The Eurasia Proceedings of Health, Environment and Life Sciences (EPHELS)
ISSN: 2791-8033

The Eurasia Proceedings of Health, Environment and Life Sciences (EPHELS), 2023

Volume 12, Pages 31-36

ICMeHeS 2023: International Conference on Medical and Health Sciences

Assessment of Occupational Risks Associated with Chemical Reagents in the Hemobiology Laboratory of an Eastern Algerian University Hospital Center

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Abstract: The variety and diversity of chemicals handled in hospital laboratories make it imperative to conduct periodic risk assessments for enhanced protection of medical personnel and the implementation of an appropriate prevention policy. It is within this context that our study was conducted in the hemobiology laboratories of an eastern Algerian university hospital center. We employed a semi-quantitative assessment method tailored to the specificities of hospitals. An inventory of chemical agents was conducted using data collection sheets detailing the product names, quantities, and frequencies of use. Relying on information from the Safety Data Sheet (SDS) and associated pictograms.We characterized the hazards posed by these chemicals and prioritized their associated risks. The hemobiology laboratory staff use 49 chemical reagents, with 28% of them considered hazardous, demanding appropriate safety precautions. The study highlighted the significance of systemic and local cutaneous effects, such as sensitivity (94.6%). Ocular risk, with severe injuries, was caused by 33.3% of the reagents. Seventeen reagents could lead to respiratory systemic effects. Ten reagents posed a carcinogenic, mutagenic, and reprotoxic (CMR) risk, such as Chloroform, Formaldehyde, ADVIA Perox 1, ADVIA Perox 2, ADVIA Perox 3. This evaluation has highlighted the multiple health risks faced by the personnel in the hemobiology laboratory. It is imperative to establish a comprehensive strategy for managing occupational risks to ensure the long-term protection of the workers.

Keywords: Chemical reagents, Chemical risks, Hemobiology laboratory, Risk assessment.

Introduction

Hospital laboratories, especially those specialized in hemobiology, expose their personnel to significant occupational risks due to the use of potentially hazardous chemicals. This arises from the very nature of laboratory activities and the diversity of chemicals handled. To date, the exposure of hospital staff to chemical agents remains poorly understood. (Berrubé and al., 2013; Baurès , 2016). The assessment of chemical risk is often less systematic and less prioritized.

However, the handled chemical reagents possess numerous toxic, corrosive, and flammable properties, which can have detrimental consequences on the health of personnel and the environment. Thus, the significant exposure of handlers to chemical reagents and the inefficacy of preventive measures underscore the importance of managing this risk to safeguard their health and ensure a higher quality of analyses. Ultimately, this contributes to the protection of patients' health (Dumas & Persoons, 2004; Vincentet al., 2005).

To ensure the safety of personnel, it is imperative to conduct periodic risk assessments, given the diversity of chemicals used. Moreover, substances classified as Carcinogenic, Mutagenic, and Reprotoxic (CMR) are subject to stringent regulations regarding their handling and the use of appropriate protective equipment. Consequently, their identification is a crucial preliminary step to enhance information and personnel protection (Dumas & Persoons, 2004; INRS, 2023a, 2023c). These assessments are essential for establishing an appropriate prevention policy and enhancing the protection of medical personnel in hospital laboratories (INRS, 2023b). In this context, a semi-quantitative methodology for the assessment of chemical risk was conducted in the hemobiology laboratories of a university hospital center in eastern Algeria.

Materials and Method

This is a cross-sectional descriptive study conducted at the hemobiology laboratory of an Algerian university hospital center. For the assessment of chemical risk, we opted for a semi-quantitative evaluation method adapted to the specificities of hospitals. The data for our study were collected from various sources to provide a comprehensive approach to the evaluation of chemical risks.

Data Inventory

We utilized a census form to systematically record specific information regarding the overall organization of hemobiology laboratories and units, equipment, medical, paramedical, and technical-administrative personnel, as well as tasks performed and the frequency of their execution. An inventory of chemical reagents was conducted using data collection forms that included product names, quantities, physical and chemical characteristics, toxic properties, usage precautions, handling procedures, storage measures, and frequency of use.

The commercial name of the product and the supplier's name were used to access the chemical product's Safety Data Sheet (SDS). The information provided in an SDS is categorized based on various criteria, including the nature of the preparation (hazardous or non-hazardous), the concentration of the chemical agent in the preparation, the presence of an occupational exposure limit (OEL), and potential risks to health and/or the environment. (Berrubé et al., 2013).

Chemical Risk Prioritization

Classes of Hazard

Based on the information provided in the SDS and associated pictograms, we assessed the hazards posed by the chemical products and established a hierarchy of associated risks. Health effects are categorized into three levels of hazard: Level 1 (slightly or moderately hazardous), Level 2 (hazardous), and Level 3 (highly hazardous). The risks associated with chemical products are linked to their toxicological, physico-chemical, and eco-toxicological properties. However, the method we employed focuses solely on toxicological hazards, which are further categorized into 9 hazard classes based on their effects on health. The prioritization of hazards is limited to the risk phrases (R phrases present in the SDS).

Exposure Analysis

To analyze personnel exposure to chemical hazards, we carefully specified the frequency of handling, the quantities manipulated, and the effectiveness of protective devices. Based on the hazard levels identified by the R risk phrases, it is possible to calculate the Hazard Index (HI) using the following formula:

IH = 10^ (hazard level)

An Exposure Index (EI) defines the potential exposure criterion and varies from 0.1 to 1. It is calculated using the following formula:

EI = 0,1 x « frequency » x « quantity of product » (Persoons and al., 2008)

We also calculated the risk index using the following formula, which helps prioritize preventive actions based on the level of risk.

Risk Index = Hazard Index x Exposure Index x Protection Index (CNRACL, 2007)

The various risk scenarios are documented in Table 1.

Table 1. Correspondence between RI, risk level, and the type of situations.

Risk Index	Risk Level	Situation
RI < 4	Low	Non-priority
4 ≤ RI ≤ 40	Moderate	Intermédiaires. May require further assessment.
RI ≥ 40	High	Priority

Results and Discussion

After compiling an inventory of 49 chemical products, specifically identifying them by their commercial names, we then proceeded to assess the associated hazard levels of these products and calculate the corresponding risk indices. In our study, we found that 28% of the chemical products were hazardous, necessitating the implementation of appropriate safety measures. This categorization classifies them into a high-risk category, requiring special attention. These products included dyes used in cytology such as May Grunwald Giemsa, certain fixatives like methanol and formaldehyde, and solvents such as chloroform and phenol.

The data analysis reveals that 27% of the reagents pose a low risk of causing systemic skin reactions, as their risk index is below 4, categorizing them as acceptable risk. Additionally, 40.6% of the reagents display a skin irritation risk index below 4, indicating a low risk, also placing them in the acceptable risk category. Furthermore, 27% of the reagents obtain a risk index below 4 for skin burns upon exposure, signifying a low risk in this scenario. Examples of these types of chemical reagents are listed in Table 2.

Table 2. Examples of chemical products with skin risk, accompanied by their hazard level and risk index.

Effect Type	Chemical Products	Hazard Level	Risk Index	Risk Level
Skin Irritation	Methylene Blue	1	0.06	
	Hematein	1	0.06	
	Chloroform	1	0.02	27 %
	Brilliant Cresyl Blue	1	0.04	Low risk
	ADVIA perox1, 2 et 3	1	0.04	
Skin Burn	Formaldehyde	2	0.6	
	Hydrochlorique Acide	2	0.4	40.6 %
	Aqueous Phenol	2	0.2	Low risk
	CELL Clean	2	0.2	
Systemic Skin	MAY GRUNWALD solution	2	0.6	
Toxicity	GIEMSA solution	2	0.6	
	Formaldehyde	2	0.6	27 %
	Xylene	1	0.02	Low risk
	Methanol	2	0.6	

The analysis of ocular risks reveals a diversity among the examined chemicals. Approximately 12.5% of these products pose a minimal risk of ocular irritation, considered acceptable. In contrast, 18.8% of them exhibit a moderate risk of ocular irritation, requiring further assessment. Only 2% display a high risk in terms of ocular irritation. Finally, 29% of the chemicals receive a high-risk index for severe ocular injuries, placing them in a category of unacceptable risk. Examples of these types of chemical reagents are listed in Table 3.

Table 3. Examples of chemicals with ocular risk, along with their hazard level and risk index.

Effect type	Chemical products	Hazard level	Risk index	Risk level
Eye irritation	MAY GRUNWALD solution	1	6	
	GIEMSA solution	1	6	- 12.5 % Low risk
	Methylene Blue	1	6	- 18.8% Moderate
	Brilliant Cresyl Blue	1	4	risk
	CELL Clean / CELL Pack	3/1	200/2	2 % High risk
	ADVIA perox1, 2 et 3	1	0.04	
Severe eye injuries	Formaldehyde	3	600	
	Hydrochloric acid	3	400	
	Aqueous Phenol	3	200	29 % High risk
	Chloroform	3	200	
	Potassium ferrocyanide	3	600	

Regarding respiratory risks, it should be noted that: 6% of the chemicals have a moderate risk index for systemic respiratory effects, placing them in an intermediate category that requires a comprehensive assessment of chemical risks. In contrast, 21% of the chemicals have a high-risk index for systemic respiratory effects, categorizing them as a priority group associated with an unacceptable risk. Finally, 8% of the chemicals pose a high risk of local respiratory effects, placing them in a priority category associated with an unacceptable risk. Examples of these types of chemical reagents are listed in Table 4.

Table 4. Examples of chemicals with respiratory risks, along with their hazard level and risk index.

Effect type	Chemical Products	Niveau de danger	Indice de risque	Niveau de risque
Systemic respiratory effect	MAY GRUNWALD solution	2	60	- 6%
	GIEMSA solution	2	60	Moderate
	Formaldehyde	2	60	risk
	Xylene	2	20	- 21 % High
	Chloroform	2	20	risk
	ADVIA cn-free HGB / ADVIA defoamer	3 /3	400/400	
Local respiratory effect	Methylene Blue	2	60	
	Hydrochloric acid	2	40	8 % High
	Brilliant Cresyl Blue	2	40	risk
	White diff	2	40	

The chemical reagents, namely ADVIA perox 1, ADVIA perox 2, ADVIA perox 3, ADVIA shealth, Fuchine basique, Gene expert, Noir soudan B, and Phénol aqueux, are all classified as carcinogens, with a hazard level of 3, representing a high health risk (Table 5).

Table 5. Chemicals with carcinogenic, mutagenic, or reprotoxic (CMR) risks

Chemical Products	Type of risk	Hazard level	Risk index
ADVIA perox 1	Carcinogenic	3	4
ADVIA perox 2	Carcinogenic	3	4
ADVIA perox 3	Carcinogenic	3	4
ADVIA shealth	Carcinogenic	3	4
Chloroform	Carcinogenic	3	200
	Reprotoxic	2	20
Formaldehyde	Carcinogenic	3	600
	Mutagenic	3	600
Basic fuchsin	Carcinogenic	3	6
Gene expert	Mutagenic	3	2
Sudan Black B	Mutagenic	3	4
Aqueous Phenol	Mutagenic	3	2

The chloroform is doubly classified as a carcinogen (hazard level 3) and toxic for reproduction (hazard level 2). Prolonged or repeated exposure to chloroform increases the risk of developing certain types of cancer, including liver and kidney cancer. Additionally, exposure during pregnancy enhances the risk of complications and

adverse effects on fetal development. It is crucial to take appropriate precautions to minimize exposure to chloroform and thereby reduce these health risks (Dumas & Persoons, 2004; INRS, 2023a).

Formaldehyde is also doubly classified as a carcinogen and mutagen, with a hazard level of 3 for both types of risks. Prolonged exposure to formaldehyde can increase the risk of developing certain types of cancer, including nasopharyngeal and sinus cancer. In addition to the carcinogenic risk, evidence of reproductive toxicity is established in animal studies, including fetal developmental anomalies and a decrease in fertility. It is crucial to take adequate measures to reduce exposure to formaldehyde and thereby minimize these health risks.

Conclusion

This in-depth study on the risk assessment of chemical reagents in hemobiology laboratories in Annaba has revealed significant risks associated with certain commonly used chemical reagents, including formaldehyde, staining reagents, and detergents. These substances have been identified as potentially causing respiratory and skin problems among laboratory personnel.

Recommendations

Our results underscore the vital importance of implementing appropriate safety measures during the handling and use of these chemical reagents in a clinical environment. It is essential to adhere to safety guidelines, wear appropriate personal protective equipment, and minimize exposure to these substances as much as possible to reduce health risks for medical personnel and patients.

Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPHELS journal belongs to the authors.

Acknowledgements or Notes

* This article was presented as a poster presentation at the International Conference on Medical and Health Sciences (www.icmehes.net) held in Antalya/Turkey on November 16-19, 2023.

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To cite this article:

Moufida, G., Djoumana, C., Meriem, K., Sara, C., & Nadia, T. B. (2023). Assessment of occupational risks associated with chemical reagents in the hemobiology laboratory of an eastern Algerian university hospital center. *The Eurasia Proceedings of Health, Environment and Life Sciences (EPHELS), 12,* 31-36.