

Assessing the Impact of ISO 45001:2018 on Reducing Occupational Accidents: A Case Study of the Port Company of Annaba (EPAN)

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Abstract :

This study analyzes the impact of the ISO 45001:2018 standard on the reduction of occupational accidents within the Port Company of Annaba (EPAN). The objective is to evaluate the effectiveness of the Occupational Health and Safety (OHS) management system in improving performance in occupational risk prevention. The methodology is based on a mixed-methods approach, combining a quantitative analysis of accident indicators (number of accidents and frequency rate) over the period 2016–2024, with a qualitative analysis based on interviews with internal stakeholders. The results highlight a significant decrease in both accidents and the frequency rate following ISO 45001 certification in 2022, as well as improvements in safety culture, employee well-being, and organizational performance. However, some sectoral disparities persist, requiring targeted actions. The study concludes that the standard has an overall positive impact, while emphasizing the importance of continuous improvement.

Key Words: ISO 45001; Occupational Health and Safety (OHS); occupational accidents; risk management; organizational performance.

JEL Classification : J28, L92, C83

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Introduction:

In a context defined by the intensification of industrial and logistics activities, Occupational Health and Safety (OHS) has emerged as a strategic priority for organizations. Beyond their human toll, workplace accidents generate significant economic costs and undermine overall corporate performance. This reality is particularly acute in high-intensity operational sectors, such as port activities, where the multiplicity of operations, the co-activity of various stakeholders, and the handling of heavy equipment increase exposure to **occupational risks**.

In response to these challenges, organizations have increasingly turned to structured management systems designed to provide a framework for risk prevention. In this regard, the **ISO 45001:2018** standard stands today as a major international benchmark, offering a normative framework based on the systematic identification of hazards, risk assessment, and the continuous improvement of OHS performance. By integrating organizational, human, and technical dimensions, this

standard aims not only to reduce accident rates but also to establish a genuine safety culture within companies.

However, while existing literature highlights the potential benefits of OHS management systems, empirical evidence of their actual effectiveness—particularly within the organizational contexts of developing countries and the maritime sector—remains limited. Specifically, the question of whether ISO 45001 certification effectively translates into a measurable reduction in workplace accidents remains at the heart of academic and managerial debates.

This study focuses on the **Port Company of Annaba (EPAN)**, a key player in the Algerian port system. The primary objective is to evaluate the impact of implementing the ISO 45001:2018 standard on the reduction of workplace accidents within this organization. Consequently, the central research problem can be formulated as follows:

"To what extent does the implementation of the ISO 45001:2018 standard at EPAN contribute to an effective reduction in workplace accidents?"

To provide a rigorous answer to this question, two hypotheses are proposed:

- **H₀ (Null Hypothesis):** The implementation of the ISO 45001 standard has no significant impact on the reduction of the accident frequency rate.
- **H₁ (Research Hypothesis):** The implementation of the ISO 45001 standard enables a significant reduction in the accident frequency rate.

Methodologically, this research adopts a **mixed-methods approach**, combining quantitative and qualitative analyses. The quantitative analysis is based on the **analysis of accident data** (number of accidents, frequency rates) over a longitudinal period from **2016 to 2024**, allowing for a comparison of performance before and after certification. Concurrently, the qualitative analysis relies on interviews conducted with internal stakeholders to understand organizational transformations, evolutions in safety culture, and employee perceptions.

The significance of this research is twofold. On one hand, it contributes to the scientific literature regarding the effectiveness of OHS management systems by providing empirical results from an Algerian port context that remains under-documented. On the other hand, it offers operational value by providing managers and HSE (Health, Safety, and Environment) officers with analytical insights to guide prevention policies, target priority actions, and strengthen workplace safety performance.

Ultimately, this study aims to provide an in-depth analysis of the role of the ISO 45001 standard as a lever for reducing occupational risks, while highlighting the organizational conditions necessary to sustain its effects within a continuous improvement framework.

Beyond a simple statistical correlation, this study addresses the **attribution challenge**. It aims to demonstrate that the observed decline in accident rates is not merely a result of chance or cyclical fluctuations, but rather a direct consequence of the organizational transformation driven by the standard. We thus isolate the impact of certification from external variables to validate its true effectiveness.

I. Theoretical and Conceptual Framework of OHS Management through ISO 45001:2018

1. Conceptual Clarifications: OHS, Risk, Accident, and Prevention:

1.1. Occupational Health and Safety (OHS):

Occupational Health and Safety (OHS) has emerged today as a major organizational challenge, transcending simple operational management to become a global human and socio-economic priority. On a global scale, statistics reveal a **persistent global crisis** where more than **6,300 people die every day** from work-related accidents or diseases. This reality compels organizations to deploy robust management structures capable of sustainably protecting the physical and mental integrity of workers. (ISO, 2024)

1.2. Occupational Risk:

Occupational risk is defined as an uncertain event whose occurrence endangers individuals in the performance of their duties. It is traditionally measured using a matrix that crosses **frequency and severity** to determine a level of criticality. It is imperative to distinguish the **hazard**, which is the potential source of harm, from the **risk**, which corresponds to the probabilistic evaluation of that hazard manifesting within a specific exposure scenario. (Officiel Prévention, 2021)

1.3. Workplace Accidents:

A workplace accident is characterized as a distinct event occurring during professional activity that results in physical or mental harm, the severity of which is assessed through standardized indicators. The **Frequency Rate (FR)** measures the number of accidents per million hours worked, while the **Severity Rate (SR)** evaluates the seriousness via the number of lost workdays, thereby allowing for the rigorous monitoring of safety performance. (Eurostat, 2025)

1.4. Prevention of Occupational Risks:

The prevention of occupational risks encompasses **all technical, human, and organizational measures** implemented to preserve employee health by acting upon the very organization of work. This approach is rooted in **Occupational Risk Assessment (EvRP)**, a central pillar of labor law, which enables the identification, analysis, and prioritization of hazards in order to define the most relevant action plans. (INRS, 2024)

2. Evolution and Architecture of the International Normative Framework:

The following overview traces the transition from national frameworks toward a unified international standardization system. In the mid-1990s, regulatory instruments such as the SEVESO II Directive and the BS 8800 standard marked the initial structuring of industrial risk prevention.

The year 1999 constituted a turning point with OHSAS 18001, the first widely adopted certifiable private standard. In 2001, the International Labour Organization (ILO) further reinforced this dynamic through the ILO-OSH Guidelines, based on global voluntary principles.

Finally, the adoption of ISO 45001 in 2018 formalized the convergence of these initiatives. This harmonized framework integrates OHS into ISO management

systems, thereby strengthening the credibility and comparability of risk prevention practices at the global level. (Bouali, 2023)

Table 01: «Key International Standards for Occupational Health and Safety Management Systems»

Standard	Country or Organization	Status	Publication Year
SEVESO II	European Union	Directive	1996
BS 8800	Great Britain	National Standard	1996
OHSAS 18001	National standardization bodies and private certification institutions, overseen by the British Standards Institution (BSI).	Private Benchmark	1999
ILO-OSH	ILO (International Labour Organization)	International Standard	2001
ISO 45001	ISO (International Organization for Standardization)	International Standard	2018

Source: Adapted from (Bouali, 2023).

2.1. Guiding Principles of the ISO 45001:2018 Standard:

The **ISO 45001:2018** standard defines the requirements for an Occupational Health and Safety (OHS) management system and provides guidelines for its implementation. Published in 2018 by the International Organization for Standardization (ISO), it stands as the primary global reference for OHS. It replaces the OHSAS 18001:2007 standard and represents the only certifiable international benchmark in this field.

Furthermore, ISO 45001 adopts a structure common to recent management system standards, notably **ISO 9001** (Quality Management) and **ISO 14001** (Environmental Management) in their 2015 versions. This harmonized structure, organized into ten **clauses**, aims to facilitate the integration of these different systems within organizations. The objective of the standard is to enable organizations to manage their OHS risks and continuously improve their performance in this area.

The requirements of ISO 45001 are broken down into seven main operational **clauses**:

- **Context of the Organization:** This involves analyzing internal and external environments, as well as the requirements of relevant interested parties—particularly workers—to define the Occupational Health and Safety Management System (OHSMS) and its associated processes.
- **Leadership and Worker Participation:** Top management is responsible for defining and communicating the OHS policy, mobilizing necessary resources, and clarifying responsibilities, while ensuring the active and effective participation of workers.

- **Planning:** This stage consists of identifying OHS risks with staff involvement, considering applicable regulatory requirements, determining risks and opportunities, formalizing action plans, and setting measurable improvement objectives.
- **Support:** This aims to ensure the availability of necessary resources, define required competencies, provide training and awareness regarding OHS risks, establish an appropriate communication system, and manage documentation.
- **Operation:** Processes must be established for the implementation and control of planned changes, prioritizing prevention measures, ensuring communication about hazards (especially in cases of subcontracting), and establishing procedures for emergency situations.
- **Performance Evaluation:** This phase involves monitoring activities that have a significant impact on OHS, evaluating compliance with legal requirements, identifying and correcting non-conformities, and conducting internal audits and management reviews.

Improvement: This consists of addressing undesirable events, non-conformities, and accidents, and implementing corrective actions with a view toward the continuous improvement of the system (BOUALI, 2023).

The standard's process approach is built around the **PDCA (Plan-Do-Check-Act) cycle**, guaranteeing a dynamic of continuous improvement through action planning, operational control, and regular performance evaluation. This cycle allows organizations to move from reactive accident management to proactive risk and opportunity management, thereby strengthening the overall resilience of the company. (ISO, 2024)

Finally, safety performance is influenced by contextual factors such as **organizational size and industry sector**, which determine the complexity of normative implementation. While large enterprises possess dedicated resources, SMEs often face higher financial and administrative barriers, making the adaptation of the normative framework a crucial issue for the **broader adoption of safety practices**. (Bouali, 2023)

2.2. Recent Empirical Contributions on the Effectiveness of OHS Management Systems:

Recent empirical research confirms the growing interest in evaluating the impact of the ISO 45001 standard on organizational performance. In this regard, the study by **Podrecca, Molinaro, Sartor, and Orzes (2024)** represents one of the first large-scale analyses based on an international sample of certified companies. Using an econometric approach combining event study and weighted regression, the authors demonstrate that companies adopting ISO 45001 **report significant improvements in productivity and profitability** compared to non-adopters, although effects on sales remain limited. These results suggest that the implementation of OHS management systems contributes to strengthening overall organizational performance, while remaining highly dependent on contextual factors

related to the sector and specific company characteristics. (Podrecca, Molinaro, Sartor, & Orzes, 2024)

Similarly, a recent empirical study conducted in the Algerian context by **Daoudi and Mendli (2025)** highlights that the implementation of ISO 45001 in SMEs contributes to a tangible improvement in occupational health and safety conditions. Their findings notably show a reduction in **workplace incidents** and a better structuring of prevention practices in an environment that remains under-explored in the literature. This contribution is particularly significant as it confirms, within a comparable national context, the effectiveness of the ISO 45001 framework as an operational tool for occupational risk management. (Daoudi & Mendli, 2025)

Furthermore, recent work by **Hesham et al. (2025)** proposes an integrated approach combining ISO 45001 with the **OSHA Process Safety Management** standard in high-risk industries. Through an empirical analysis based on worker perceptions and factor analysis, the authors identify key variables influencing safety performance, such as **employee participation, training, performance evaluation, and incident analysis**. The results show that the integration of these frameworks significantly improves risk management and strengthens overall OHS performance, emphasizing the central role of integrated systems in the effectiveness of prevention mechanisms. (Hesham, Hosny, Mahmoud, & Ghatas, 2025)

In addition, recent research on **safety culture** highlights its mediating role in the relationship between management systems and safety performance. A longitudinal study of 829 European companies (2024) shows that the development of an organizational safety culture directly contributes to both safety and financial performance improvements. It underscores that frameworks like ISO 45001 only produce significant effects when accompanied by **genuine engagement of stakeholders** and integration into the organization's daily practices. (Bautista-Bernal, Quintana-García, & Marchante-Lara, 2024)

Finally, recent studies emphasize the differences observed between certified and non-certified companies regarding OHS performance. Empirical research conducted in **Korea (2023–2024)** shows that ISO 45001-certified organizations present higher levels of OHS integration into **overall management**, as well as increased involvement of leadership and workers in prevention processes. However, the authors note that these differences should be interpreted with caution, as they may also reflect pre-existing organizational characteristics. This approach highlights the need to distinguish the specific effect of certification from that of internal organizational capabilities. (Joo & Kyungmin Baek, 2024).

II. Methodological Framework and Presentation of the Study:

1. Adopted Methodology:

This research follows an empirical approach aimed at analyzing the impact of the ISO 45001:2018 standard on the reduction of workplace accidents within the Port Company of Annaba (EPAN). To this end, a **mixed-methods approach** has been adopted, combining both quantitative and qualitative analyses.

1.1. Type of Research:

This study is based on a case study that is both **descriptive and analytical**.

- **Descriptive:** It aims to present and characterize the evolution of Occupational Health and Safety (OHS) indicators within EPAN.
- **Analytical:** It seeks to interpret these developments in relation to the implementation of the ISO 45001 standard, specifically by comparing performance levels before and after certification.

1.2. Data Collection Methods:

The data collection relies primarily on two complementary sources:

- **Documentary Analysis:** Based on the **analysis of internal company documents** (OHS reports, accident statistics, operational data), providing reliable information on the evolution of workplace accidents.
- **Accident Indicator Analysis:** Specifically focusing on the **number of workplace accidents** and the **frequency rate**, used as the primary variables to evaluate health and safety performance.

Furthermore, a qualitative approach was utilized through **interviews conducted with internal stakeholders**. This **complements the quantitative analysis** by providing a better understanding of organizational transformations, employee perceptions, and the evolution of the safety culture.

1.3. Sample and Study Period

The study covers all data related to the Port Company of Annaba, treated as a unique case study representative of a port organization committed to the ISO 45001 certification process.

The quantitative analysis spans a **longitudinal period from 2016 to 2024**, allowing for a comparison of the situation before and after the certification was obtained in **2022**. This timeframe makes it possible to highlight **trends in workplace accident indicators** and to evaluate the long-term impact of the OHS management system.

2. Presentation of the Port Company of Annaba (EPAN):

2.1. History and Organization of EPAN:

The Port Company of Annaba (**Entreprise Portuaire d'Annaba-EPAN**) is a Public Economic Enterprise and a joint-stock company (EPE-SPA), resulting from the transformation of the former Port Company under Law 88-01. It possesses its own legal personality, financial autonomy, and a share capital of **3,000,000,000 DA**, 100% of which is held by the **SERPORT Group**.

EPAN manages the Port of Annaba, which ranks among Algeria's ten primary commercial ports. Today, it stands as the **leading port in the country for non-**

hydrocarbon exports and the fifth for container traffic, maintaining a dual industrial and commercial profile. Its facilities cover an area of approximately **130 hectares**, including 24,750 m² of covered warehouses and 3,680 linear meters of quays distributed across 22 berths. These are organized into three basins (the outer harbor, the large basin, and the small basin), allowing for the **accommodation of vessels** of various sizes.

The enterprise operates and develops port infrastructure and superstructure while providing essential port services (handling, berthing, terminal management, etc.). EPAN is committed to continuous modernization, notably through the implementation of advanced management tools, 24/7 services for the container terminal, and the adoption of e-billing and electronic payment solutions. (Entreprise Portuaire de Annaba, 2025)

2.2. EPAN Workforce:

The workforce of the Port Company of Annaba (EPAN) consists of approximately **1,100 employees**, reflecting the significant human resource requirements needed to ensure the continuity and diversity of its port activities. This **overall workforce** includes technical, administrative, and operational personnel dedicated to various missions related to cargo handling, logistics, and infrastructure management.

In line with its strategy for modernization and performance enhancement, EPAN recruited an additional **one hundred workers in 2025**, specifically assigned to implement a continuous shift system. This measure has strengthened existing teams and guaranteed **24/7 operations**, thereby meeting the growing demands of maritime traffic and the competitive imperatives of the port (Algeria INVEST, 2025).

2.3. Main Directorates of EPAN:

According to EPAN, these directorates directly manage on-site port activities:

Table 02: Missions of the Main Directorates of EPAN

Directorate	Full Name	Primary Missions
DMA	Maintenance and Resources Directorate	Ensures the availability and reliability of port equipment and infrastructure. Plans and executes preventive and corrective maintenance to reduce breakdowns and extend the lifespan of facilities. Plays a strategic role in operational continuity and safety.
D.COM	Commercial Directorate	Manages prospecting, customer loyalty, and relations with clients and partners. Develops offers, negotiates commercial terms, and applies pricing policies. Contributes to revenue growth and the attractiveness of EPAN.
D.TECH	Technical Directorate	Designs, monitors, and implements technical and infrastructure projects. Conducts studies, supervises works, and ensures compliance with quality, safety, and performance standards. Supports continuous improvement and innovation.
D.TC	Traffic / Container Terminals Directorate	Organizes and controls the flow of goods. Plans handling operations, loading, unloading, storage, and delivery. Ensures a smooth, fast, and secure flow in coordination with port stakeholders.
D.CAP	Harbor Master's Office (Capitainerie)	Ensures policing and security of the port domain (land and sea). Regulates ship movements, assigns berths, and ensures regulatory compliance. Guarantees the safety of people, property, and the environment.
DARH	Administration and Human Resources Directorate	Manages administrative, legal, and social aspects of personnel. Handles recruitment, training, career management, and the social climate. Contributes to overall performance by enhancing human capital.

Source Prepared by the author based on data from EPAN (2025).

3. ISO 45001 Certification Process at EPAN:

The Port Company of Annaba (**EPAN**) has followed a progressive path toward the certification of its management systems. The first stage consisted of implementing a **Quality Management System (QMS)** compliant with the **ISO 9001:2008** standard, followed by a successful renewal audit in December 2014, which recorded zero non-conformities.

The second stage focused on integrating environmental management: a diagnostic audit according to the **ISO 14001:2015** framework was conducted in February 2016. This was followed by a partnership with the **Higher Institute of Management of Annaba (ISGA)** to implement an **Environmental Management System (EMS)** and integrate it with the updated version of the QMS (**ISO**

9001:2015). The certification audit for the integrated Quality/Environment system was completed in October 2018, followed by surveillance audits in 2019 and 2020.

Finally, as part of its continuous improvement strategy, EPAN's 2021 objectives aimed to design and implement the third management pillar: **Occupational Health and Safety (OHS)** according to the **ISO 45001:2018** standard. The ultimate goal was to establish an **Integrated Management System (IMS)** encompassing the objectives of all three systems: Quality, Environment, and OHS. (Entreprise Portuaire de Annaba, 2025)

III. Indicators, Analysis, and Discussion:

1. Quantitative Indicators:

1.1. Evolution of the Number of Accidents and Frequency Rate at EPAN:

The table below presents the evolution of workplace accidents recorded at EPAN over the period from **2016 to 2024**. For each year, it highlights the number of accidents, the number of lost workdays, and the frequency and severity indicators.

These data allow for an analysis of safety trends and the identification of high-risk years. Notably, certain periods are marked by severe accidents, including fatalities. This comprehensive information serves as an essential tool for guiding prevention strategies and improving working conditions.

Table 03: Status of Workplace Accidents at EPAN (2016 - 2024)

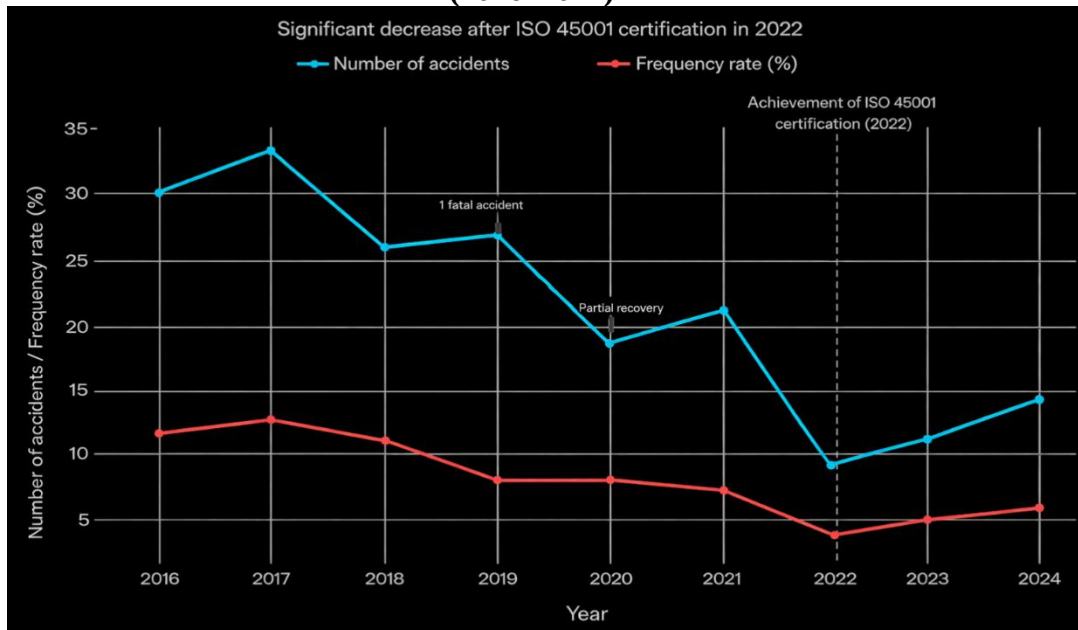
Year	Number of Accidents	Number of Lost Days	Frequency Rate	Severity Rate	Observations
2016	30	308	11.32%	0.11%	
2017	33	419	12.30%	0.15%	
2018	26	360	10.92%	0.13%	
2019	27	6,215	07.24%	02.12%	+ 1 Fatality
2020	19	6,137	07.19%	02.32%	+ 1 Fatality
2021	21	303	06.45%	0.10%	
2022	09	106	02.86%	0.03%	ISO 45001 Certification
2023	11	129	03.68%	0.04%	
2024	14	204	06.29%	0.09%	

Source: (EPAN, 2025).

The data illustrates the evolution of workplace accidents and the frequency rate between 2016 and 2024 within the studied enterprise. It reveals an initially high level of accident rates, followed by a marked decline starting in 2021.

The most distinct break in the trend occurs in **2022**, the year corresponding to the achievement of **ISO 45001:2018 certification**, which saw a simultaneous drop in both the absolute number of accidents and the frequency rate. While the years 2023 and 2024 show a slight uptick in these indicators, they remain significantly lower than the levels observed prior to certification. This suggests a **globally positive and sustainable effect** of the OHS management system on the company's safety performance.

Figure 01: « Evolution of the Number of Accidents and Frequency Rate (2016–2024) »



Source: Prepared by the author based on data from EPAN (2025).

The evolution of workplace accidents at EPAN between 2016 and 2024 reveals two distinct phases. Prior to 2020, the company recorded high accident rates—ranging from 26 to 33 annual incidents with a frequency rate between 7% and 12%—corresponding to a **"frequent"** risk level.

Starting in 2021, and most notably following the ISO 45001 certification in 2022, a significant decrease was observed: the number of accidents fell below 10, and the frequency rate dropped to approximately 3%.

The slight rebound observed in 2024 suggests a **"transition effect"** linked to the shift to a 24/7 operational system. This change introduces major ergonomic constraints, particularly fatigue related to circadian cycles—a recognized factor in diminished alertness within industrial environments. Concurrently, the integration of 100 new recruits creates a temporary gap between normative compliance (theoretical knowledge of ISO 45001) and operational experience (safety reflexes). This phase necessitates a "maturation" period through the transfer of expertise from veteran workers to new hires to restabilize performance.

From an analytical perspective, this evolution marks a shift from a high-risk environment to a controlled one. According to the criticality matrix ($C = F \times S$), risks have migrated from **"unacceptable"** levels toward **"tolerable"** thresholds, confirming the overall effectiveness of the Occupational Health and Safety (OHS) management system in mitigating professional risks.

A point of caution concerns the year 2020, where the number of accidents fell to 19. This decline could be interpreted as a mechanical effect of the global slowdown in port activity during the COVID-19 pandemic. However, the robustness of ISO 45001 is evidenced by the **2022** data. Despite a full recovery in traffic and

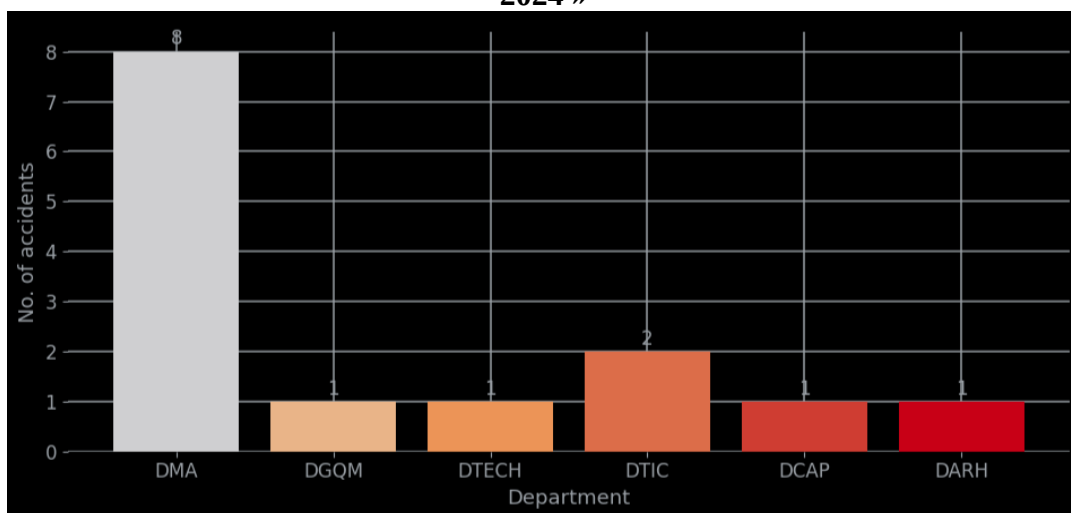
the transition to a sustained operational rhythm (24/7), the number of accidents dropped to **9**, reaching its lowest level throughout the 2016–2024 period. This contrast between 2020 (decline due to inactivity) and 2022 (decline due to rigorous management) proves that the standard acted as an effective safety regulator during the operational ramp-up.

1.2. Distribution of Workplace Accidents by Directorate:

The figure below represents the distribution of workplace accidents by directorate for the year **2024**, highlighting a high concentration of events within the **DMA**. With **8 accidents**, this directorate accounts for **57%** of all recorded accidents, compared to only 1 or 2 accidents in the other departments.

This configuration suggests that the DMA constitutes the primary risk center within the organization, necessitating targeted prevention actions. The data provides an empirical basis for prioritizing occupational health and safety interventions toward the most exposed organizational units.

Figure 02: « Distribution of Workplace Accidents by Directorate for the Year 2024 »



Source: Prepared by the author based on data from EPAN (2025).

This asymmetrical distribution reflects a **sectoral concentration of risk**. Due to the technical nature of its activities (equipment maintenance, interventions on installations), the **DMA** is exposed to a higher accident frequency, which corresponds to a "frequent" level on the internal frequency scale. When combined with potentially high severity, this situation places the associated risks in a "**significant**" or even "**unacceptable**" category, requiring priority corrective actions.

In contrast, other directorates show a low accident frequency, corresponding to an "infrequent" level, and thus to risks that are generally considered "**tolerable**" according to internal risk classifications. Consequently, this comparative analysis

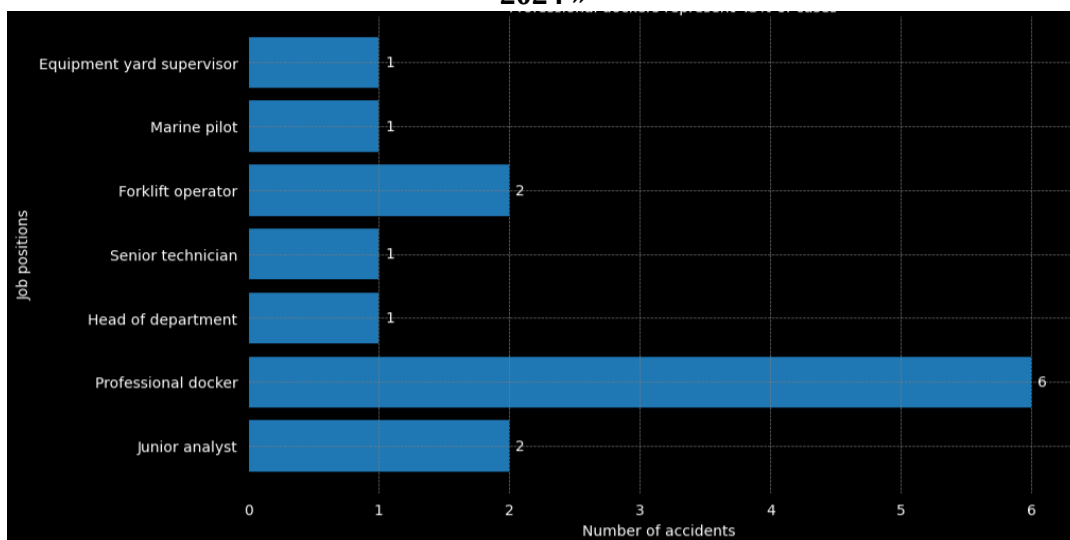
highlights the necessity of a **differentiated prevention approach**, prioritizing the high-exposure directorates.

1.3. Distribution of Workplace Accidents by Job Position:

The figure below presents the distribution of workplace accidents by job position for the year **2024**, highlighting a strong concentration of cases among **professional dockworkers**. This group accounts for **6 accidents**, or **43%** of all injured personnel, making it the most exposed category.

The remaining accidents are distributed much more thinly across other roles: **equipment operators (forklift drivers)** and **research officers** (2 cases each), followed by **fleet managers**, **maritime pilots**, **senior technicians**, and **department heads** (1 case each). This statistical profile suggests that prevention efforts should be primarily targeted at **port handling activities**, while maintaining a monitoring system for other functions.

Figure 03: « Distribution of Workplace Accidents by Job Position for the Year 2024 »



Source: Prepared by the author based on data from EPAN (2025).

This distribution highlights a **direct correlation** between the level of risk exposure and the nature of the activities performed. Operational roles, particularly those related to **port handling**, exhibit a higher frequency of accidents and more demanding working conditions, placing them at "significant" risk levels.

Conversely, administrative and management positions are associated with "**negligible**" or "**tolerable**" risks due to their low exposure to physical hazards.

This analysis confirms the relevance of a **targeted prevention approach by profession**, focusing primarily on handling activities and equipment operation.

2. Qualitative Indicators:

2.1. Interview within EPAN:

The interview was conducted with a **Research Officer** from the Quality Management Department, who also serves as a **Division Head within the OHS Cell**. This profile was selected for its cross-functional perspective and direct technical expertise regarding the implementation of the ISO 45001 standard within EPAN.

Table 04: « Synthesis of Interview Questions and Responses at EPAN »

No.	Question	Response
Q1	Has there been a decrease in accidents and injuries since obtaining ISO 45001 certification?	Yes, injuries have decreased since the ISO 45001 certification was implemented at EPAN. The standard has contributed positively to accident reduction, even though other factors—such as increased vessel traffic and the 24/7 continuous work shift—also influence the results.
Q2	Has employees' psychological health and job satisfaction improved?	Yes, there has been a significant improvement in psychological health and employee satisfaction. The ISO 45001 standard protects the worker, reduces risks, and strengthens the sense of security, which in turn reduces stress and anxiety while improving overall well-being.
Q3	Have costs related to accidents and injuries decreased?	Yes, overall costs—specifically those related to medical care, compensation, and equipment breakdowns—have dropped thanks to the OHS management system, risk prevention, and better organization (e.g., the 24/7 system and the 5S method).
Q4	Has the confidence of customers and suppliers been strengthened?	Yes, ISO 45001 certification has clearly reinforced the trust of customers, suppliers, and partners by improving procedures, stability, and the port's image of reliability and safety.
Q5	Has certification boosted morale and productivity, and made safety feel like a priority?	Yes, since 2022, employee motivation and confidence in the work environment have increased. The perception that "their safety is a priority" has translated into a rise in productivity over the medium and long term.
Q6	Has there been a decrease in absenteeism linked to the reduction in accidents?	The marked reduction in accident severity and frequency rates following ISO 45001 has been accompanied by improved work continuity. This indicates a decrease in absenteeism and more consistent productivity levels.

Source: Prepared by the author based on an interview with an EPAN executive (2025).

Qualitatively, this performance is rooted in post-certification structural changes: the adoption of the **5S methodology** in maintenance workshops (DMA) has reduced risks related to clutter, while the systematization of risk analysis prior to each handling operation has established a proactive culture. The shift from reactive safety to managed safety is manifested by increased leadership commitment, transforming normative protocols into operational reflexes on the ground.

2.2. Analysis of Interview Responses:

The achievement of ISO 45001 certification has generated multidimensional positive outcomes. On a human level, there is a measurable decrease in injuries and a clear improvement in psychological well-being. By strengthening the sense of security, the standard has helped reduce worker stress and anxiety.

Economically, the company has recorded a drop in accident-related costs (medical care, compensation, and operational downtime), facilitated by a structured risk management approach and organizational optimization (continuous shift systems and the 5S method). This impact extends beyond internal operations by consolidating the trust of external stakeholders, such as customers and suppliers, through enhanced operational control.

Ultimately, these transformations have boosted overall performance: since 2022, both motivation and productivity have increased. The significant reduction in accident frequency and severity rates now ensures better business continuity while enhancing the organization's brand image.

3. Interpretation of Results in Relation to Hypotheses:

The empirical results obtained in this study provide clear answers to the research problem and allow for the testing of the formulated hypotheses.

On one hand, the **quantitative analysis** highlights a significant reduction in the number of workplace accidents and the frequency rate following the implementation of the ISO 45001 standard, particularly from 2022 onward. The transition from high accident levels during the 2016–2020 period to a markedly lower level after 2021 reflects a tangible improvement in OHS performance. This trend indicates better control of professional risks, confirmed by the shift in criticality levels from "significant or intolerable" to "tolerable and controlled."

On the other hand, the **qualitative results** from the interviews reinforce these findings. They reveal an improved safety culture, increased worker involvement, and a perceived decrease in accidents, associated costs, and absenteeism. Furthermore, the improvement in employee well-being and job satisfaction underscores the positive organizational impact of the standard beyond simple quantitative indicators.

However, the analysis also highlights certain limitations and nuances. The slight uptick in indicators after 2022, as well as the concentration of accidents within specific departments (notably the DMA) and roles (dockworkers), shows that the effect of the standard—though significant—is neither uniform nor automatic. It depends heavily on the stakeholders' ownership of the system and the continuous implementation of targeted prevention actions.

To test the statistical significance of the differences observed before and after ISO 45001 implementation, a **one-way ANOVA** was performed. The results indicate a value of $F = 5.93$ with a $p\text{-value} = 0.0379$ ($p < 0.05$), revealing a statistically significant difference between the studied groups.

Conclusion of Hypothesis Testing:

- **H0 (Null Hypothesis) is rejected**, as empirical data demonstrates a significant impact of ISO 45001 on reducing the accident frequency rate at EPAN.

- **H1 (Research Hypothesis) is confirmed**, as ISO 45001 certification is accompanied by a measurable, multidimensional improvement in OHS performance, both quantitatively (reduction in accidents) and qualitatively (improvement in organizational climate and employee well-being).

4. Comparative Analysis and Positioning By comparing these results with other national port infrastructures, EPAN distinguishes itself through its transition from a regulatory compliance model to an operational excellence model. While other Algerian ports exhibit fluctuating safety indicators, the stability of EPAN's results since 2022 brings it closer to international standards. This dynamic places the company on the trajectory of **Smart Ports**, where Occupational Health and Safety (OHS) performance becomes an indicator of technological and managerial maturity.

Conclusion:

This research aimed to evaluate the impact of implementing the ISO 45001:2018 standard on the reduction of workplace accidents at EPAN. Through a mixed-methods approach, the study provided rich and nuanced empirical results.

The findings reveal a significant overall improvement in OHS performance following the implementation of the standard. Quantitatively, a notable drop in accidents and frequency rates was observed starting in 2021, with a particularly sharp break in 2022. Despite a slight rise in indicators in 2023 and 2024, levels remain lower than those recorded prior to certification, reflecting a lasting positive effect. Furthermore, the analysis identified risk concentration zones, specifically within the **Maintenance and Resources Directorate (DMA)** and among **dockworkers**, highlighting the need for targeted prevention.

Qualitatively, the results confirm these trends by showcasing an improved safety culture, increased worker engagement, reduced accident costs, and enhanced employee motivation and productivity. ISO 45001 thus appears as a structural lever for organizational transformation.

Scientifically, this research enriches the literature on OHS management system effectiveness by providing data from an under-explored Algerian port context. Practically, it offers HSE managers and decision-makers concrete evidence to guide prevention policies and prioritize risk-reduction actions.

Nevertheless, this research has limitations. As a single case study, the generalizability of the results to other sectors may be limited. Additionally, the qualitative analysis relies on a limited number of interviews, which may introduce perception bias. External factors, such as increased port activity or the shift to continuous 24/7 operations, may also have influenced the results independently of the standard. These limits open future research perspectives, such as comparative studies across multiple companies or the integration of indicators like psychosocial risks.

To ensure the sustainability of these results, EPAN must move toward the integration of Industry 4.0 technologies. The use of **Digital Twins** to simulate flows and identify high-risk congestion zones, coupled with the installation of **IoT** sensors on handling equipment (anti-collision systems), would help overcome the limits of

human vigilance, particularly during night shifts. These tools would transform current prevention into predictive safety management.

Based on these results, several recommendations are proposed for the Port Company of Annaba:

- **Strengthen targeted prevention** in high-exposure units (DMA and handling activities) through specific training and ergonomic improvements.
- **Consolidate safety culture** by increasing worker participation and developing predictive risk analysis tools.
- **Maintain continuous improvement** by reinforcing internal audits and feedback loops to anticipate emerging risks.

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