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Article

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IMPROVEMENT OF ENTERPRISE RISK VISUALIZATION: RISK MAPPING

The object of the study is the risks that disrupt the accomplishment of any enterprise's missions. Therefore, mastering these risks is a significant asset for organizations and the overall health of the enterprise. Thus, working comprehensively on organizational risk prevention enables the enterprise to formulate a strategy aimed at guarding against all risk factors. Simultaneously, it identifies areas where more targeted actions need to be undertaken, potentially leading to positive changes within the company. To achieve this and allow for a robust and reliable assessment for better governance of harmful elements in the enterprise, we have used the risk mapping method. It is a data visualization tool aimed at highlighting vulnerabilities in various processes and activities that an organization faces, even allowing for informed decisions to prevent and cope with risks. Risk mapping is defined as the approach of identifying, evaluating, prioritizing, and managing risks inherent in an enterprise's activities. It even delves into a thorough investigation of all managerial, operational, and support processes that activities require implementing. This mapping technique is based on an objective, structured, and documented description of existing risks. The assessment allows for a more detailed analysis of initial and residual risks at all levels of the enterprise, thereby facilitating the development of a prioritized action plan accompanied by an analysis of its funding. This obligation is part of a continuous improvement approach to the quality of life and working conditions, even engaging in a sustainable management process. As a case study, we have chosen to focus on the SAIDAL Group of Constantine. Through this case study, we aim to illustrate the practical implications and benefits of using risk mapping as a strategic tool for risk management in a complex organizational context. Now, having a risk map not only promotes a proactive approach to risk mitigation but also contributes to broader goals of continuous improvement and sustainable risk management practices: a necessity for any enterprise.

Keywords: *risk mapping, assessment, improvement, sustainable management, managing risks, health and safety at work.*

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1. Introduction

Zero risk does not exist; however, avoidable risk does [1–4]. Risk disrupts the achievement of the missions of any enterprise [5]. Nowadays, mastering these risks is a significant asset for organizations, as the company's well-being is also well-being within the company [6]. Therefore, every company is subject to establishing a level of risk acceptability [7, 8]. As a result, conducting a comprehensive organizational risk prevention approach enables the company to formulate a strategy focused on safeguarding against various risk factors, be they organizational or operational. Simultaneously, it aids in pinpointing specific areas necessitating targeted interventions, potentially prompting behavioral changes [1, 2, 9–12]. To do this, a risk assessment is required, and a risk mapping is constructed. Risk assessment is a complex process that primarily involves assessing the organizational and operational factors that could compromise the health and safety of employees [13]. Subsequently, having a risk mapping allows an organization to better understand its risk profile and obtain specific details regarding the nature and impact of these risks [14, 15]. Risk mapping is a data visualization tool aimed at highlighting vulnerabilities in various processes and activities that an organization faces, and it even enables making informed decisions to prevent and address risks [16, 17].

Nowadays, risk mapping has become a vital tool for anticipating the impact of risks, as it provides a clear and precise visualization of a company's risks in the form of a graph [18, 19]. It is defined as the process of identifying, evaluating, prioritizing, and managing the risks inherent to an organization's activities, and it can even delve deeply into the full spectrum of managerial, operational, and support processes that activities require to be implemented. It enables a more detailed analysis of initial and residual risks at all levels of the company, facilitating the development of an action plan accompanied by a financing analysis [20–23]. This provides the leader with a comprehensive, simultaneously synthesized and precise, view of the identified adverse effects [24]. It is a management tool and

an indispensable lever for steering risks, enabling the maintenance and enhancement of its contemporary performance.

However, since each company's objectives are influenced by its unique culture, the mapping serves as the cornerstone of the enterprise's risk management strategy [25, 26], which is *the aim of this research*. This aim allows determining one's tolerance level. As a case study, it is chosen a joint-stock company, the «SAIDAL Group» of Constantine. Thus, the risk mapping strategy is built upon the company's future vision, aiming to chart a well-defined path. This strategy gradually allows for moving away from individual risk analysis missions to adopting a much broader, integrated, and potentially sustainable structure.

2. Materials and Methods

Risk management enables enterprise to identify the risks it faces, prioritize them, and implement necessary preventive and/or corrective actions. It is a continuous and evolving process designed to establish context, including identifying risk factors, measuring and assessing their severity, designing countermeasures, implementing these measures, and evaluating their performance. Among these objectives, let's find the promotion and maintenance of the highest possible degree of physical, mental, and social well-being of workers across all professions on one hand [27, 28].

Moreover, the prevention of adverse effects on workers' health due to their working conditions for future generations on the other hand [29], even extending to retirement in good health. To achieve this and assess these alterations while governing a quality of life and working conditions (QLWC) within any company, we have utilized risk mapping [30]. The latter is based on an objective, structured, and documented description of existing risks and lessons learned. The description highlights the existence of risks and their probability (occurrence), elements that could exacerbate them (aggravating factors), and the responses provided or to be provided within an action plan. This step aims to establish a typology of risks to which the organization is exposed in the context of its activities. It is not about outlining the theoretical typology of risks an organization might face but conducting a precise assessment to identify, in a specific and well-documented manner, the risks unique to it, including the actual risks encountered in situ. It is a priori risk assessment approach, inspired by the overall risk analysis (ORA), aiming to identify undesirable events that could occur, evaluate existing measures to prevent their occurrence or limit their consequences, and implement actions to reduce the frequency and/or severity of consequences. This approach should serve as a source of progress and continuous improvement in the face of concrete realities, as depicted in Fig. 1.

Presentation of the Group: Currently, SAIDAL is a Joint-Stock Company with a capital of 2.5 billion Algerian Dinars. 80 % of the capital of the SAIDAL Group is owned by the State, and the remaining 20 % was sold in 1999 to institutional investors and individuals [31]. It represents the pharmaceutical manufacturer of generic drugs in Algeria. Founded in 1982 to establish a local pharmaceutical industry capable of ensuring the availability of medicines and improving citizens' access to treatments. Today, SAIDAL is organized as an industrial group specialized in the development, production and commercialization of pharmaceutical products for human use. Its current aspirations include consolidating its position as a leader in the production of generic drugs in Algeria and becoming an essential reference and preferred partner in the Africa and Middle East region. SAIDAL has 09 specialized production factories distributed across Algerian territory, including Constantine Plant 2 dedicated to liquid forms, the focus of our study, in addition to Constantine Plant 1, specialized in the production of insulin in vials and cartridges.

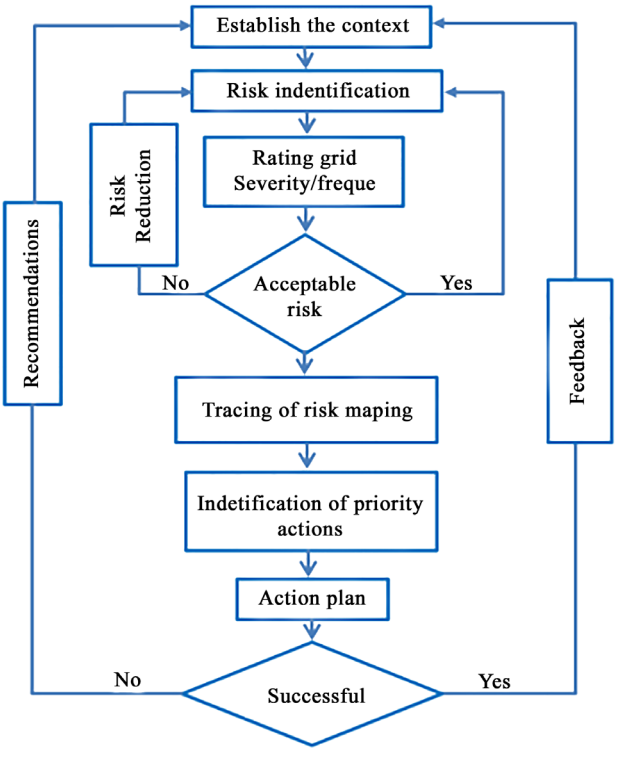

Fig. 1. The essential steps of risk analysis

3. Results and Discussion

3.1. Methodology process. In the first phase of the study, let's divide the company into zones and proceeded with risk identification. To gather all relevant identification data, let's conduct investigations, utilized lessons learned, and conducted direct and structured interviews with those involved. The company was divided into four (04) zones: open-air zone, laboratory zone, production zone, and storage zone. Based on this identification, it is aimed to determine various accident scenarios for each zone and highlight the most critical ones. A list of pre-established generic hazards was chosen, which was further broken down into hazardous events. These hazards are diverse and have been documented as follows, as shown in Table 1.

Once the hazards were identified, let's proceed to establish hazardous situations by cross-referencing the list of hazards with the system elements. The aim was to identify the most vulnerable elements within the system with the identified hazardous events. A total of 39 hazardous situations were identified, namely:

- 13 hazardous situations of priority 1.
- 14 hazardous situations of priority 2.
- 12 hazardous situations of priority 3.

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Table 1

Identified hazards

Generic hazards	Specific hazards	Hazardous events or elements
Environment	Contamination	Lack of hygiene when handling chemicals
	Waste	Inadequate of waste management
Chemical products	Chemical interaction	Non-compliance with work standards
	Fire	Storage and use of chemical products
	Explosion	Chemical substances
Insecurity	Incident	Unqualified laboratory personnel, staff ignorance and negligence
Human factor	Negligence/Malicious intent	Ignorance and/or negligence
Technology	Asphyxiation by the emitted gases	Lack of oxygen and poor ventilation
Materials and equipment	Explosion	Presence of incompatible substances
	Noise	Non-compliant equipment
Management	Human Resources	Poor management and qualification of the staff

In the second phase, let's proceed with the Preliminary Risk Scenario Analysis (APRs) [32]. This analysis involves assessing the system vulnerabilities by detailing the hazardous situations identified in the system APR as scenarios. It involves identifying the feared events, their triggering and initiating events, as well as their potential consequences. In this context, a third component of risk is introduced: risk perception. It is defined by the subjective assessment of severity or probability, referred to as the likelihood of the risk. Perceived risks in a business activity, from the grassroots level to the highest governance level, can be considered as a snapshot of the overall perceived risks of the company. The previously defined criticality matrix makes it possible to prioritize the identified risks. Thus, the decision framework is constructed based on severity and likelihood scales, as shown in Table 2. This allows to qualify the acceptability of the risk and to visualize the criticalities [33] as depicted in Fig. 2.

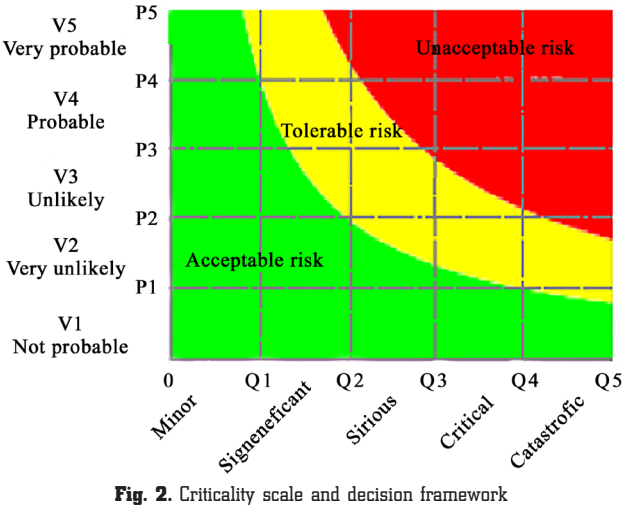


Fig. 2. Criticality scale and decision framework

These scales allow to prioritize risks, establishing the action items to be implemented within the enterprise and even formulating an action plan that meets the organization's expectations.

In the third phase, let's proceed with the determination of risk mapping. The statistical processing of hazardous situations and different scenarios mainly results in establishing the initial and residual risk mapping by hazard and system elements. The analysis results and assessment of initial and residual risks are visualized through two diagrams (Kiviat and Farmer), known as risk maps, shown in Fig. 3.

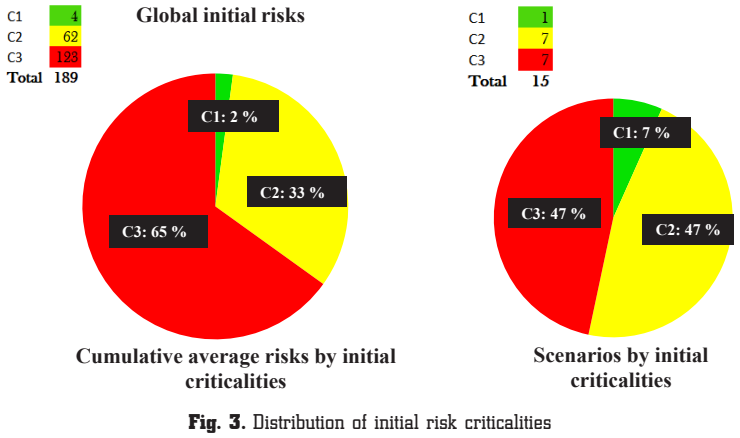


Fig. 3. Distribution of initial risk criticalities

Table 2

Severity and likelihood rating scales

Criticality classes	Titles of class	Titles of decisions and actions
C1	Acceptable	No action needs to be taken
C2	Tolerable under control	It is necessary to establish a risk management monitoring system
C3	Unacceptable	It is necessary to eject the situation and implement risk reduction measures; otherwise, it is necessary to reject all or part of the activity

As a reminder, the Kiviat diagram visualizes the average initial and residual risks [34]. Its representation allows for visualizing the level of criticality for risks related to classes of generic hazards or system elements. It facilitates comparisons of risks on each axis and provides an overall view of risk before and after implementing risk reduction actions. On the other hand, the Farmer diagram visualizes the source (severity or likelihood) of initial and residual risks associated with classes of generic hazards or system elements. As an outcome of the comprehensive evaluation of initial risks. As a result, of the overall analysis of initial

risks, there is the distribution of initial criticalities as shown in Fig. 3.

Among the 15 identified scenarios, there are:

– 47 % of them were classified with a criticality of 2 «tolerable under control», justifying a risk management and monitoring approach;

– 47 % of them were classified with a criticality of 3 «unacceptable». They require a risk mitigation and reduction approach;

– 6 % of them were classified with a criticality of 1 «acceptable». They need a daily risk management approach.

The risk reduction process is based on the concept of risk criticality, which can only be implemented when risk governance has initially categorized all activity risks into three zones corresponding to their criticality, following the ALARA principle (As Low As Reasonably Achievable). Thus, once risk reduction actions have been implemented, the analysis shows that there are no longer any scenarios with an unacceptable Criticality Level 3. The following diagram visualizes the distribution of residual criticalities, as shown in Fig. 4.

The results show that 6 % of the remaining scenarios remain at Criticality 2, «Tolerable under control», which will be subject to residual risk monitoring. These control actions are defined within safety parameters. Similarly, the distribution of the average risk criticalities is slightly different. However, the cumulative average risks of Criticality 2 scenarios represent a higher weight of 68 %. As a result, the analysis and assessment results of initial and residual risks are visualized through two diagrams (Kiviat and Farmer), known as risk maps. The number of hazardous situations and scenarios analyzed by hazards is presented in Fig. 5.

Due to the specificity of the pharmaceutical activity, it is observed that the exposure rate to hazards related to chemical products is the highest compared to other hazards. These results are presented in Fig. 6.

As a result, this mapping provides with a comprehensive diagnosis of risks at all levels of the company. This allows to represent the min-max ranges, which depict both the spread of values across different activities within a given sub-process or process, as well as the dispersion of collected values of parameters when the same activity is audited multiple times (for example, if it is distributed across multiple sites). Analyzing this dispersion is equally fundamental as analyzing mean values and can highlight dysfunctions or heterogeneous perceptions of the same hazard. Such heterogeneity often reveals operational issues. Therefore, to clarify our risk mapping, let's proceed to the following analyses.

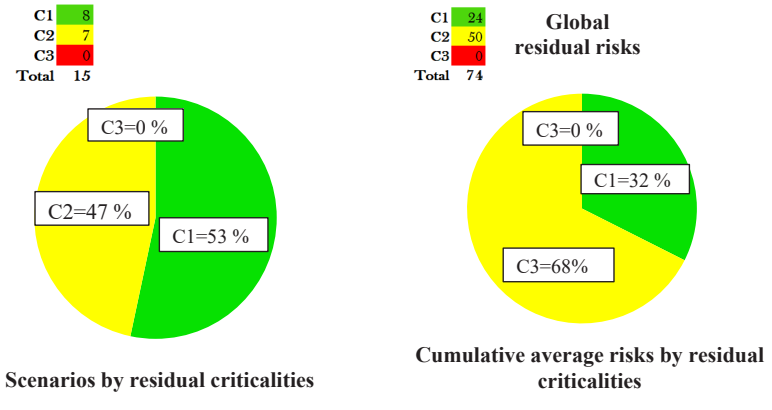
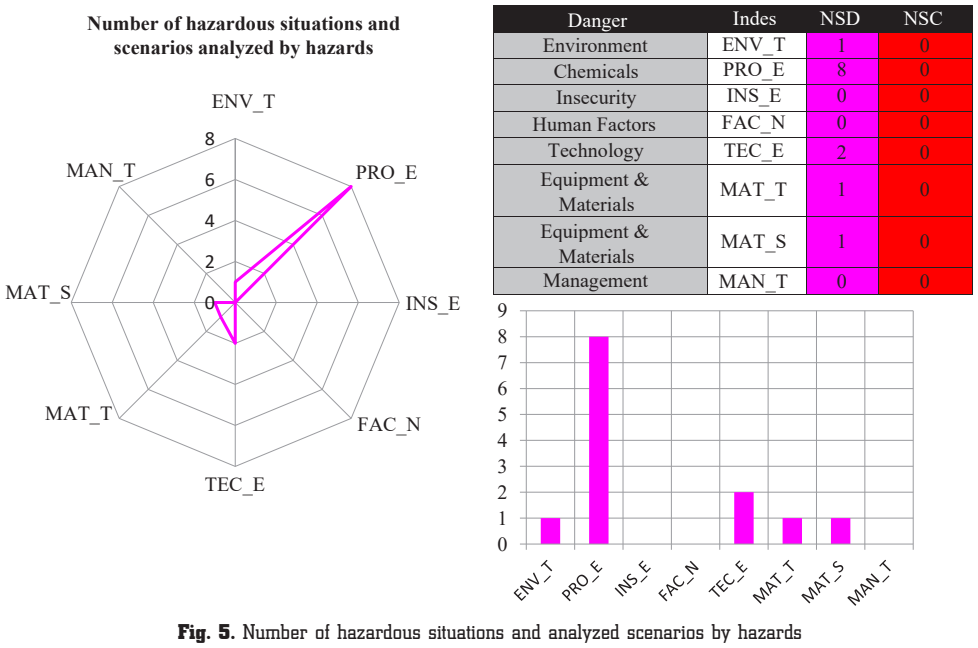


Fig. 4. Distribution of residual average risks by criticality class



Danger	Indes	NSD	NSC
Environment	ENV_T	1	0
Chemicals	PRO_E	8	0
Insecurity	INS_E	0	0
Human Factors	FAC_N	0	0
Technology	TEC_E	2	0
Equipment & Materials	MAT_T	1	0
Equipment & Materials	MAT_S	1	0
Management	MAN_T	0	0

Fig. 5. Number of hazardous situations and analyzed scenarios by hazards

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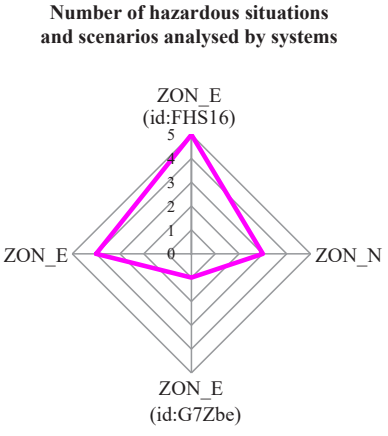

Zone	Index	NSD	NSC
Laboratory area	ZON_E (id:FHS16)	5	0
Production area	ZON_N	3	0
Storage area	ZON_E(id:G7Zbe)	1	0
Open Air area	ZON_E	4	0

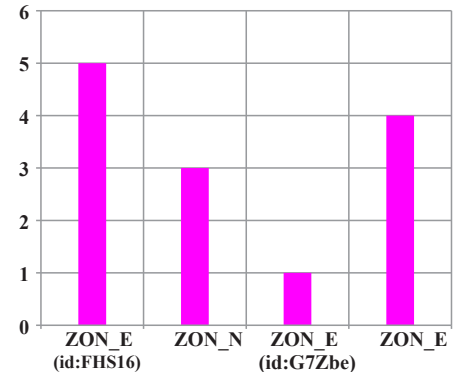

Fig. 6. Number of identified hazardous situations and analyzed scenarios by system

within the acceptable zone. Nevertheless, this diagram indicates that most risks need to be monitored. Additionally, risks related to Constantine Plant 2 are in the Criticality 3 (unacceptable) zone.

The analysis of the initial average risk mapping by hazards, represented by the Farmer diagram, shows that the majority of hazards are positioned above the red hyperbola, indicating that the safety of the system is compromised, as shown in Fig. 8.

Regarding the average residual risks, the Farmer Diagram reveals that hazards related to technology and chemicals have been mitigated and pass into the acceptable zone after treatment.

It should be noted that risks associated with environmental hazards, equipment and materials, and human factors, after being treated through risk reduction measures, remain within the tolerable zone under control.

3.2. Generic hazard analysis. The initial risk mapping is represented in Fig. 7.

The analysis of the Kiviat diagram of initial risks shows that only the risks related to chemical products are tolerable under control, while risks related to the environment, human factors, and equipment are unacceptable (gap between average risk and maximum risk), gap=«0». The average risks of other hazards (technology) are tolerable under control but close to unacceptable. However, the residual risk mapping shows that after implementing actions to reduce initial risks, all risks fluctuate within the «tolerable under control» zone, and risks related to chemical products fluctuate

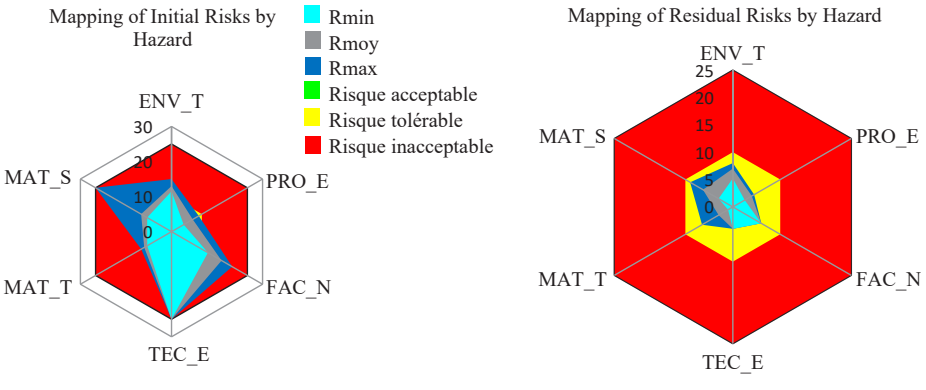

Fig. 7. Residual risk mapping using KIVIAT diagram

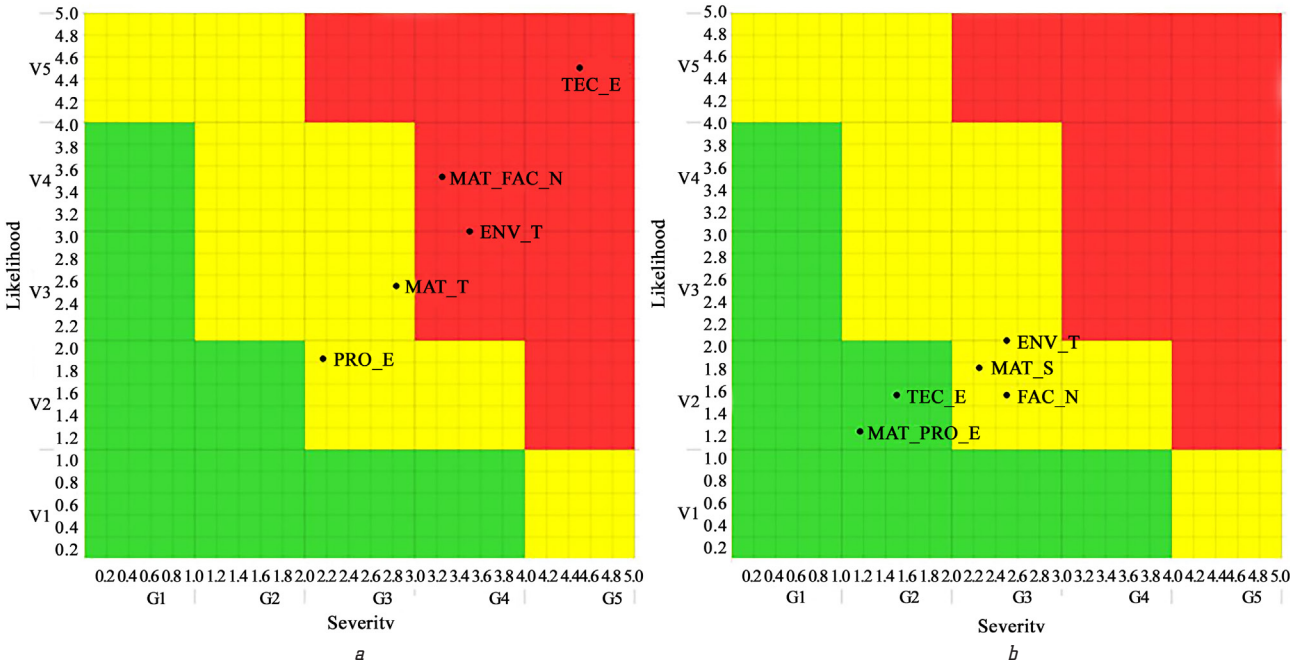

Fig. 8. Farmer diagram: *a* – mapping of initial risks by hazard; *b* – mapping of residual risks by hazard

3.3. System analysis. *Risk Mapping by Zone:* The results are presented in Fig. 9.

The analysis of the Kiviat diagram for initial system risks shows that only the risks related to the laboratory zone and the storage zone are unacceptable. The risks associated with the open-air zone and the production zone are at their maximum, bordering on unacceptable, and require control (gap between average risk and maximum risk), gap=«0».

After treatment and the implementation of preventive measures, the analysis of residual system risks (zone) demonstrates the potential to minimize risks by zones. With simple measures, the open-air and production zones transition from maximum risk to acceptable risk. However, the mapping of residual risks, as shown in Fig. 10, illustrates that after the implementation of the risk reduction action plan, let's observe that three zones have moved out of the unacceptable region. The production zone has transitioned from the unacceptable region to the tolerable region, primarily due to the implemented measures and the unique characteristics of this zone. However, the storage zone has shifted from the tolerable region to the acceptable region with strict measures and stringent access conditions. Both the laboratory and open-air zones remain in the tolerable region due to their specific nature. The laboratory zone is influenced by the handling of chemicals, whereas the open-air zone's access is not controlled by authorization. Both of these zones will require daily monitoring.

The analysis of the initial average risk mapping by phases described in the Farmer diagram, Fig. 10, indicates that most of the risks associated with the phases are within the unacceptable zone. Consequently, the Open-air and Storage zones transition from unacceptable risk to tolerable risk under control. It is noteworthy that the production and laboratory zones move into the acceptable zone after treatment through risk reduction actions.

3.4. Global risk analysis by hazards and initial criticality classes. The analysis of the Kiviat diagram for global risks by hazards and initial criticality classes, shown in Fig. 11, indicates that only the risks associated with the laboratory zone and the storage zone are unacceptable. Moreover, the risks linked to the open-air zone and the production zone are at their maximum, bordering on unacceptable zone, and require control (gap between average risk and maximum risk), gap=«0».

The analysis of residual system risks (zone) demonstrates that after treatment and preventive measures, it is possible to minimize risks by zones. With simple measures, the open-air and production zones transition from maximum risk to acceptable risk.

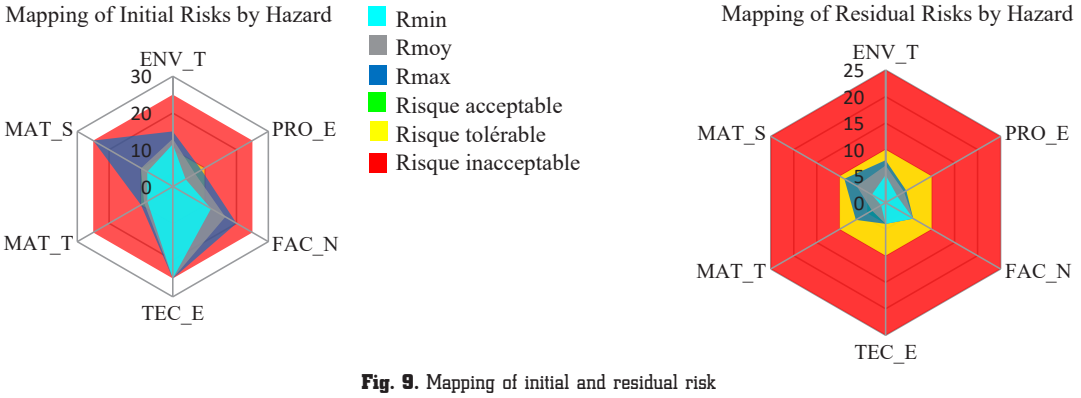

Fig. 9. Mapping of initial and residual risk

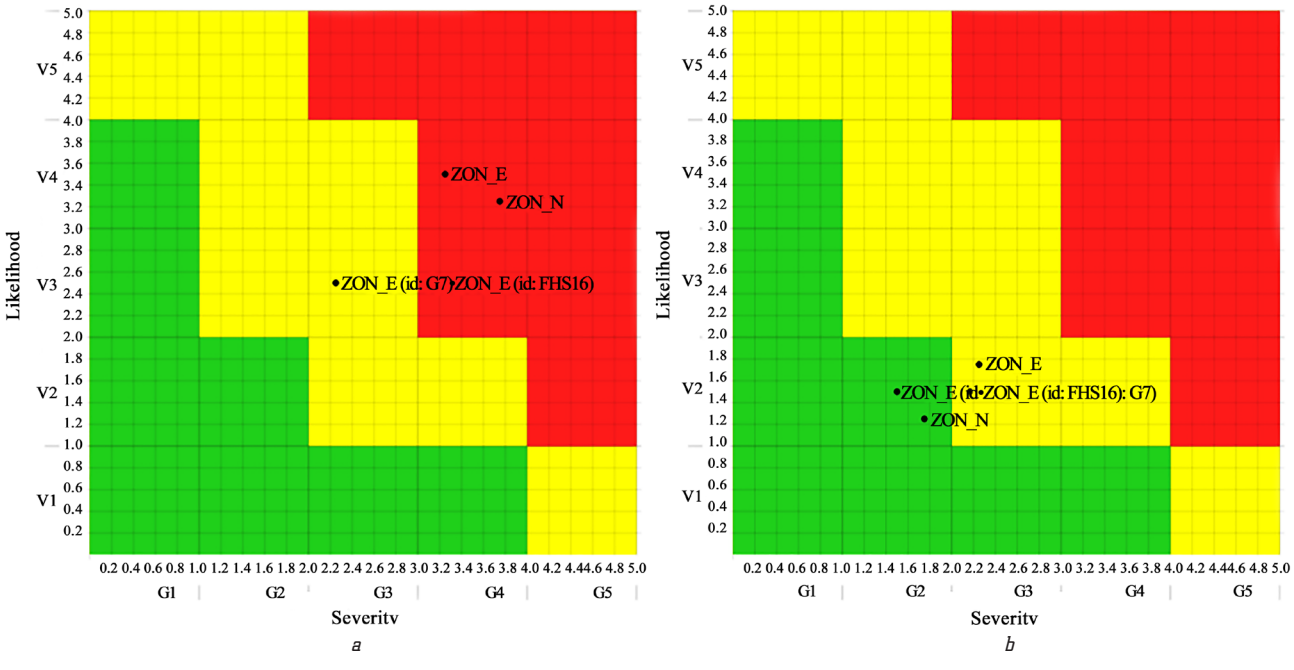

Fig. 10. Mapping of: *a* – initial system risks; *b* – residual system risks

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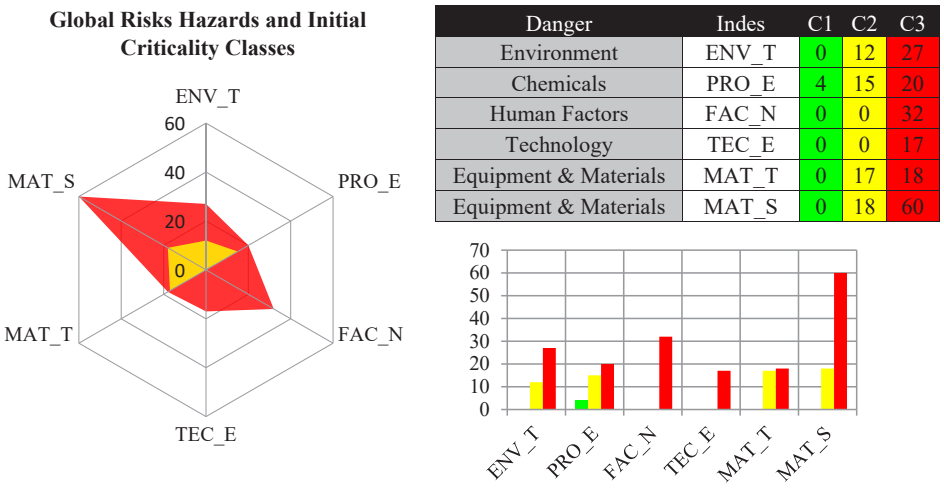
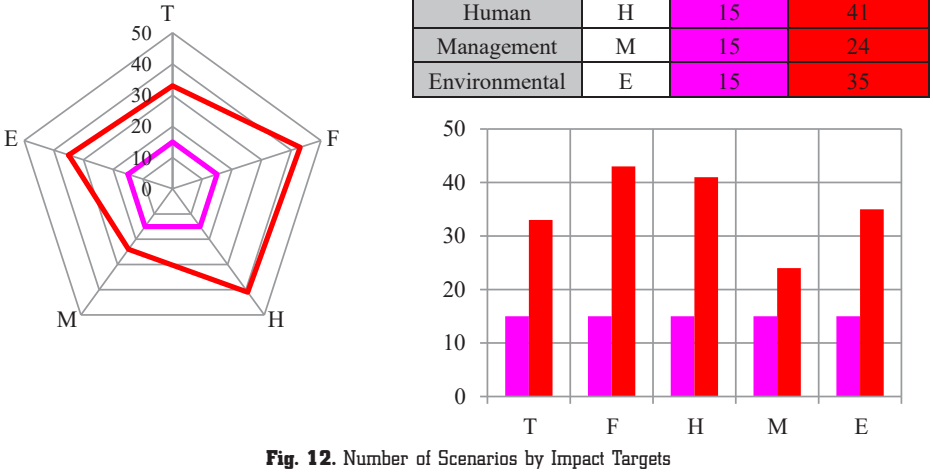


Danger	Indes	C1	C2	C3
Environment	ENV_T	0	12	27
Chemicals	PRO_E	4	15	20
Human Factors	FAC_N	0	0	32
Technology	TEC_E	0	0	17
Equipment & Materials	MAT_T	0	17	18
Equipment & Materials	MAT_S	0	18	60

Fig. 11. Global risks by hazards and initial criticality classes

3.5. Impact target analysis. The analysis of the Kiviat diagram for the number of scenarios by impact target, depicted in Fig. 12, highlights that the identified scenarios primarily exhibit a financial impact. Any damage within the company leads to significant financial losses. Following this, there is the human impact, which is not negligible, as incidents such as fires or explosions could result in fatalities. Environmental impact comes next, involving the degradation of assets or the work environment. However, regarding technical impact, it could have consequences on pharmaceutical production, causing delivery delays and subsequently affecting the entire management strategy of the company (gap between average risk and maximum risk), gap = «0». level of risk. Creating a risk map provides a clear view of various risk factors, enabling decision-makers to take appropriate measures. Statistical processing of the mapping of hazardous situations and different primarily scenarios helped to determine the mapping of initial and residual risks by hazard and system elements. This approach relies on the quality of information and data collected on the system, following various approaches, whether qualitative, semi-quantitative, or quantitative. However, it is important to note that residual risk persists in daily management and must be constantly considered. This residual risk must be evaluated in comparison to acceptable risk, a concept encompassing economic, social, and psychological dimensions. Risk acceptability is a subjective concept depending on socio-economic context, culture, and individual attitudes (risk aversion) of decision-makers and evolves over time.



Impact target	Indes	N	Weight
Technical	T	15	33
Financial	F	15	43
Human	H	15	41
Management	M	15	24
Environmental	E	15	35

Fig. 12. Number of Scenarios by Impact Targets

Thus, the analysis of the Kiviat diagram of initial risks reveals that only risks related to chemicals are tolerable under control, while risks related to the environment, human factors, and equipment are acceptable (gap between average risk and maximum risk equal to «0»). However, the analysis of the mapping of average initial risks by hazards, represented by the Farmer diagram, shows that most hazards position themselves above the red hyperbola, indicating a compromise to the system's safety.

3.6. Discussion. For effective management in an enterprise, consideration of quality of life and working conditions must be integrated into strategic objectives to be taken into account on a daily basis. This is essential to anticipate the impacts of economic changes, constituting a crucial step in every prevention initiative. An appropriate prevention strategy involves a precise, detailed, and documented evaluation of risks specific to the enterprise, as well as the reality of in situ risks, to determine optimal solutions to minimize the overall level of criticality necessary to achieve an acceptable

Therefore, the mapping of residual risks shows that after implementing actions to reduce initial risks, all risks fluctuate in the «tolerable under control» zone, while risks related to chemicals fluctuate in the acceptable zone. However, this diagram emphasizes that most risks require continuous monitoring. Due to the specificity of pharmaceutical activity, it is found that the exposure rate to risks related to chemicals is the highest compared to other risks, requiring an effective response in dynamic management strategies.

However, this approach has some limitations. On one hand, the «frequency» and «severity» components are not necessarily independent, which can skew results when calculating the criticality level of certain risks compared to others. Indeed, the notions of occurrence frequency and severity are rarely determined absolutely certain. Other variables of psychosociological or cognitive dimensions come into play, likely to influence the value attributed to these two essential criteria in risk assessment. Moreover, this largely depends on knowledge, interpersonal relationships, and individual experiences. These elements can lead to errors related to the frequency or severity of risks, as well as their immediate or delayed consequences. This can manifest in the form of denial, collective repression of danger, or conversely, exaggerated catastrophism, unnecessarily and unjustifiably mobilizing resources.

3.7. Recommendations. The most effective prevention strategy is primary prevention, achieved through the implementation of technologies that enable actions on products (elimination or use of substitution products with lower potential impact on humans) and/or actions on processes (use of equipment or machinery that minimizes impacts, such as very low atmospheric emissions, low noise levels, etc.). Employees should also be informed and educated about the hazardous substances being used and trained in safe professional practices.

Safety Data Sheets (SDS), which are mandatory for any hazardous chemical product, contain information about the toxicity of the products. Additionally, enhanced medical monitoring is required for employees exposed to chemical risks.

4. Conclusions

This work allowed to identify the various risks present in situ, evaluate them, and prioritize them, pinpointing the most dangerous ones within the unit. This enabled to direct our actions towards the prioritized decisions without disrupting the scheduled daily activities. However, despite the preventive measures taken, eliminating all risks at once appears practically impossible, and residual risk is constantly present in the workplace, a factor that should not be overlooked in daily management. This residual risk must be compared to the acceptable risk, a notion encompassing economic, social, and psychological dimensions. The acceptability of risks is a subjective concept depending on the socio-economic context, culture, and individual attitudes (risk aversion) of decision-makers, evolving over time. As a result, preventive measures are adapted, taking into account the realities of each work situation, and, above all, considering individuals. At the end of this process, the employer has a map of initial and residual risks by danger and by system elements based on the quality of information and data collected on the system, providing a clear picture of various risk factors. This allows decision-makers to take appropriate actions in line with production expectations. This approach can be generalized to other sectors. Consequently, every company, regardless of its size or industry, must comply with its health and safety obligations. Now, the use of computer tools (classification, evaluation, risk prioritization) is a crucial tool for implementing comprehensive risk management. Although the development of this tool relies on a one-time mobilization of stakeholders to identify and assess risks, despite the particularly heavy implementation procedure, it has credible and shared data to master and define prioritized actions.

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Conflict of interest

The authors declare that they have no conflict of interest in relation to this study, including financial, personal, authorship, or any other, that could affect the study and its results presented in this article.

Financing

The research was performed without financial support.

Data availability

The manuscript has no associated data.

Use of artificial intelligence

The authors confirm that they did not use artificial intelligence technologies when creating the current work.

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