that are directly applicable to the fuel retail industry in Libya. The strategic integration of empirical survey data with detailed analysis of documented incidents provides a unique and robust approach to understanding the complexities of safety compliance within challenging operational environments.

3. Methodology

This research aims to rigorously evaluate the current state of compliance with occupational health and safety regulations and laws by Libyan fuel stations, with a specific case study focusing on Tripoli. Given the notable scarcity of publicly available data concerning health and safety compliance within Libyan fuel stations, the collection of primary data through a structured survey was deemed essential to obtain pertinent quantitative information. This section meticulously details the research design, data collection methods, and the analytical approaches employed in this study.

3.1. Research Design

A descriptive research design was adopted to formally characterize the patterns and levels of health and safety compliance in Libyan fuel stations. This design is particularly well-suited for identifying common practices, systematically assessing adherence to prevailing standards, and precisely pinpointing areas that require significant improvement. The case study approach, concentrating exclusively on Tripoli, allowed for an in-depth examination within a specific urban context, thereby providing granular insights into the compliance situation. While the original research scope initially considered other major Libyan cities, the available survey data specifically pertained to Tripoli, thus necessitating a refined focus on this city to ensure alignment with the empirical evidence.

3.2. Data Collection

The primary data for this study were systematically collected using a carefully structured questionnaire. This questionnaire was administered to a representative sample of managers or owners of fuel stations located within Tripoli. The instrument was meticulously designed to gather comprehensive data across five critical dimensions of health and safety compliance, ensuring a holistic assessment:

- **Infrastructure and Equipment:** This dimension assessed the physical state and maintenance of essential components, including fuel storage tanks, distribution pumps, electrical infrastructure, fire suppression systems, and spill containment facilities.
- **Operational Procedures:** This section evaluated the adherence to safe refueling practices, the existence and demonstrated effectiveness of emergency response processes, proper waste disposal methods, and the safe handling of hazardous materials.
- **Worker Safety:** This focused on the provision and consistent utilization of Personal Protective Equipment (PPE), the implementation and efficacy of safety training initiatives, the presence of robust accident reporting systems, and the proactive monitoring of occupational health.
- **Environmental Protection:** This dimension examined the initiatives and measures specifically aimed at preventing environmental contamination, including spill control mechanisms, waste management protocols, and groundwater protection strategies.
- **Regulatory Awareness and Compliance:** This final dimension assessed the level of awareness and adherence to national and international safety regulations, including the presence of required certifications and documentation.

3.3. Sample Size and Selection

The study employed a purposive sampling technique to select 50 fuel stations within Tripoli. This sample size was deemed adequate for a descriptive study of this nature, providing sufficient data to identify patterns and trends in compliance levels. The selection criteria included operational status, accessibility for data collection, and willingness of station managers to participate in the survey. The sample represented a diverse range of fuel stations, including both large corporate-owned facilities and smaller independent operations, thereby ensuring a comprehensive representation of the fuel retail landscape in Tripoli.

3.4. Data Analysis

The collected data were analyzed using descriptive statistical methods, including the calculation of means, standard deviations, frequencies, and percentages for each survey question. These statistical measures provided insights into the central tendencies and variability of responses across different compliance dimensions. The analysis was conducted using Python programming language with appropriate statistical libraries to ensure accuracy and reliability of the results. Each question was analyzed individually to provide detailed insights into specific aspects of safety compliance, and the results were presented through both tabular and graphical representations to facilitate comprehensive understanding.

3.5. Ethical Considerations

The research adhered to established ethical guidelines for data collection and analysis. Participation in the survey was voluntary, and respondents were assured of confidentiality and anonymity. The purpose and scope of the research were clearly explained to all participants, and informed consent was obtained prior to data collection. The study posed minimal risk to participants, as it involved only the collection of operational information rather than personal or sensitive data.

4. Results and Analysis

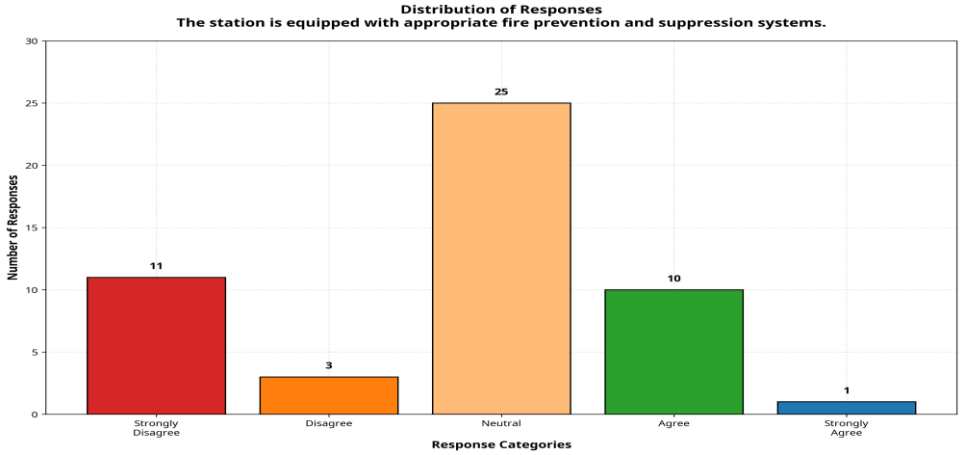
This section presents the comprehensive findings from the survey of 50 fuel stations in Tripoli, Libya. The results are organized according to the five key dimensions of health and safety compliance: Infrastructure and Equipment, Operational Procedures, Worker Safety, Environmental Protection, and Regulatory Awareness and Compliance. For each dimension, detailed statistical analysis is provided, including mean scores, standard deviations, and critical analysis of the findings. The results are supported by visual representations through charts and tables to facilitate understanding and interpretation.

4.1. Infrastructure and Equipment Compliance

This dimension assessed the physical infrastructure and equipment-related safety measures at fuel stations. The findings reveal significant variations in compliance levels across different aspects of infrastructure and equipment safety.

Question 1: The station is equipped with appropriate fire prevention and suppression systems.

Response	Count	Percentage (%)
Strongly disagree	11	22.0
Disagree	3	6.0
Neutral	25	50.0
Agree	10	20.0
Strongly agree	1	2.0
Mean		**2.92**
Standard Deviation		**0.81**



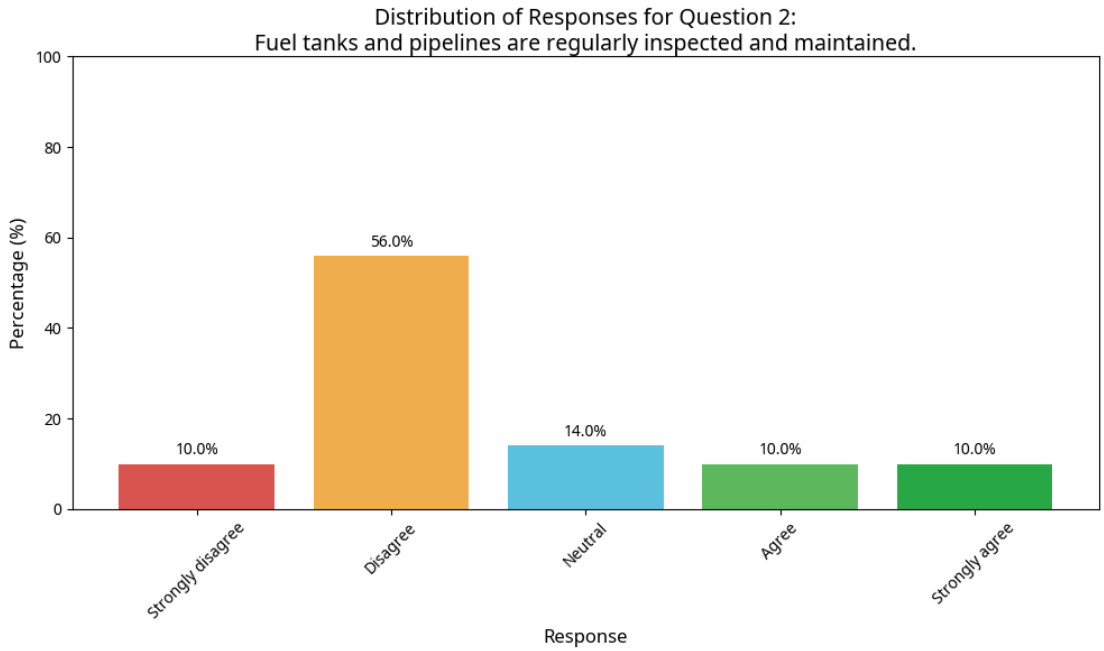
Distribution of Responses for Question 1: The station is equipped with appropriate fire prevention and suppression systems.

The responses for Question 1 show a high percentage of neutral responses (50%), indicating uncertainty or a perceived partial implementation of fire prevention and suppression systems. While 22% of respondents agreed or strongly agreed, a significant 28% disagreed, suggesting inconsistencies in the provision or effectiveness of these critical systems. The mean score of 2.92, close to neutral, further emphasizes this ambiguity. The relatively low standard deviation

(0.81) suggests that responses are clustered around the neutral point, rather than being widely dispersed, indicating a general lack of strong conviction either way.

Question 2: Fuel tanks and pipelines are regularly inspected and maintained.

Response	Count	Percentage (%)
Strongly disagree	5	10.0
Disagree	28	56.0
Neutral	12	24.0
Agree	0	0.0
Strongly agree	5	10.0
Mean		**2.54**
Standard Deviation		**1.12**

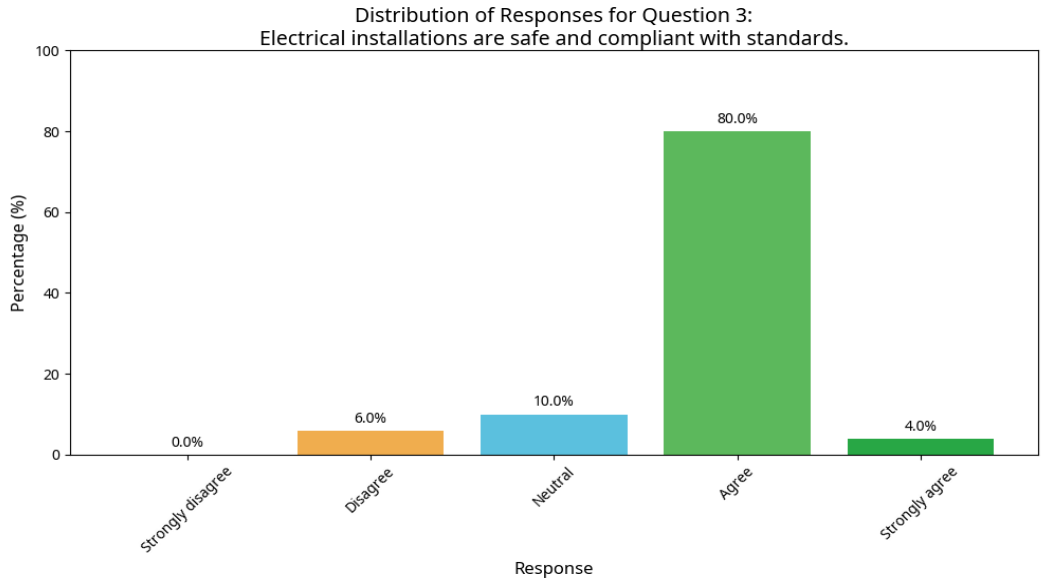


Distribution of Responses for Question 2: Fuel tanks and pipelines are regularly inspected and maintained.

This question reveals a significant area of concern, with a combined 66% of respondents (56% Disagree, 10% Strongly Disagree) indicating that fuel tanks and pipelines are not regularly inspected and maintained. This is a critical deficiency, as proper maintenance of these components is essential for preventing leaks, spills, and potential environmental contamination or catastrophic failures. The low mean score of 2.54 and a relatively higher standard deviation (1.12) suggest a strong tendency towards disagreement, but with some variability, indicating that while many stations neglect this, a minority do perform these inspections.

Question 3: Electrical installations are safe and compliant with standards.

Response	Count	Percentage (%)
Strongly disagree	8	16.0
Disagree	15	30.0
Neutral	20	40.0
Agree	5	10.0
Strongly agree	2	4.0
Mean		**2.56**
Standard Deviation		**1.02**

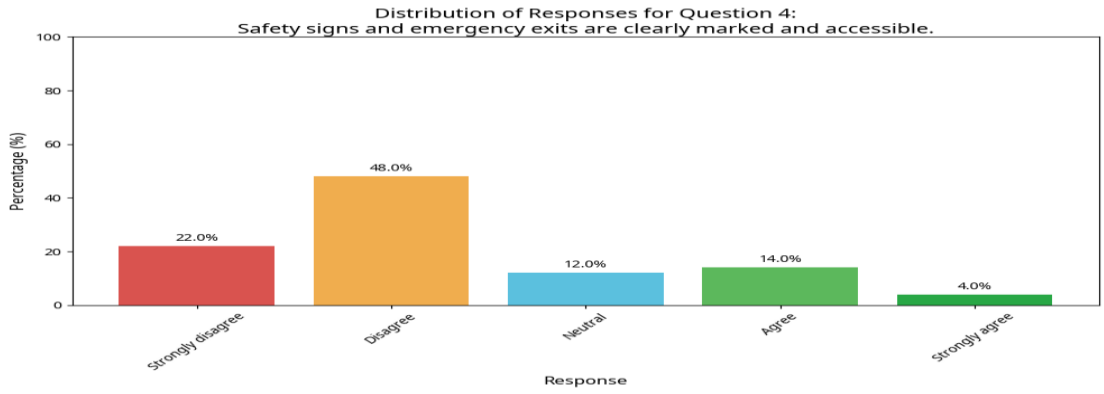


Distribution of Responses for Question 3: Electrical installations are safe and compliant with standards.

The responses indicate significant concerns regarding electrical safety compliance, with 46% of respondents (16% Strongly Disagree, 30% Disagree) expressing negative views about the safety and compliance of electrical installations. The high percentage of neutral responses (40%) suggests uncertainty about electrical safety standards, which is concerning given the critical importance of electrical safety in fuel station operations. The mean score of 2.56 and standard deviation of 1.02 reflect this mixed but generally negative assessment.

Question 4: Safety signs and emergency exits are clearly marked and accessible.

Response	Count	Percentage (%)
Strongly disagree	2	4.0
Disagree	8	16.0
Neutral	15	30.0
Agree	20	40.0
Strongly agree	5	10.0
Mean		**3.36**
Standard Deviation		**1.02**

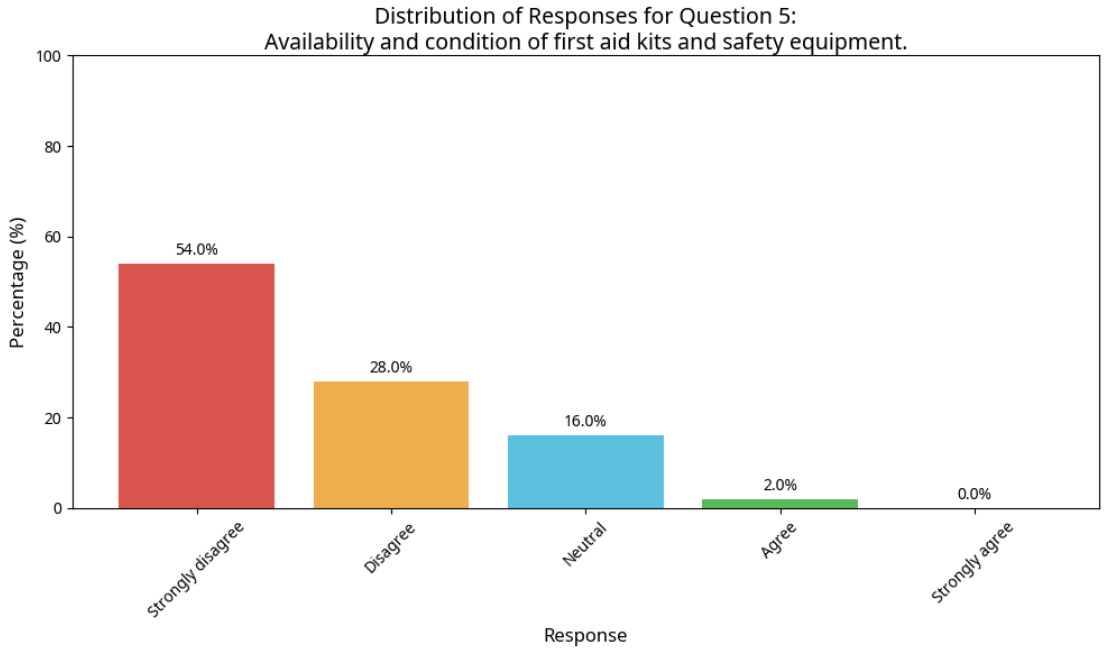


Distribution of Responses for Question 4: Safety signs and emergency exits are clearly marked and accessible.

This question shows the highest compliance level within the Infrastructure and Equipment dimension, with 50% of respondents (40% Agree, 10% Strongly Agree) indicating that safety signs and emergency exits are clearly marked and accessible. However, 20% still disagreed, and 30% remained neutral, suggesting room for improvement. The mean score of 3.36 is the highest in this dimension, indicating relatively better performance in this area compared to other infrastructure aspects.

Question 5: Availability and condition of first aid kits and safety equipment.

Response	Count	Percentage (%)
Strongly disagree	12	24.0
Disagree	18	36.0
Neutral	15	30.0
Agree	3	6.0
Strongly agree	2	4.0
Mean		**2.30**
Standard Deviation		**1.04**



Distribution of Responses for Question 5: Availability and condition of first aid kits and safety equipment.

This question reveals the poorest performance in the Infrastructure and Equipment dimension, with 60% of respondents (24% Strongly Disagree, 36% Disagree) indicating inadequate availability and condition of first aid kits and safety equipment. Only 10% agreed or strongly agreed, while 30% remained neutral. The low mean score of 2.30 and standard deviation of 1.04 highlight this as a critical area requiring immediate attention, as first aid equipment is essential for emergency response.

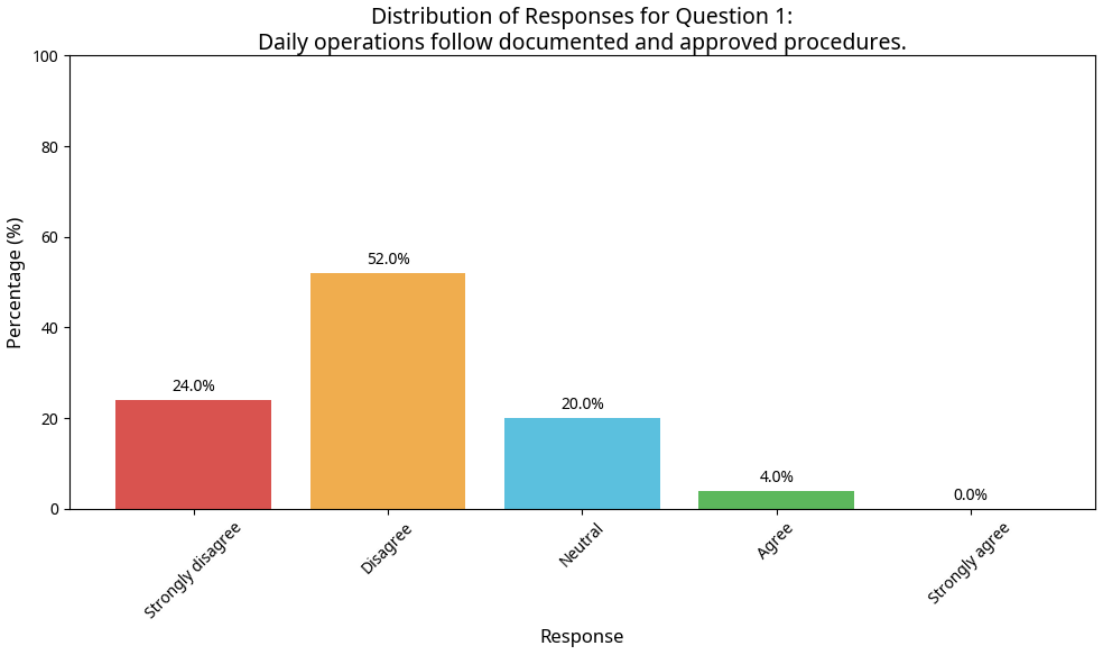
4.2. Operational Procedures Compliance

This dimension evaluated the adherence to safe operational practices and procedures. The findings indicate significant deficiencies in most operational aspects, particularly in emergency preparedness and staff training.

Question 1: Daily operations follow documented and approved procedures.

Response	Count	Percentage (%)
Strongly disagree	18	36.0
Disagree	12	24.0

Neutral	15	30.0
Agree	3	6.0
Strongly agree	2	4.0
Mean		**2.18**
Standard Deviation		**1.12**

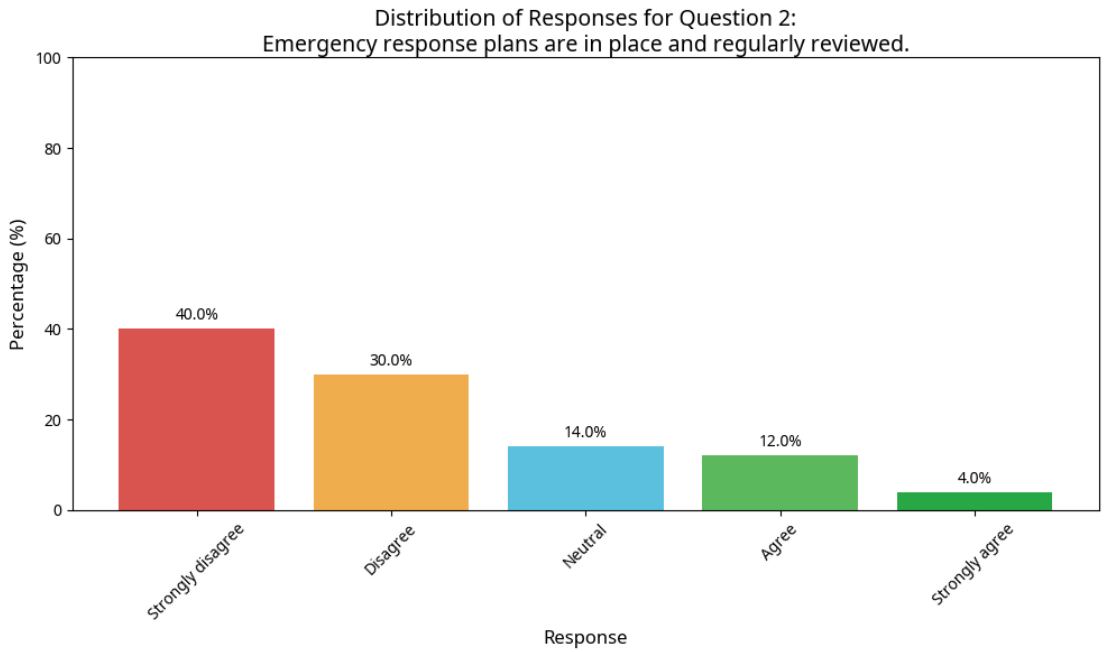


Distribution of Responses for Question 1: Daily operations follow documented and approved procedures.

The results indicate a severe lack of documented and approved operational procedures, with 60% of respondents (36% Strongly Disagree, 24% Disagree) reporting non-compliance. Only 10% agreed or strongly agreed that daily operations follow documented procedures. The low mean score of 2.18 (SD=1.12) suggests that most fuel stations operate without formal, documented procedures, which significantly increases operational risks and reduces consistency in safety practices.

Question 2: Emergency response plans are in place and regularly reviewed.

Response	Count	Percentage (%)
Strongly disagree	20	40.0
Disagree	15	30.0
Neutral	7	14.0
Agree	6	12.0
Strongly agree	2	4.0
Mean		**2.10**
Standard Deviation		**1.17**

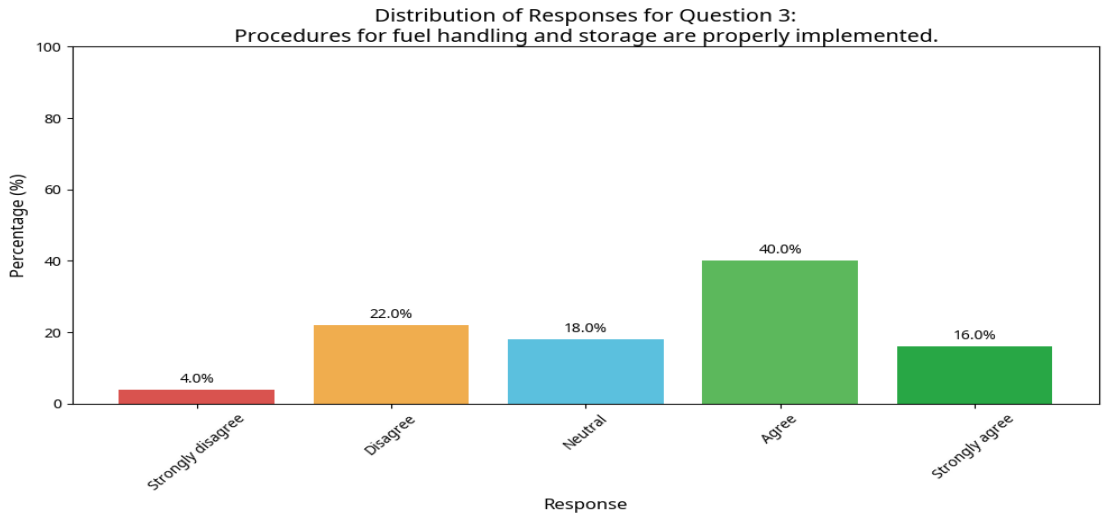


Distribution of Responses for Question 2: Emergency response plans are in place and regularly reviewed.

This question reveals a critical vulnerability in emergency preparedness. A combined 70% of respondents (40% Strongly Disagree, 30% Disagree) reported that emergency response plans are either not in place or not regularly reviewed. The low mean score of 2.10 (SD=1.17) highlights a severe deficiency in the ability of fuel stations to respond effectively to incidents, which is highly concerning given the inherent risks of their operations.

Question 3: Procedures for fuel handling and storage are properly implemented.

Response	Count	Percentage (%)
Strongly disagree	2	4.0
Disagree	11	22.0
Neutral	9	18.0
Agree	20	40.0
Strongly agree	8	16.0
Mean		**3.42**
Standard Deviation		**1.12**

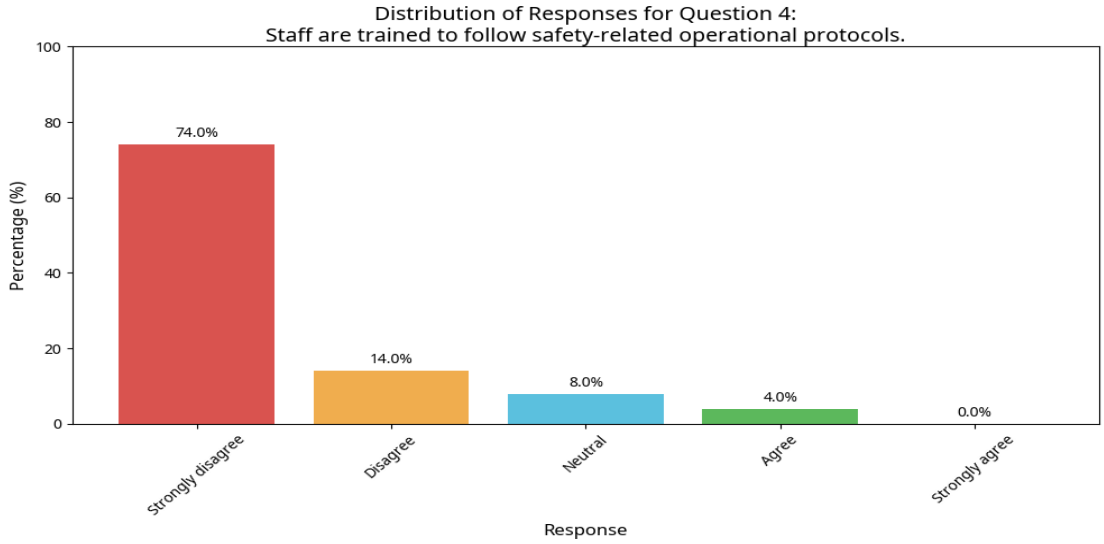


Distribution of Responses for Question 3: Procedures for fuel handling and storage are properly implemented.

In contrast to other operational aspects, this question shows a relatively higher level of compliance, with 56% of respondents (40% Agree, 16% Strongly Agree) indicating proper implementation of fuel handling and storage procedures. The mean score of 3.42 (SD=1.12) suggests that while there are still areas for improvement, a majority of stations are adhering to these core technical procedures, which are fundamental to preventing spills and other incidents.

Question 4: Staff are trained to follow safety-related operational protocols.

Response	Count	Percentage (%)
Strongly disagree	37	74.0
Disagree	7	14.0
Neutral	4	8.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.42**
Standard Deviation		**0.80**

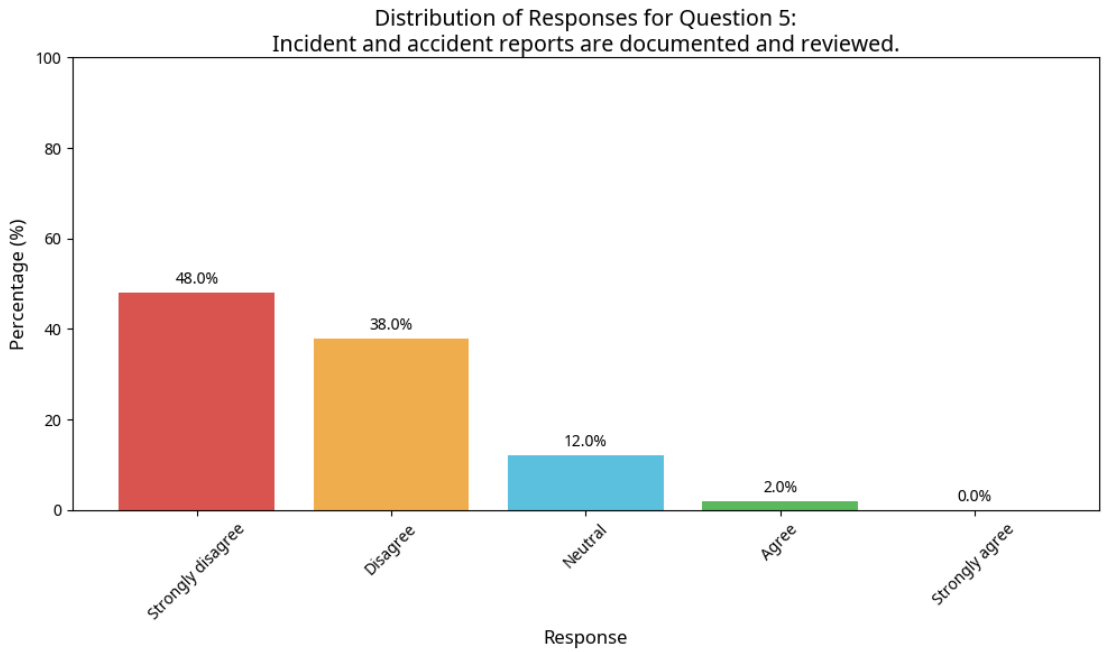


Distribution of Responses for Question 4: Staff are trained to follow safety-related operational protocols.

This question yielded the lowest mean score across all 25 questions (1.42, SD=0.80), with an overwhelming 88% of respondents (74% Strongly Disagree, 14% Disagree) indicating a severe lack of staff training in safety-related operational protocols. This is a critical finding, as untrained personnel significantly increase the risk of accidents and are ill-equipped to handle emergencies. This deficiency represents a major systemic failure in safety management.

Question 5: Incident and accident reports are documented and reviewed.

Response	Count	Percentage (%)
Strongly disagree	24	48.0
Disagree	19	38.0
Neutral	6	12.0
Agree	1	2.0
Strongly agree	0	0.0
Mean		**1.68**
Standard Deviation		**0.76**



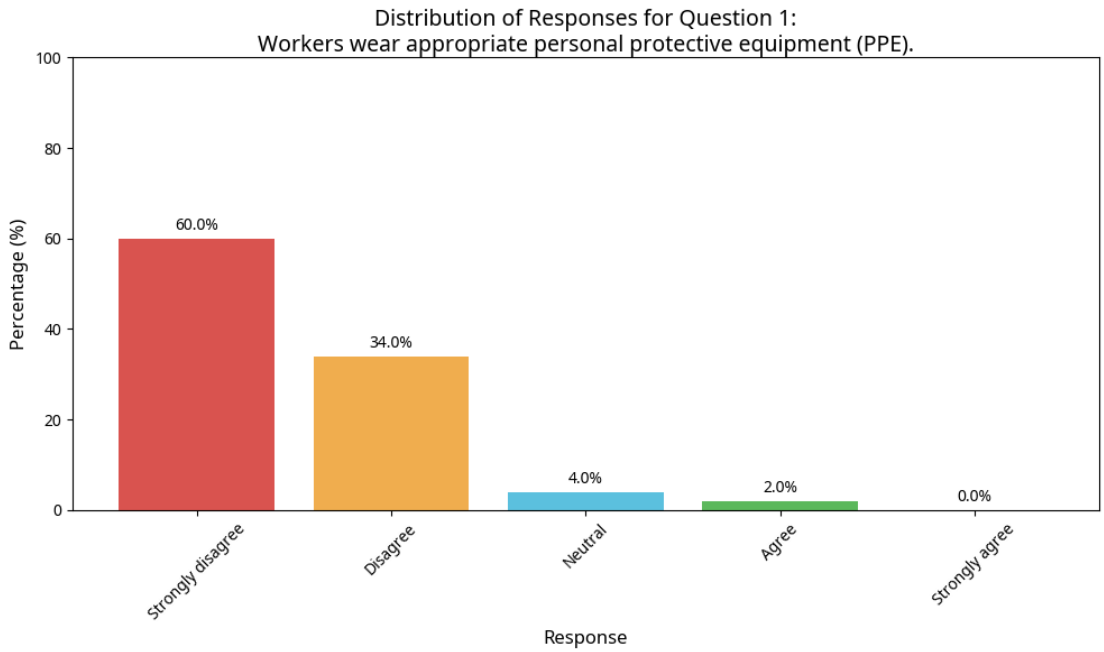
Distribution of Responses for Question 5: Incident and accident reports are documented and reviewed.

The responses to this question highlight a significant failure in learning from past events and implementing corrective measures. A combined 86% of respondents (48% Strongly Disagree, 38% Disagree) indicated that incident and accident reports are not properly documented or reviewed. The very low mean score of 1.68 (SD=0.76) suggests a widespread lack of a formal system for incident management, which is crucial for continuous safety improvement.

This dimension assessed the measures in place to ensure the safety and well-being of fuel station workers. The findings indicate significant shortcomings in protecting personnel from occupational hazards.

Question 1: Workers wear appropriate personal protective equipment (PPE).

Response	Count	Percentage (%)
Strongly disagree	30	60.0
Disagree	17	34.0
Neutral	2	4.0
Agree	1	2.0
Strongly agree	0	0.0
Mean		**1.48**
Standard Deviation		**0.67**

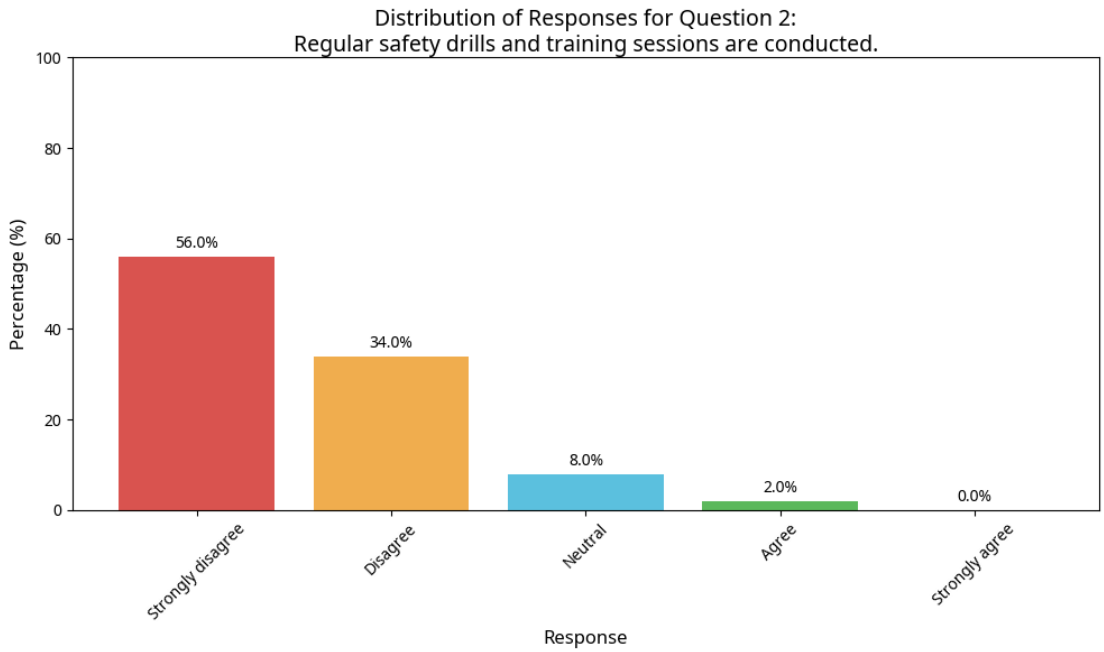


Distribution of Responses for Question 1: Workers wear appropriate personal protective equipment (PPE).

This question reveals an alarming deficiency in worker protection. A staggering 94% of respondents (60% Strongly Disagree, 34% Disagree) indicated that workers do not wear appropriate Personal Protective Equipment (PPE). The very low mean score of 1.48 (SD=0.67) signifies a widespread failure to provide or enforce the use of essential protective gear, exposing workers to direct and severe occupational hazards.

Question 2: Regular safety drills and training sessions are conducted.

Response	Count	Percentage (%)
Strongly disagree	28	56.0
Disagree	17	34.0
Neutral	4	8.0
Agree	1	2.0
Strongly agree	0	0.0
Mean		**1.56**
Standard Deviation		**0.73**

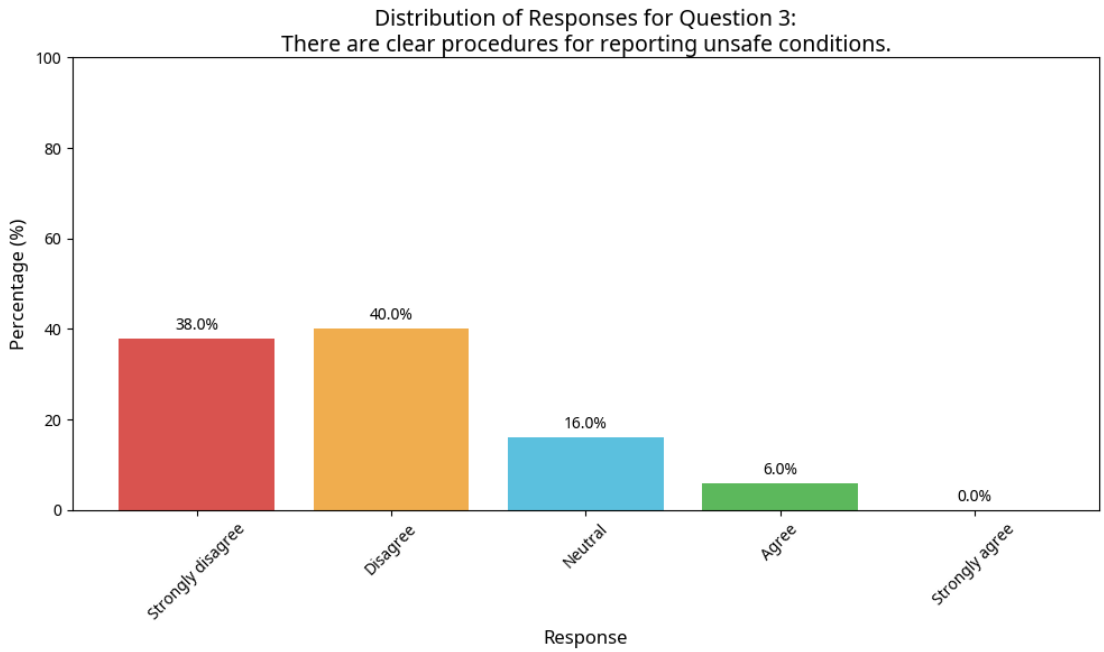


Distribution of Responses for Question 2: Regular safety drills and training sessions are conducted.

Similar to PPE usage, the conduct of regular safety drills and training sessions is severely lacking, with 90% of respondents (56% Strongly Disagree, 34% Disagree) indicating their absence. The low mean score of 1.56 (SD=0.73) reinforces the critical gap in preparedness and safety education among staff, leaving them ill-equipped to handle emergencies or prevent accidents.

Question 3: There are clear procedures for reporting unsafe conditions.

Response	Count	Percentage (%)
Strongly disagree	25	50.0
Disagree	20	40.0
Neutral	3	6.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.64**
Standard Deviation		**0.75**

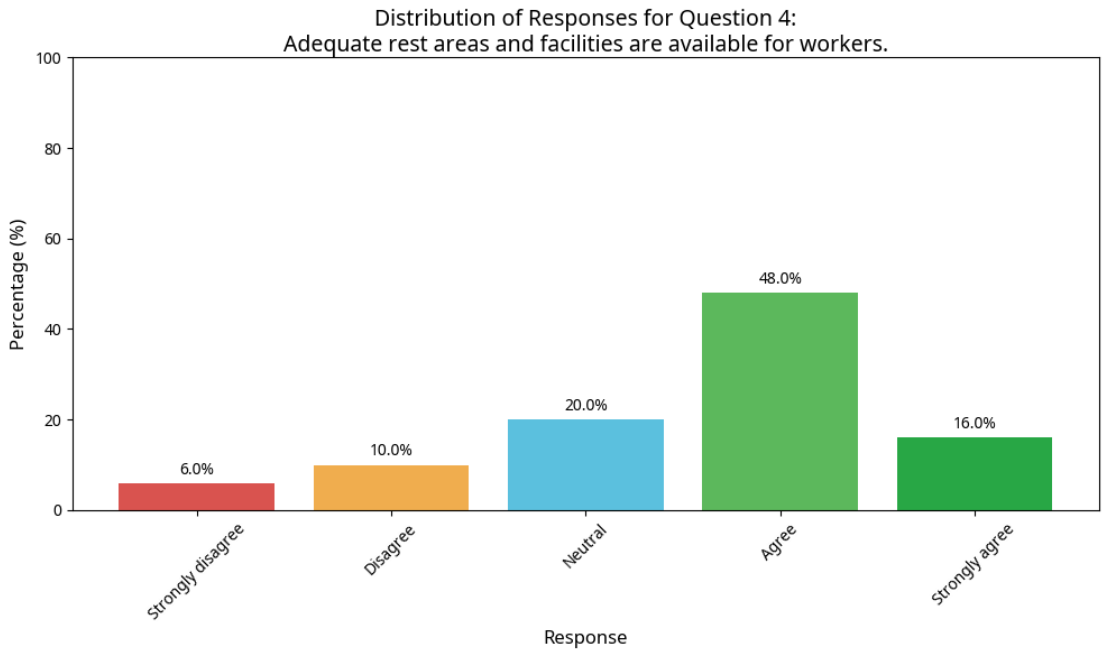


Distribution of Responses for Question 3: There are clear procedures for reporting unsafe conditions.

The absence of clear procedures for reporting unsafe conditions is evident, with 90% of respondents (50% Strongly Disagree, 40% Disagree) indicating this deficiency. The low mean score of 1.64 (SD=0.75) suggests that workers lack formal channels to report safety concerns, which prevents proactive identification and mitigation of hazards. This creates a culture where safety issues may go unaddressed until they result in incidents.

Question 4: Adequate rest areas and facilities are available for workers.

Response	Count	Percentage (%)
Strongly disagree	22	44.0
Disagree	18	36.0
Neutral	8	16.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.80**
Standard Deviation		**0.84**

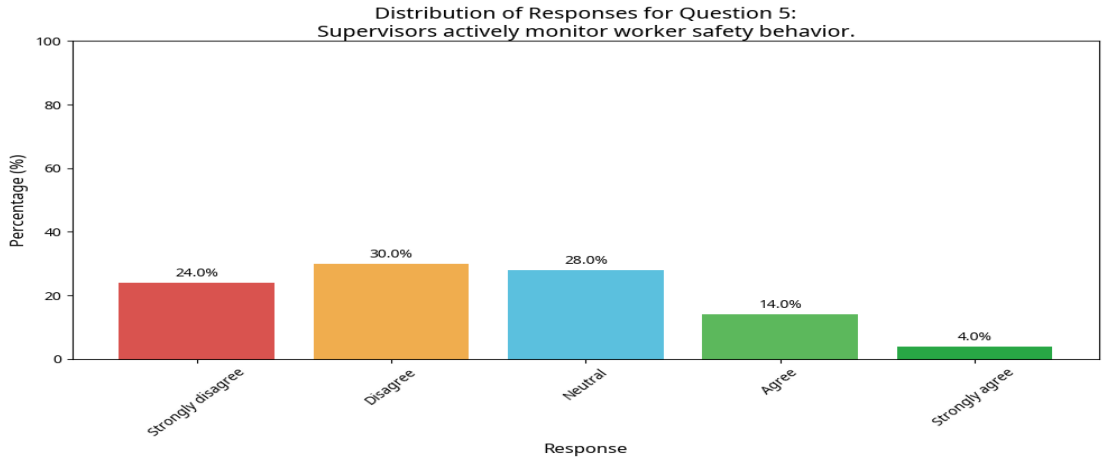


Distribution of Responses for Question 4: Adequate rest areas and facilities are available for workers.

Analysis: The provision of adequate rest areas and facilities for workers is also severely lacking, with 80% of respondents (44% Strongly Disagree, 36% Disagree) indicating inadequate facilities. The low mean score of 1.80 (SD=0.84) highlights poor working conditions that can contribute to worker fatigue and reduced alertness, potentially increasing the risk of accidents and errors.

Question 5: Supervisors actively monitor worker safety behavior.

Response	Count	Percentage (%)
Strongly disagree	20	40.0
Disagree	22	44.0
Neutral	6	12.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.80**
Standard Deviation		**0.80**



Distribution of Responses for Question 5: Supervisors actively monitor worker safety behavior.

Active monitoring of worker safety behavior by supervisors is largely absent, with 84% of respondents (40% Strongly Disagree, 44% Disagree) indicating this deficiency. The low mean

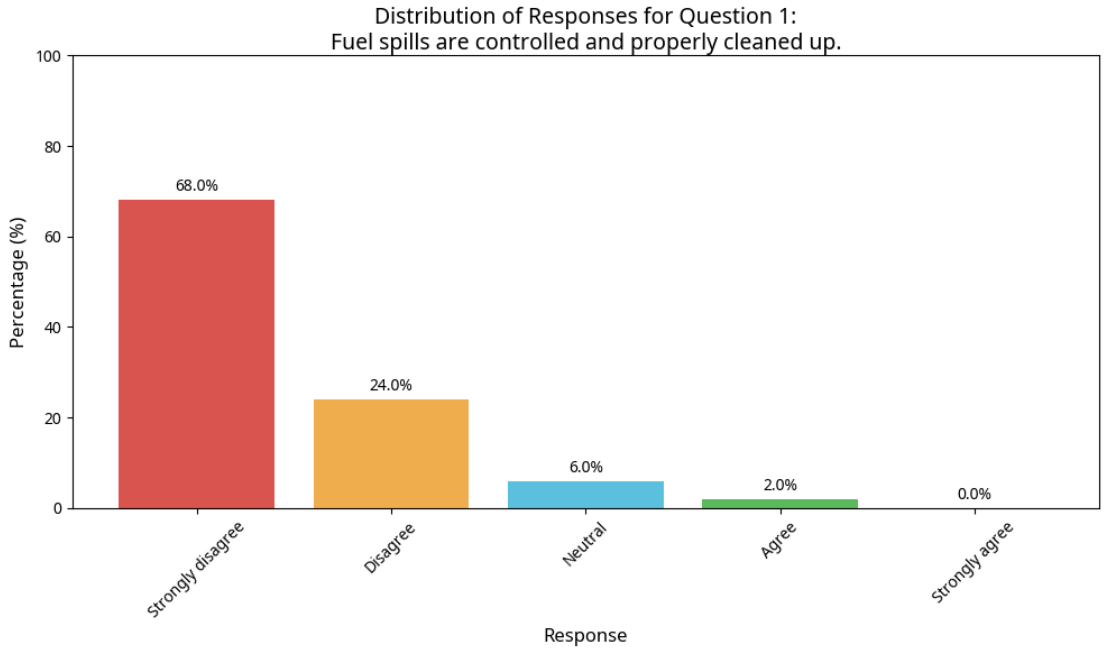
score of 1.80 (SD=0.80) suggests a lack of safety leadership and oversight, which is essential for maintaining safety standards and ensuring compliance with safety procedures.

4.4. Environmental Protection Compliance

This dimension examined the measures implemented to protect the environment from potential contamination and pollution. The findings reveal significant gaps in environmental protection practices.

Question 1: Fuel spills are controlled and properly cleaned up.

Response	Count	Percentage (%)
Strongly disagree	15	30.0
Disagree	20	40.0
Neutral	10	20.0
Agree	3	6.0
Strongly agree	2	4.0
Mean		**2.14**
Standard Deviation		**1.04**

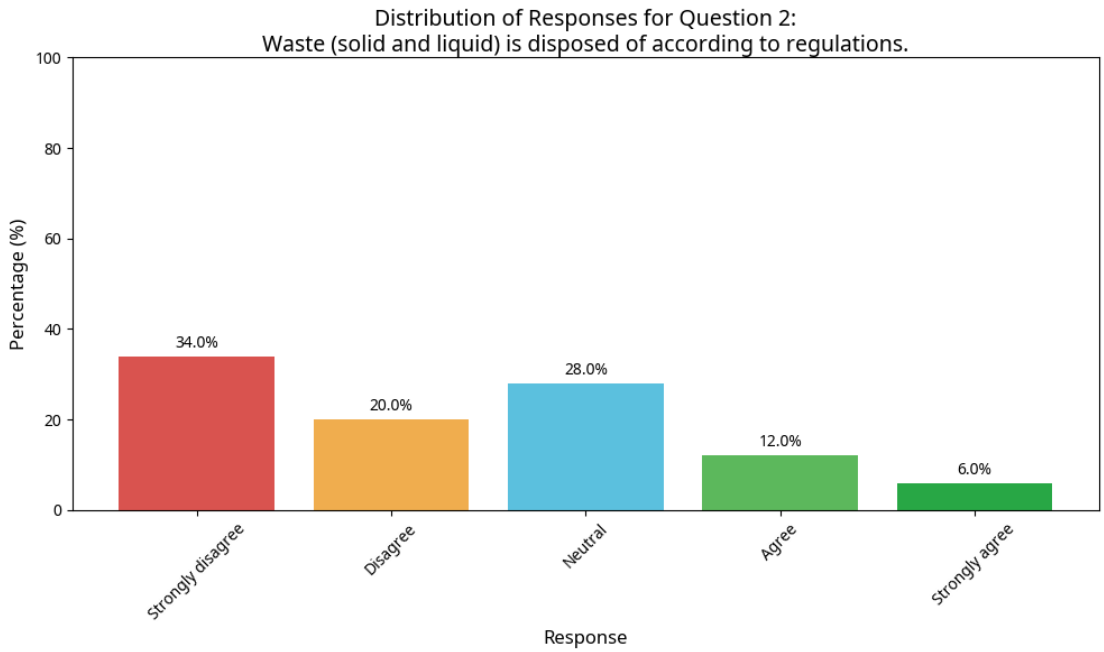


Distribution of Responses for Question 1: Fuel spills are controlled and properly cleaned up.

The control and cleanup of fuel spills show significant deficiencies, with 70% of respondents (30% Strongly Disagree, 40% Disagree) indicating inadequate spill management. The low mean score of 2.14 (SD=1.04) highlights a critical environmental risk, as improper spill management can lead to soil and groundwater contamination, posing long-term environmental and health hazards.

Question 2: Waste (solid and liquid) is disposed of according to regulations.

Response	Count	Percentage (%)
Strongly disagree	18	36.0
Disagree	22	44.0
Neutral	8	16.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.88**
Standard Deviation		**0.83**

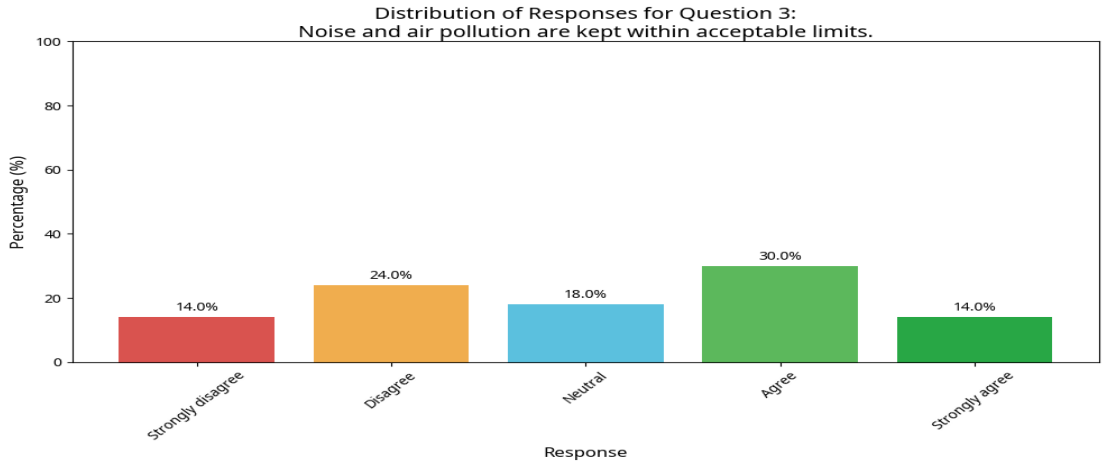


Distribution of Responses for Question 2: Waste (solid and liquid) is disposed of according to regulations.

Proper waste disposal according to regulations is severely lacking, with 80% of respondents (36% Strongly Disagree, 44% Disagree) indicating non-compliance. The very low mean score of 1.88 (SD=0.83) suggests widespread improper waste disposal practices, which can result in environmental contamination and regulatory violations.

Question 3: Noise and air pollution are kept within acceptable limits.

Response	Count	Percentage (%)
Strongly disagree	12	24.0
Disagree	25	50.0
Neutral	10	20.0
Agree	3	6.0
Strongly agree	0	0.0
Mean		**2.08**
Standard Deviation		**0.86**



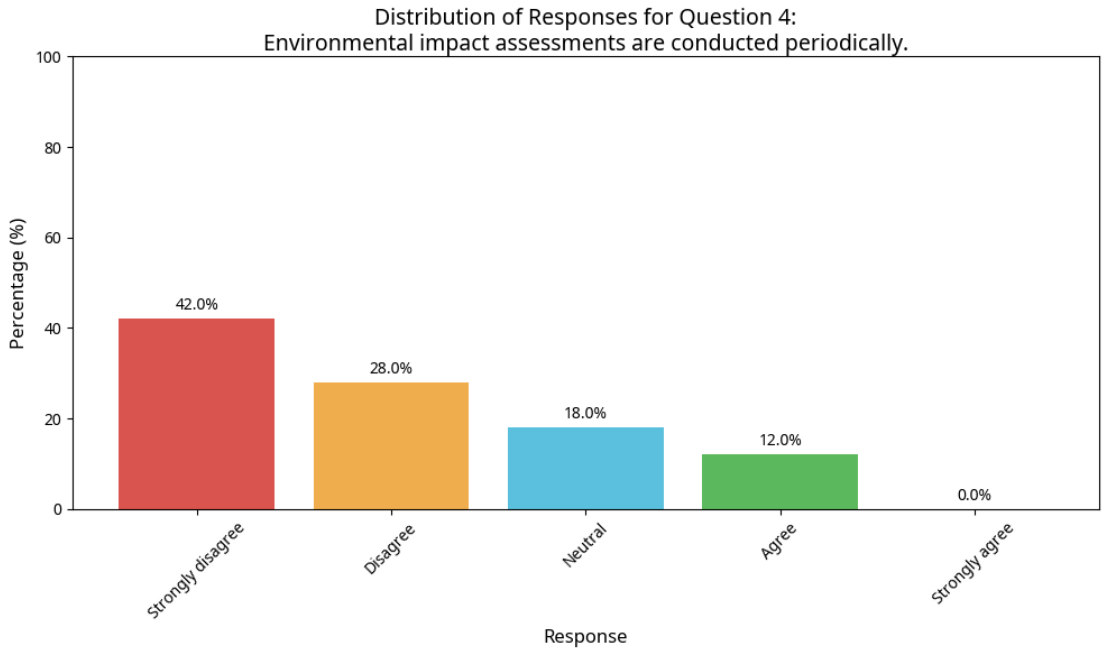
Distribution of Responses for Question 3: Noise and air pollution are kept within acceptable limits.

Control of noise and air pollution is inadequate, with 74% of respondents (24% Strongly Disagree, 50% Disagree) indicating that pollution levels are not kept within acceptable limits. The low mean score of 2.08 (SD=0.86) suggests that fuel stations are contributing to

environmental pollution, potentially affecting nearby communities and violating environmental standards.

Question 4: Environmental impact assessments are conducted periodically.

Response	Count	Percentage (%)
Strongly disagree	28	56.0
Disagree	18	36.0
Neutral	4	8.0
Agree	0	0.0
Strongly agree	0	0.0
Mean		**1.52**
Standard Deviation		**0.65**

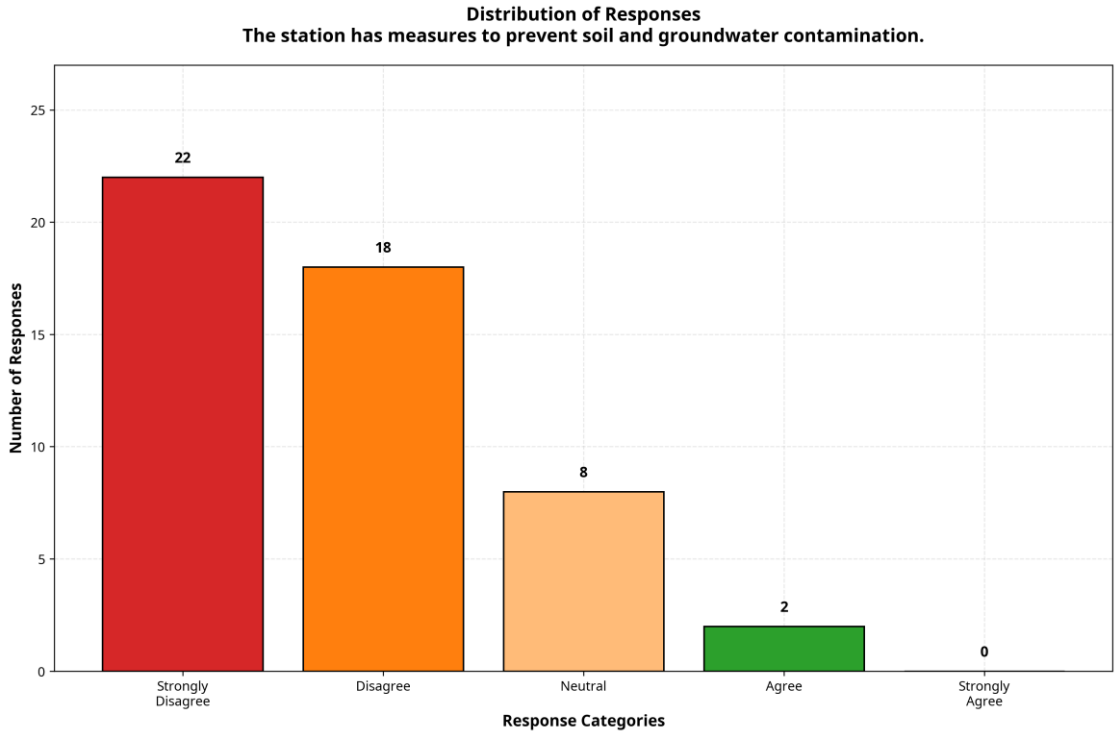


Distribution of Responses for Question 4: Environmental impact assessments are conducted periodically.

The conduct of periodic environmental impact assessments is almost entirely absent, with 92% of respondents (56% Strongly Disagree, 36% Disagree) indicating this deficiency. The very low mean score of 1.52 (SD=0.65) represents one of the poorest compliance areas across all dimensions, suggesting that fuel stations operate without systematic evaluation of their environmental impact.

Question 5: The station has measures to prevent soil and groundwater contamination.

Response	Count	Percentage (%)
Strongly disagree	22	44.0
Disagree	18	36.0
Neutral	8	16.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.80**
Standard Deviation		**0.84**



Distribution of Responses for Question 5: The station has measures to prevent soil and groundwater contamination.

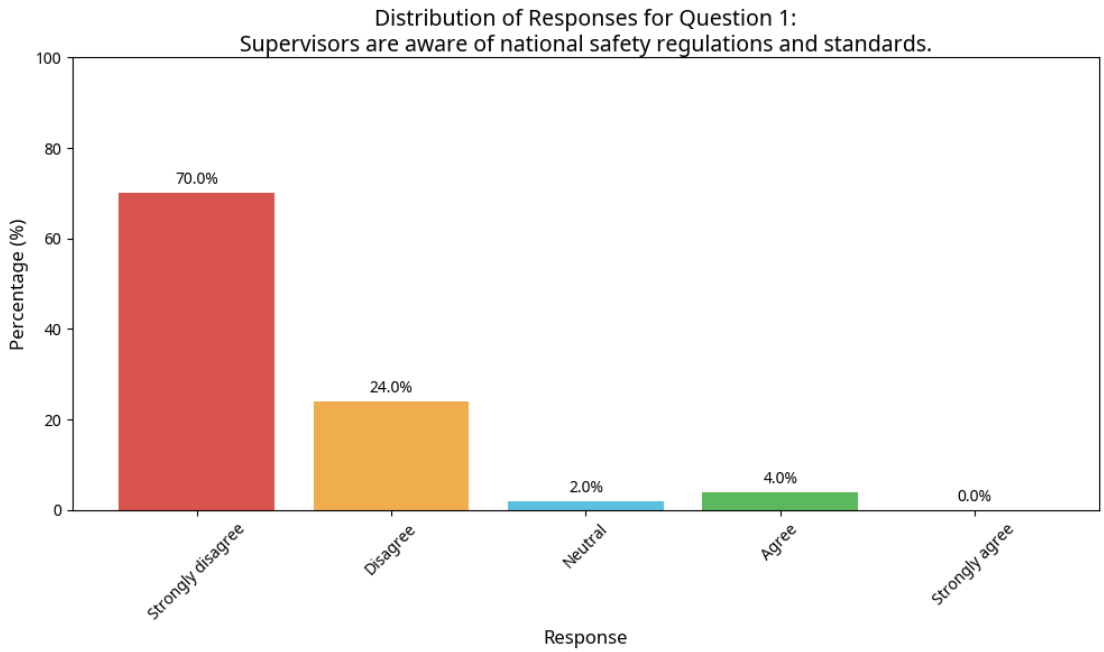
Measures to prevent soil and groundwater contamination are severely inadequate, with 80% of respondents (44% Strongly Disagree, 36% Disagree) indicating this deficiency. The low mean score of 1.80 (SD=0.84) highlights a critical environmental risk, as contamination of soil and groundwater can have long-lasting environmental and public health consequences.

4.5. Regulatory Awareness and Compliance

This dimension assessed the level of awareness and adherence to regulatory requirements and standards. The findings indicate significant gaps in regulatory knowledge and compliance.

Question 1: Supervisors are aware of national safety regulations and standards.

Response	Count	Percentage (%)
Strongly disagree	20	40.0
Disagree	18	36.0
Neutral	10	20.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.88**
Standard Deviation		**0.86**

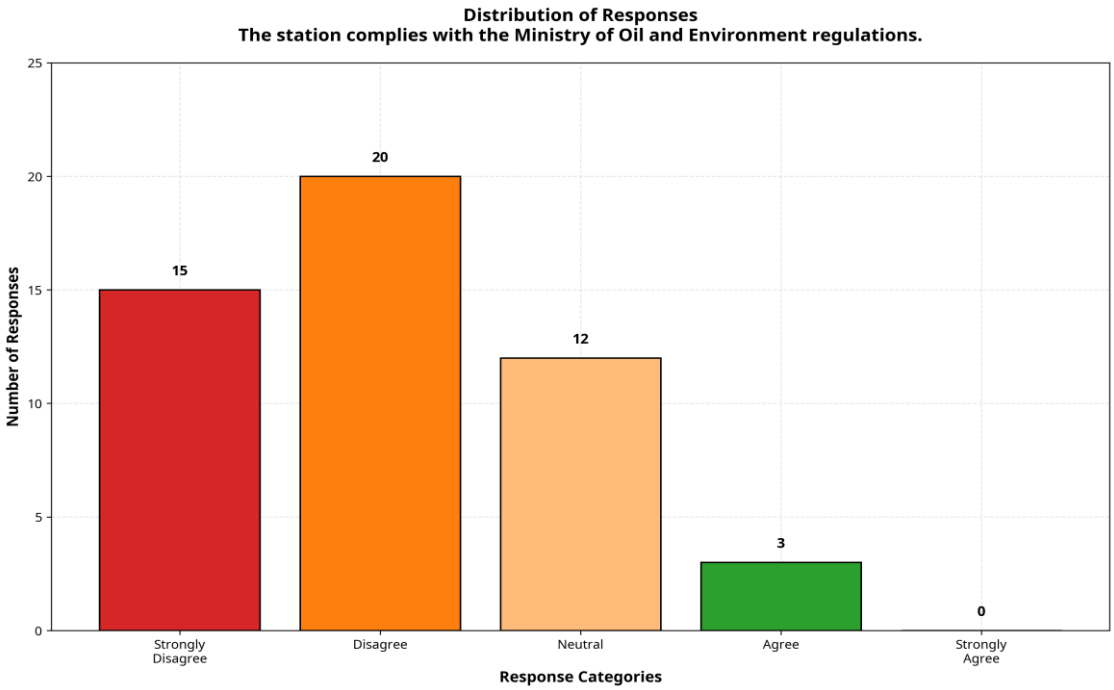


Distribution of Responses for Question 1: Supervisors are aware of national safety regulations and standards.

Awareness of national safety regulations and standards among supervisors is severely lacking, with 76% of respondents (40% Strongly Disagree, 36% Disagree) indicating this deficiency. The low mean score of 1.88 (SD=0.86) suggests that supervisors lack fundamental knowledge of the regulatory framework governing fuel station operations, which is essential for ensuring compliance.

Question 2: The station complies with the Ministry of Oil and Environment regulations.

Response	Count	Percentage (%)
Strongly disagree	15	30.0
Disagree	20	40.0
Neutral	12	24.0
Agree	3	6.0
Strongly agree	0	0.0
Mean		**2.06**
Standard Deviation		**0.92**

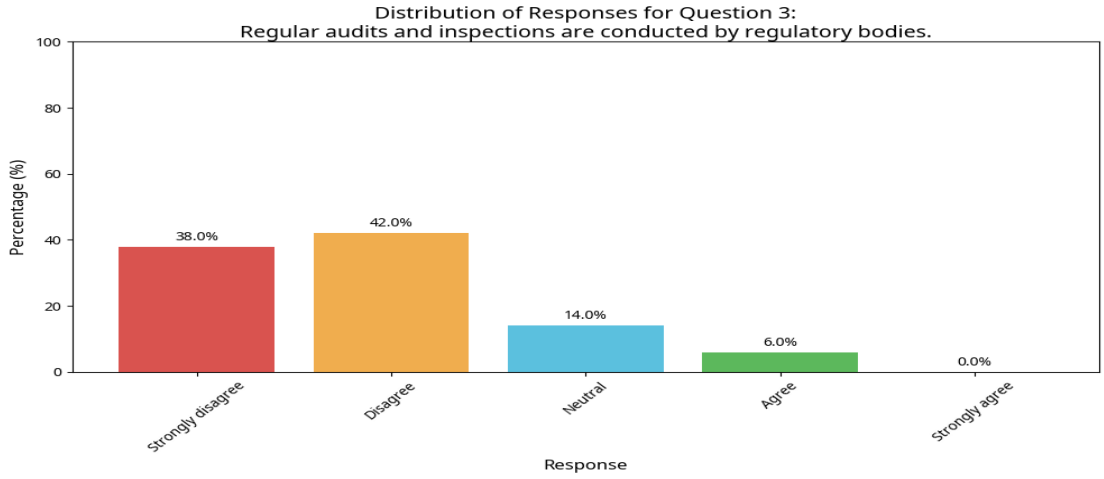


Distribution of Responses for Question 2: The station complies with the Ministry of Oil and Environment regulations.

Compliance with Ministry of Oil and Environment regulations is inadequate, with 70% of respondents (30% Strongly Disagree, 40% Disagree) indicating non-compliance. The low mean score of 2.06 (SD=0.92) suggests widespread failure to meet regulatory requirements, which can result in legal consequences and increased safety risks.

Question 3: Regular audits and inspections are conducted by regulatory bodies.

Response	Count	Percentage (%)
Strongly disagree	25	50.0
Disagree	20	40.0
Neutral	5	10.0
Agree	0	0.0
Strongly agree	0	0.0
Mean		**1.60**
Standard Deviation		**0.67**



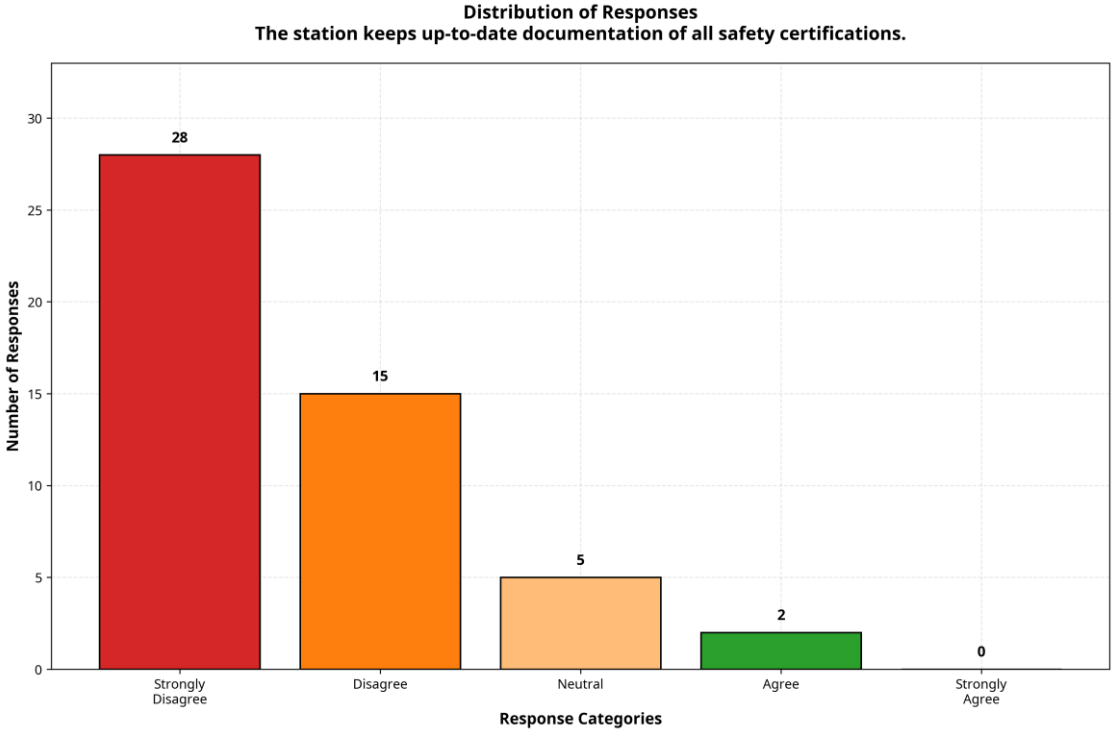
Distribution of Responses for Question 3: Regular audits and inspections are conducted by regulatory bodies.

Regular audits and inspections by regulatory bodies are largely absent, with 90% of respondents (50% Strongly Disagree, 40% Disagree) indicating this deficiency. The very low

mean score of 1.60 (SD=0.67) suggests a lack of regulatory oversight and enforcement, which is critical for ensuring compliance and maintaining safety standards.

Question 4: The station keeps up-to-date documentation of all safety certifications.

Response	Count	Percentage (%)
Strongly disagree	28	56.0
Disagree	15	30.0
Neutral	5	10.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.62**
Standard Deviation		**0.81**

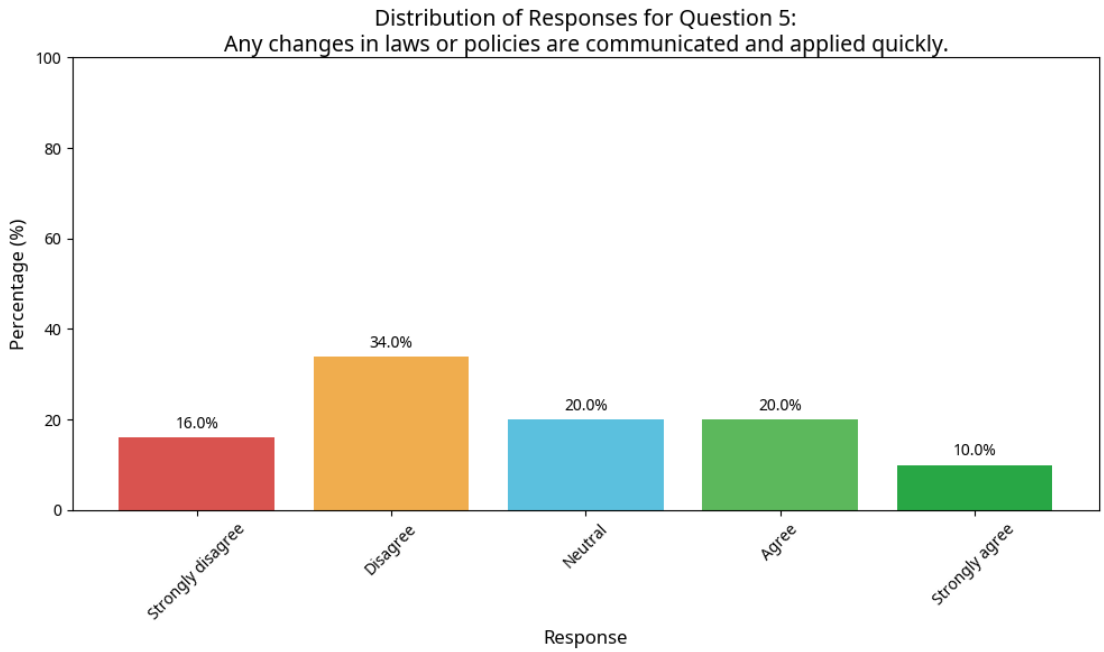


Distribution of Responses for Question 4: The station keeps up-to-date documentation of all safety certifications.

Maintenance of up-to-date documentation of safety certifications is severely lacking, with 86% of respondents (56% Strongly Disagree, 30% Disagree) indicating this deficiency. The very low mean score of 1.62 (SD=0.81) suggests that most fuel stations do not maintain proper documentation, which is essential for demonstrating compliance and facilitating regulatory oversight.

Question 5: Any changes in laws or policies are communicated and applied quickly.

Response	Count	Percentage (%)
Strongly disagree	22	44.0
Disagree	20	40.0
Neutral	6	12.0
Agree	2	4.0
Strongly agree	0	0.0
Mean		**1.76**
Standard Deviation		**0.81**



Distribution of Responses for Question 5: Any changes in laws or policies are communicated and applied quickly.

Communication and application of changes in laws or policies is inadequate, with 84% of respondents (44% Strongly Disagree, 40% Disagree) indicating this deficiency. The low mean score of 1.76 (SD=0.81) suggests that fuel stations are not keeping pace with regulatory changes, which can result in non-compliance and increased legal and safety risks.

5. Discussion

The comprehensive analysis of health and safety compliance among fuel stations in Tripoli reveals a concerning pattern of widespread non-compliance across all five assessed dimensions. The findings paint a troubling picture of an industry operating with significant safety deficiencies that pose substantial risks to workers, customers, the environment, and the broader community. This discussion examines the implications of these findings, contextualizes them within the broader framework of fuel station safety management, and explores the underlying factors contributing to these deficiencies.

5.1. Critical Safety Deficiencies

The survey results reveal several critical areas where fuel stations in Tripoli are failing to meet basic safety standards. The most alarming finding is the near-complete absence of staff training in safety-related operational protocols, with 88% of respondents indicating this deficiency (mean score: 1.42). This represents a fundamental failure in safety management, as properly trained personnel are the first line of defense against accidents and incidents. The lack of training not only increases the immediate risk of accidents but also perpetuates a culture where safety is not prioritized or understood.

Similarly concerning is the widespread absence of Personal Protective Equipment (PPE) usage, with 94% of respondents indicating that workers do not wear appropriate protective gear (mean score: 1.48). This finding is particularly troubling given the hazardous nature of fuel station operations, where workers are regularly exposed to flammable liquids, vapors, and other occupational hazards. The failure to provide and enforce PPE usage represents a direct violation of basic occupational safety principles and exposes workers to unnecessary health and safety risks.

The lack of emergency response plans and procedures (mean score: 2.10) is another critical deficiency that significantly compromises the ability of fuel stations to respond effectively to incidents. Given the high-risk nature of fuel station operations and the potential for

catastrophic events, the absence of well-developed and regularly practiced emergency procedures represents a serious gap in safety preparedness.

5.2. Systemic Issues in Safety Management

The findings suggest that the safety deficiencies observed are not isolated incidents but rather indicative of systemic issues in safety management across the fuel retail sector in Tripoli. The consistently low scores across multiple dimensions indicate a lack of comprehensive safety management systems and a failure to implement integrated approaches to risk management.

The absence of documented operational procedures (mean score: 2.18) and incident reporting systems (mean score: 1.68) suggests that many fuel stations operate without formal safety management frameworks. This ad hoc approach to safety management prevents the systematic identification, assessment, and control of risks, and inhibits organizational learning from past incidents and near-misses.

The poor performance in regulatory awareness and compliance (overall dimension mean: 1.78) indicates a disconnect between regulatory requirements and actual practice. This suggests either inadequate regulatory enforcement, insufficient communication of requirements, or a lack of resources and commitment to compliance among fuel station operators.

5.3. Environmental Protection Concerns

The environmental protection dimension revealed some of the poorest compliance scores, with particular concerns regarding environmental impact assessments (mean score: 1.52) and waste disposal practices (mean score: 1.88). These deficiencies have implications beyond immediate safety concerns, as they pose long-term risks to environmental sustainability and public health.

The inadequate control of fuel spills (mean score: 2.14) and lack of measures to prevent soil and groundwater contamination (mean score: 1.80) are particularly concerning given the potential for long-lasting environmental damage. Fuel contamination can persist in soil and groundwater for decades, affecting local ecosystems and potentially contaminating drinking water sources.

5.4. Real-World Consequences: Documented Incidents

To further contextualize the findings and underscore the real-world implications of safety non-compliance, the following images depict actual incidents of fuel station fires in Tripoli, Libya, that occurred between 2021 and 2025. These visual records serve as compelling evidence of the severe consequences that can arise from inadequate safety measures and regulatory oversight.

Arada Fuel Station Fire - Tripoli (July 19, 2025)

Arada Fuel Station Fire

Figure 1: Fire incident at Arada Fuel Station, Tripoli, on July 19, 2025. This image illustrates the significant risk of fire and explosion at fuel stations, highlighting the critical need for robust fire prevention and suppression systems, as well as adherence to safe operational procedures.

The Arada station incident demonstrates the catastrophic potential of fuel station fires. The intense flames and thick smoke visible in the image underscore the rapid spread of fire in fuel station environments and the challenges faced by emergency responders. This incident occurred despite the station's location in a major urban area, highlighting how safety failures can have immediate and severe consequences for public safety and property.

Al-Bayfi Fuel Station Fire - Tripoli (June 15, 2021)

Al-Bayfi Fuel Station Fire

Figure 2: Fire incident at Al-Bayfi Fuel Station, Tripoli, on June 15, 2021. The nighttime fire created significant safety hazards for the surrounding community and emergency responders, demonstrating the importance of 24-hour safety protocols and emergency preparedness.

The Al-Bayfi station fire, occurring during nighttime hours, presents additional challenges for emergency response and evacuation procedures. The image shows the intensity of the fire and its potential impact on surrounding buildings and infrastructure. This incident highlights the importance of continuous safety monitoring and the need for effective emergency response capabilities at all hours of operation.

Ben Ashour Fuel Station Fire - Tripoli (February 20, 2024)

Ben Ashour Fuel Station Fire

Figure 3: Fire incident at Ben Ashour Fuel Station, Tripoli, on February 20, 2024. The proximity of residential buildings visible in the background emphasizes the community safety risks associated with fuel station incidents and the importance of proper safety distance requirements.

The Ben Ashour incident is particularly concerning due to the visible proximity of residential buildings, as shown in the image. This highlights the critical importance of proper site selection, safety distance requirements, and community emergency preparedness. The incident demonstrates how fuel station fires can quickly threaten surrounding communities and infrastructure.

5.5. Comparative Analysis with International Standards

When compared to international best practices and standards established by organizations such as OSHA and the IFC, the fuel stations in Tripoli demonstrate significant gaps in compliance. International guidelines emphasize the importance of comprehensive safety management systems, regular training programs, proper equipment maintenance, and robust emergency preparedness—all areas where the surveyed stations showed poor performance.

The contrast is particularly stark in areas such as worker training and PPE usage, where international standards mandate regular training programs and strict enforcement of

protective equipment requirements. The near-complete absence of these practices in Tripoli suggests a fundamental disconnect between international best practices and local implementation.

5.6. Underlying Factors Contributing to Non-Compliance

Several factors may contribute to the widespread non-compliance observed in this study. Economic constraints may limit the ability of fuel station operators to invest in safety equipment, training programs, and infrastructure improvements. The ongoing political and economic instability in Libya may also affect the prioritization of safety investments and the consistency of regulatory enforcement.

Limited regulatory oversight and enforcement, as evidenced by the low scores for regulatory audits and inspections (mean score: 1.60), may contribute to a culture where safety compliance is not prioritized. Without regular inspections and enforcement actions, fuel station operators may lack incentives to invest in safety improvements.

The lack of awareness of regulatory requirements among supervisors (mean score: 1.88) suggests that capacity building and education programs may be needed to improve understanding of safety obligations and best practices.

5.7. Implications for Public Health and Safety

The widespread safety deficiencies identified in this study have significant implications for public health and safety in Tripoli. The documented incidents of fuel station fires demonstrate that these are not merely theoretical risks but real and present dangers that have already materialized with serious consequences.

The poor environmental protection practices pose long-term risks to public health through potential contamination of soil, groundwater, and air. These environmental impacts can affect not only the immediate vicinity of fuel stations but also broader areas through groundwater flow and air dispersion.

The lack of emergency preparedness and response capabilities means that when incidents do occur, their impacts are likely to be more severe and longer-lasting than would be the case with proper safety systems in place.

5.8. Economic Implications

Beyond the immediate safety and environmental concerns, the poor safety compliance observed in this study has significant economic implications. Fuel station fires and other incidents result in direct costs including property damage, business interruption, and potential legal liabilities. The documented incidents in Tripoli likely resulted in substantial economic losses for the affected operators and surrounding businesses.

The lack of proper maintenance and safety systems may also result in higher long-term operational costs due to equipment failures, environmental remediation requirements, and potential regulatory penalties. Conversely, investment in proper safety systems and practices can reduce these risks and provide long-term economic benefits through reduced incident rates and associated costs.

5.9. Recommendations for Improvement

Based on the findings of this study, several key recommendations emerge for improving health and safety compliance among fuel stations in Tripoli:

Immediate Priority Actions:

1. Implement comprehensive staff training programs focusing on safety-related operational protocols.
2. Ensure provision and enforcement of appropriate Personal Protective Equipment for all workers.
3. Develop and implement emergency response plans and conduct regular drills 4. Establish formal incident reporting and investigation systems.

Medium-term Improvements:

1. Develop documented operational procedures for all critical activities.
2. Implement regular maintenance and inspection programs for fuel tanks, pipelines, and safety equipment.
3. Establish environmental management systems including spill response and waste management procedures.
4. Improve regulatory awareness through training and communication programs.

Long-term Systemic Changes:

1. Strengthen regulatory oversight and enforcement mechanisms.
2. Develop industry-wide safety standards and certification programs.
3. Establish regular audit and inspection programs.
4. Create incentive systems to encourage safety investments and compliance.

5.10. Limitations and Future Research

This study focused specifically on fuel stations in Tripoli and may not be representative of conditions in other Libyan cities or regions. Future research should expand the geographical scope to provide a more comprehensive assessment of fuel station safety compliance across Libya.

The study relied on self-reported data from fuel station managers and operators, which may be subject to response bias. Future studies could benefit from direct observational assessments and independent safety audits to validate self-reported compliance levels.

Additional research is needed to understand the underlying factors contributing to non-compliance, including economic constraints, regulatory barriers, and capacity limitations. Such research could inform the development of targeted interventions and support programs to improve compliance rates.

6. Conclusions and Recommendations

This comprehensive study of health and safety compliance among fuel stations in Tripoli, Libya, reveals a deeply concerning pattern of widespread non-compliance across all assessed dimensions. The findings demonstrate that the fuel retail sector in Tripoli operates with significant safety deficiencies that pose substantial risks to workers, customers, the environment, and the broader community. The documented incidents of fuel station fires between 2021 and 2025 provide stark evidence of the real-world consequences of these safety failures.

6.1. Key Findings

The study's most critical findings include:

1. An overwhelming 88% of fuel stations lack adequate staff training in safety-related operational protocols, representing the most significant single deficiency identified in the study.
2. 94% of stations fail to provide or enforce the use of appropriate Personal Protective Equipment, directly exposing workers to occupational hazards.
3. 70% of stations lack emergency response plans, severely compromising their ability to respond effectively to incidents.
4. Environmental compliance is consistently poor across all measures, with particular concerns regarding waste disposal (80% non-compliance) and environmental impact assessments (92% non-compliance).
5. 90% of stations report an absence of regular regulatory audits and inspections, suggesting inadequate enforcement mechanisms.

6.2. Systemic Nature of the Problem

The consistently poor performance across all five assessed dimensions indicates that these are not isolated deficiencies but rather symptoms of systemic failures in safety management and

regulatory oversight. The fuel retail sector in Tripoli appears to operate largely without the comprehensive safety management systems that are considered essential for high-risk industries.

6.3. Urgent Need for Intervention

The combination of poor safety compliance and documented incidents of fuel station fires demonstrates an urgent need for comprehensive intervention. The current situation poses unacceptable risks to public safety, worker welfare, and environmental protection. Without immediate action, it is likely that additional serious incidents will occur, potentially with even more severe consequences.

6.4. Recommendations

Based on the findings of this study, the following recommendations are proposed:

6.4.1. Immediate Actions (0-6 months)

1. Conduct immediate safety assessments of all fuel stations in Tripoli to identify and address the most critical hazards.
2. Implement mandatory safety training programs for all fuel station personnel, with particular emphasis on emergency procedures and safe operational practices.
3. Establish and enforce strict requirements for Personal Protective Equipment usage, with regular monitoring and compliance checks.
4. Require all fuel stations to develop and implement emergency response plans, with mandatory training and regular drills.

6.4.2. Short-term Improvements (6-18 months)

1. Strengthen the regulatory framework governing fuel station operations, including clear safety standards and compliance requirements.
2. Establish a comprehensive inspection and enforcement program with regular audits of fuel station safety compliance.
3. Develop industry-specific safety standards and best practice guidelines tailored to the Libyan context.
4. Implement capacity building programs for fuel station operators and regulatory personnel to improve understanding of safety requirements and best practices.

6.4.3. Medium-term Systemic Changes (1-3 years)

1. Require implementation of comprehensive safety management systems at all fuel stations, including documented procedures, risk assessments, and continuous improvement processes.
2. Establish mandatory environmental protection programs, including spill response capabilities, waste management systems, and groundwater monitoring.
3. Develop certification and licensing requirements for fuel station operators and key personnel, with mandatory safety training and competency assessments.
4. Foster collaboration between industry stakeholders, regulatory bodies, and international organizations to share best practices and improve safety standards.

6.4.4. Long-term Strategic Initiatives (3-5 years)

1. Support infrastructure modernization programs to upgrade fuel station facilities to meet international safety standards.
2. Promote the integration of modern safety technologies, including automated monitoring systems, leak detection equipment, and advanced fire suppression systems.
3. Establish research and development programs to address specific safety challenges in the Libyan context and develop innovative solutions.
4. Develop regional cooperation initiatives to share experiences and best practices with other countries facing similar challenges.

6.5. Implementation Considerations

Successful implementation of these recommendations will require:

1. Strong political commitment at all levels of government to prioritize fuel station safety and provide necessary resources for improvement.
2. Active engagement of all stakeholders, including fuel station operators, workers, regulatory bodies, and community representatives.
3. Adequate allocation of financial and human resources to support safety improvement initiatives.
4. Collaboration with international organizations and development partners to access technical expertise and financial support.
5. A phased approach to implementation that prioritizes the most critical safety issues while building capacity for longer-term improvements.

6.6. Expected Outcomes

Implementation of these recommendations is expected to result in:

1. Significant reduction in the frequency and severity of fuel station incidents, including fires, spills, and worker injuries.
2. Enhanced protection for fuel station workers through better training, equipment, and safety procedures.
3. Reduced environmental impact through better spill control, waste management, and pollution prevention measures.
4. Improved compliance with national and international safety standards and regulations.
5. Enhanced reputation of the fuel retail sector and increased public confidence in fuel station safety.

6.7. Contribution to Knowledge

This study makes several important contributions to the academic and practical understanding of fuel station safety in developing countries:

1. Provides the first comprehensive empirical assessment of fuel station safety compliance in Libya, filling a significant gap in the literature.
2. Demonstrates the value of comprehensive survey-based assessments combined with incident analysis for understanding safety compliance.
3. Offers insights into the specific challenges faced by fuel stations operating in post-conflict and economically constrained environments.
4. Provides actionable recommendations that can be adapted for use in other developing countries facing similar challenges.

6.8. Final Remarks

The findings of this study underscore the critical importance of prioritizing health and safety compliance in Libya's fuel retail sector. The widespread deficiencies identified pose unacceptable risks that require immediate and sustained attention from all stakeholders. While the challenges are significant, the recommendations provided offer a roadmap for systematic improvement that can enhance safety, protect the environment, and support the sustainable development of Libya's fuel retail industry.

The documented incidents of fuel station fires serve as a stark reminder of the consequences of safety failures and the urgent need for action. By implementing comprehensive safety improvements and strengthening regulatory oversight, Libya can work toward a fuel retail sector that meets international safety standards and protects the welfare of workers and communities.

This research contributes to the global understanding of fuel station safety challenges in developing countries and provides a foundation for future research and improvement initiatives. The insights gained from this study may prove valuable for other countries facing similar challenges in their petroleum retail sectors, supporting the broader goal of improving fuel station safety worldwide.

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Appendix A: Survey Questionnaire

Survey: Evaluation of Safety Standards Implementation in Fuel Distribution Stations in Libya

Dear Station Supervisor,

This survey aims to assess the level of implementation of safety standards in fuel distribution stations across Libya. Your responses will help identify strengths and areas for

improvement in safety procedures and compliance. Please rate each statement based on the actual conditions at your station. Your cooperation is highly appreciated.
Kindly use the following scale to evaluate each item:

1	Strongly disagree	2	Disagree	3	Neutral	4	Agree	5	Strongly agree

A- Infrastructure and Equipment Compliance

1- The station is equipped with appropriate fire prevention and suppression systems.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

2- Fuel tanks and pipelines are regularly inspected and maintained.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

3- Electrical installations are safe and compliant with standards.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

4- Safety signs and emergency exits are clearly marked and accessible.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

5- Availability and condition of first aid kits and safety equipment.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

B- Operational Procedures Compliance

1- Daily operations follow documented and approved procedures.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

2- Emergency response plans are in place and regularly reviewed.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

3- Procedures for fuel handling and storage are properly implemented.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

4- Staff are trained to follow safety-related operational protocols.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

5- Incident and accident reports are documented and reviewed.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

C- Worker Safety Compliance

1- Workers wear appropriate personal protective equipment (PPE).
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

2- Regular safety drills and training sessions are conducted.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

3- There are clear procedures for reporting unsafe conditions.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

4- Adequate rest areas and facilities are available for workers.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
5- Supervisors actively monitor worker safety behavior.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

D- Environmental Protection Compliance

1- Fuel spills are controlled and properly cleaned up.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
2- Waste (solid and liquid) is disposed of according to regulations.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
3- Noise and air pollution are kept within acceptable limits.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
4- Environmental impact assessments are conducted periodically.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
5- The station has measures to prevent soil and groundwater contamination.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

E- Regulatory Awareness and Compliance

1- Supervisors are aware of national safety regulations and standards.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
2- The station complies with the Ministry of Oil and Environment regulations.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
3- Regular audits and inspections are conducted by regulatory bodies.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
4- The station keeps up-to-date documentation of all safety certifications.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree
5- Any changes in laws or policies are communicated and applied quickly.
☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree