

Using the ELMERI Observation Method to Investigate and Compare Laboratories at Isfahan Public Health School in Terms of Occupational Health and Safety

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Abstract

Aims: The present study aims to investigate laboratory safety situations using the ELMERI observation method. **Methods:** This cross-sectional study was conducted in 2023 in the Faculty of Health, Isfahan University of Medical Sciences laboratory. The survey data were applied with the ELMERI observation method, and the laboratories' safety indicators were evaluated. **Results:** The findings provide important insights into the current state of laboratory safety. The average ELMERI index score for the laboratories was 69.32, indicating that overall health and safety performance is at an average level. Laboratories in five dimensions of building safety, safety of devices and equipment, personal safety, safety of chemicals, and waste management were at a good level. However, in three dimensions of electrical safety, fire safety, and safety management and the dimension of emergency response management, there is room for improvement. **Conclusion:** The general safety situation in the laboratories is at an average level, highlighting the need for better planning at the university and faculty levels. Enhanced planning is essential for improving safety management, particularly in emergency response and can have a significant impact on occupational health and safety in laboratories.

Keywords: ELMERI, laboratory, safety

INTRODUCTION

Statistical results indicate that accidents cost an estimated 70 billion dollars annually worldwide. While risk is inevitable, the need for effective risk management is urgent. Incidents can be minimized through an effective risk management programme, especially in large-scale incidents that often lead to the loss of many human lives and cause enormous environmental and material damage. This need for more effective risk management is a key motivation for our research.^[1]

Educational centers play a vital role in crisis management, but incidents still occur despite safety measures in areas such as laboratories and libraries, leading to injuries, damage, and disruption. Universities, which often have educational and research laboratories, must ensure safety since many inexperienced students work with materials and equipment, requiring careful engineering and planning.^[2]

In the last few decades, there have been numerous significant incidents causing casualties, economic losses, and damage to valuable documents in educational institutions. According to the US government statistics, nearly 10,000 incidents were reported in research laboratories in 2005.^[3] Between December 1997 and May 2004, 21 incidents occurred in Taiwanese university laboratories, injuring faculty, and students.^[4,5] An explosion in the biochemistry laboratory of Tarbiat Modares University in Tehran in 1375 led to the death of one person and the destruction of laboratory equipment.^[6] The

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laboratory environment poses potential risks due to dangerous chemicals, complex devices and equipment, and special working methods. If the safety and health of the laboratories are not given, adequate attention, accidents, and personal and financial damages are likely. Therefore, laboratories are important businesses that require thorough research.

Occupational safety is addressed through various methods, such as laws, standards, guidelines, inspections, and safety management analysis. Techniques include management monitoring and risk tree diagram, energy tracking and protection analysis, preliminary hazard assessment, hazard and operability study, risk assessment by operation and support hazard analysis, and the ELMERI method. Each method has unique characteristics and limitations depending on the specific field.^[7,8]

The ELMERI method was developed in Finland in 1990 and is commonly used in various manufacturing industry sectors to assess occupational health and safety. This method provides numerical information about the potential causes of accidents and the effectiveness of safety and health management systems. It helps identify the development needs, establish goals, and evaluate the results of precautionary measures in occupational health and safety. ELMERI can be used as a feedback tool to develop safe behaviors based on the entire work context in a workplace or from representative sampling. The ELMERI observation method aims to improve the current situation by conducting observations weekly, monthly, or at intervals determined by the users. This allows security vulnerabilities identified in previous audits to be kept under the constant control. The ELMERI method measures the effectiveness of the occupational health and safety (OHS) management system with numerical data and helps measure corrective and preventive action steps. In addition, the ELMERI observation method indirectly supports OHS training. Furthermore, the method can be adapted to the specific needs of laboratories, ensuring a thorough assessment of both general and specialized safety concerns. This approach emphasizes ongoing safety education, feedback, and improvements, making it particularly effective in dynamic and high-risk environments such as research laboratories, where traditional safety measures may fall short.^[9-12]

Laitinen applied this method to 60 companies producing metal products and found a significant correlation between the safety index and the percentage of accidents. When inspectors are trained, this method provides reliable results and can be used to determine the risks of accidents.^[13] Furthermore, Dalyan *et al.* utilized this method to investigate and compare several research laboratories concerning occupational safety and health. They recommended using the ELMERI method for assessing laboratory safety.^[12]

The ELMERI monitoring method is considered an effective way to measure the number of errors and behaviors of workers. It is believed to be more accessible and simpler to use than other methods. This study examines the implementation of

occupational health and safety in the laboratories of Isfahan Faculty of Health. In addition, it analyzes and evaluates work safety precautions based on the ELMERI method and assesses safety indicators calculated from the laboratories.

MATERIALS AND METHODS

The present cross-sectional study was conducted at Isfahan Public Health School in 2023. The research covers 10 laboratories in the environmental health engineering department, including waste, environment, hydraulics, environmental toxicology, environmental health research, molecular biology, central instrument analysis, environmental microbiology, environmental chemistry, and air pollution. There are also five occupational health and safety engineering laboratories including safety, toxicology, chemical agents, physical factors, chemical agents research, and industrial ventilation. In addition, there are three laboratories related to nutrition, namely molecular biology, food microbiology, and food chemistry.

This study's tool was an audit checklist designed using a model of the Finnish Institute of Occupational Health's ELMERI index. Malakoutikhah *et al.*^[9] used the native and completed version of the ELMERI index in this study.

This method does not use a scoring table, and complex calculations are not performed. The implementation of the method is straightforward. In other words, a safety inspector using this method can evaluate the workplace quickly. In this study, experienced occupational health experts were employed to assess and identify laboratory safety indicators. ELMERI creates a safety index by monitoring the existing safety standards in the workplace. The safety index can range from 0% to 100%. For example, an index of 60% means that 60 out of 100 observed subjects comply with workplace occupational safety standards and implementation.^[13]

The observations in this study, based on the native and complete version of the ELMERI index, include nine items, which are detailed in Table 1.

The ELMERI method shows instantaneous positions at the observation time, so it is necessary to repeat the observation normally. Therefore, observations were made in the laboratories by visiting each laboratory thrice on different dates in October and November 2023.

To calculate the ELMERI index, it is first necessary to observe all the above nine safety and health issues in each workstation selected for evaluation. Then, each of the questions in the checklist is scored as correct observations if the workplace's minimum safety and health standards have been observed and otherwise as incorrect observations. If any of the items in the checklist are not met in the workstation case, the term "no observation" is recorded in the index calculation steps. In the last stage, when all the selected workstations have been observed, the ELMERI index can be calculated. Finally,

Table 1: ELMERI dimensions examined in the checklist

Investigated areas	Number of items	Items
Electrical safety	7	Condition of the electrical panel, cables and wires, earth measurement, etc.
Fire safety	5	Fire alarm and extinguishing equipment, personnel training in the field of using fire extinguishing equipment, proper placement of fire extinguishers, periodic inspection of equipment, etc.
Building safety	7	Checking the plumbing system, lighting, how to arrange devices and equipment, etc.
Management of response in emergencies	7	Emergency exit, signs and boards, training, etc.
Safety of chemicals	9	Handling, maintaining, and storing chemicals, etc.
Personal safety	4	Use and availability of personal protective equipment, etc.
Safety of devices and equipment	7	Checking suction levels of gas cylinders and laboratory hoods, etc.
Waste management	6	Waste management techniques and trash can checks, etc.
Safety management	7	Safety principles training, accident recording and reporting, employee duties communication, periodic inspections, etc.

according to the Equation 1, the ELMERI safety index is calculated as a percentage of correct observations compared to the total observations.

$$ELMERI\ Index = \frac{Correct\ observations}{Correct\ Observations + Incorrect\ Observation} \times 100 \quad (1)$$

The laboratory safety index was classified and evaluated in four levels: good (75%–100%), average (50%–75%), poor (25%–50%), and very poor (0%–25%).

RESULTS

Table 2 shows detailing the number of observations carried out in laboratories. According to the table, 3186 observations were recorded in three separate sessions at different times. Of these, 2034 were correct, 900 were incorrect, and 252 were not observed.

In Table 3, the ELMERI index and its various dimensions are displayed for the laboratories. The table shows that the overall status of the ELMERI index of 17 laboratories is at the average level, and only one laboratory is classified as good. Regarding electrical safety, 7 (38.8%) laboratories are in good condition, while 11 (61.1%) are at an average level. All laboratories (100%) have average fire safety levels. Regarding building safety, 13 (72.2%) laboratories are in good condition, while 5 (27.8%) laboratories are in average condition. In emergency response management, 9 (50%) laboratories are at an average level, with the other 9 (50%) laboratories also at an average level. For chemical safety, 7 (38.8%) laboratories are in good condition, 8 (44.4%) laboratories are at an average level, and 3 (16.6%) laboratories have not been observed. Personal safety is rated as good in 16 out of 18 (88.89%) laboratories and average in 2 (11.1%) laboratories. Moreover, 11 (61.1%) laboratories have good device and equipment safety conditions, while 7 (38.8%) have average conditions. Waste management is in good condition in 11 out of 18 (61.1%) laboratories and, on average, in 7 (38.8%). Safety management was rated moderate in 17 (94.44%) laboratories,

and only 1 (5.56%) laboratory was classified as having poor safety management.

The hydraulic laboratory had the lowest safety index score at 58.43, while the central instrument analysis laboratory had the highest safety index score at 76.07, indicating good performance. Regarding emergency response management, 50% of the laboratories had a weak level, and the remaining 50% had an average level, showing poor performance in this dimension. However, personal safety was rated the best, with no laboratory rated as weak or weak. 11.1% of the laboratories had an average level, and 88.9% were rated as having a good safety level.

Figure 1 represents the safety index status of the laboratories under investigation in various dimensions. It uses green to represent good safety levels, yellow for medium, and red for poor. The laboratories excel in safety in five dimensions: building safety, device and equipment safety, personal safety, chemical safety, and waste management. However, they only meet average safety levels in three dimensions: electrical safety, fire safety, and emergency response management. The lowest safety level was observed in emergency response management at 49.73%, while the highest was found in personal safety at 81.53%. Overall, the laboratories achieved an average safety score of 69.32%.

DISCUSSION

The study's findings suggest that the overall health and safety performance of the investigated laboratories are average based on the nine indicators of ELMERI. The average safety index is due to the absence of specific safety requirements, inadequate monitoring, and a lack of development of programs and instructions for each dimension studied. These results are consistent with previous studies, such as Yari *et al.*'s investigation of the health, safety, and environmental conditions of educational laboratories, which also concluded that these places are in unfavorable conditions.^[14] The study found that the electricity safety index is average and close to being in good condition. Nonconformities include defects in

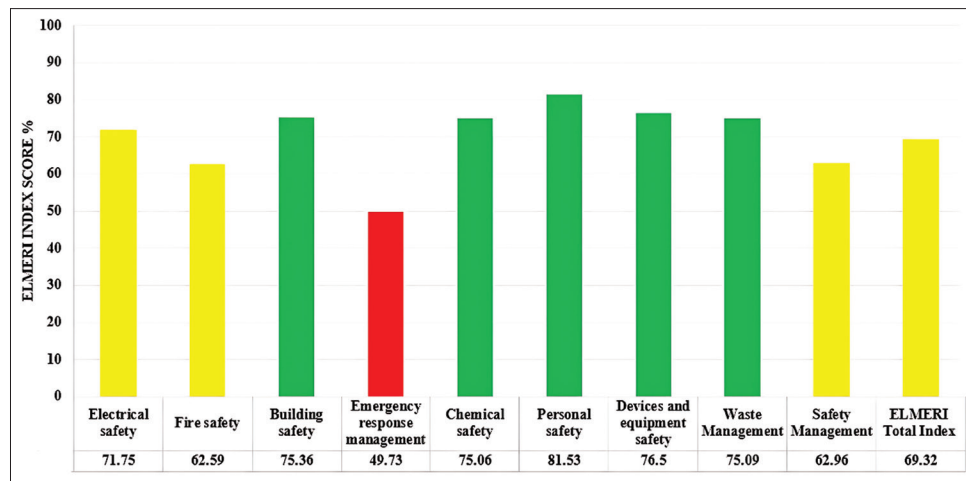


Figure 1: The status of the safety index of the investigated laboratories

Table 2: Number of observations in each laboratory

Indexes	Total items	Correct items	Incorrect items	No observation
Electrical safety	378	254	100	24
Fire safety	270	169	101	0
Building safety	378	260	85	33
Emergency response management	378	188	190	0
Chemical safety	486	304	101	81
Personal safety	216	159	36	21
Devices and equipment safety	378	254	78	46
Waste management	324	208	69	47
Safety management	378	238	140	0
Total	3186	2034	900	252

the earthing system, failure to connect devices to the earth wire, noncompliance with safety standards in electrical panels and fuse boxes, and lack of insulating flooring in front of electrical panels. In a study by Darvishi *et al.*, the electrical safety situation was deemed inadequate due to defects in the protection systems such as earth connection and life-saving switch editions.^[15] Conversely, in another study, Ahmadi *et al.* reported that the overall safety status of the educational laboratories at the Health Faculty of Yazd University of Medical Sciences is relatively favorable.^[16] The study found that the laboratories scored highest in personal safety, indicating adherence to proper safety practices, consistent with Malakoutikhah *et al.*'s study.^[9]

The findings regarding the emergency response management indicator from the ELMERI evaluation, where it received the lowest score among laboratory safety indicators, align with results found in the related literature. The common issues, such as the lack of emergency plans, insufficient emergency exits, inadequate signage, and poor training, are consistent with challenges identified in other studies focused on laboratory safety. For example, Malakoutikhah *et al.* highlighted the

insufficient preparedness for handling emergencies, noting the absence of comprehensive emergency plans and crisis management strategies in laboratories. They emphasized that laboratories frequently lack designated exits and proper safety signage, both of which are essential for rapid responses in emergency situations.^[9] The findings from other studies also indicate a poor emergency response in laboratories. These studies attribute the low level of preparedness to the absence of regular emergency maneuvers and inadequate employee training for handling emergency situations.^[1,17]

The study found that the electrical safety, fire safety, and laboratory safety management indicators showed an average level of safety [Figure 1]. There were 378 observations related to the fire safety of laboratories, out of which 100 were incorrect [Table 2]. None of the investigated laboratories had automatic fire alarm and extinguishing systems. In addition, there were no other protection systems such as emergency exits, and people had little knowledge of operating hand fire extinguishers. The university laboratories are not located on the ground floor, which could pose challenges for rescue and firefighting efforts in case of a fire. Previous studies have also indicated low levels of fire safety in laboratories.^[18,19] Recommendations for improvement include providing periodic fire extinguishing training, installing fire extinguishing systems based on the National Fire Protection Association standards, and using special fire-resistant cupboards for storing chemicals in the laboratories of environmental health and chemical agents. These cupboards should have proper ventilation to prevent the accumulation of chemical vapors and the occurrence of fires.

The study highlights that the electrical safety index is rated as average but nearing a good level. Nonconformities identified include defects in the earthing system, improper connections of devices to earth wires, noncompliance with electrical panel standards, and the absence of insulating flooring in front of electrical panels. Similar studies in the literature often report comparable issues related to electrical safety. Research indicates that earthing system failures and insufficient

Table 3: ELMERI index and its different dimensions in laboratories

Laboratory	ELMERI indexes										
	Electrical safety	Fire safety	Building safety	Emergency response management	Chemical safety	Personal safety	Devices and equipment safety	Waste management	Safety management	ELMERI total index	
Chemical agents lab	66.66	66.66	78.94	42.85	70.37	75	71.42	80	57.14	66.86	
Safety lab	83.33	60	83.33	42.85	No observation*	80	71.42	66.66	57.14	66.66	
Physical factors lab	83.33	60	66.66	57.14	No observation*	100	75	75	57.14	69.10	
Chemical agents research lab	72.22	60	78.94	42.85	74.07	75	77.77	75	61.90	68.09	
Industrial ventilation lab	61.90	53.33	68.42	57.14	No observation*	81.81	73.33	80	66.66	66.66	
Environmental microbiology lab	57.14	73.33	77.77	57.14	77.77	90	83.33	66.66	61.90	71.59	
Environmental chemistry lab	66.66	53.33	76.19	57.14	74.07	75	80.95	83.33	66.66	70.62	
Air pollution lab	72.22	60	61.90	57.14	74.07	81.81	83.33	73.33	57.14	68.26	
Molecular biology lab	66.66	60	83.33	57.14	70.37	80	83.33	72.22	66.66	70.41	
Hydraulic lab	61.90	53.33	61.90	42.85	59.25	70	66.66	75	47.61	58.43	
Central instrument analysis lab	76.19	66.66	84.21	57.14	81.48	100	83.33	75	71.42	76.07	
Environmental toxicology lab	83.33	60	76.19	52.38	70.37	75	71.42	77.77	66.66	70.11	
Waste lab	72.22	73.33	75	52.38	81.48	75	83.33	72.22	71.42	72.94	
Environmental health research lab	83.33	60	71.42	42.85	81.48	100	76.19	76.92	66.66	71.68	
Environmental lab	66.66	60	77.77	42.85	85.18	81.81	72.22	77.77	61.90	69.41	
Molecular biology lab	76.19	66.66	83.33	42.85	77.77	72.72	66.66	72.22	57.14	68.20	
Food microbiology lab	76.19	73.33	76.19	42.85	66.66	83.33	80.95	77.77	61.90	70.05	
Food chemistry lab	71.42	66.66	77.77	47.619	81.48	83.33	76.19	72.22	66.66	71.26	

*Chemical safety items were not observed in the safety, physical factors, and industrial ventilation laboratories.

insulation are common in laboratory settings, which aligns with the findings of this study. Moreover, other studies also emphasize the importance of proper wiring, adherence to standards, and the presence of insulating materials for reducing electrical hazards, highlighting a general trend in the need for improvement in this area across various laboratory environments.^[15,20]

The chemical safety index is generally good, but nearly half of the laboratories are only in average condition. Proper storage conditions for chemicals, including protection from heat, light, and other substances, are crucial. Gas detectors should be appropriately placed in chemical laboratories. Reports show that incidents in scientific laboratories are significantly higher than in industrial laboratories.^[21,22]

The safety management status of the laboratories in this study was evaluated to be average. The key nonconformities related to safety management include the lack of a risk assessment and management plan, insufficient recording and reporting of incidents, failure to prepare safety instructions, and absence of periodic safety inspections. Establishing an occupational health and safety management system with necessary supervision is crucial for safety management in these environments, especially in educational laboratories where proper supervision is essential. It is recommended that higher education institutions standardize the use of postgraduate supervisors for practical work in laboratories and tailor the level and type of supervision to the student's skill, knowledge, and experience, as well as the risks and complexities of their tasks.^[23] Studies have found that safety management in various dimensions, including hospitals, is relatively weak.^[18]

Despite all the strengths of ELMERI, this method has some limitations, such as not considering control costs, not measuring effectiveness, and evaluating the level of the environment, which is also evident in this study.

CONCLUSION

The results indicate that the overall safety status of Isfahan Faculty of Health laboratories is at an average level. Personal safety, equipment safety, building safety, and waste management scored above 75, reflecting good performance in these areas. However, fire safety, electrical safety, and safety management were rated as average. To enhance and improve the safety status of these indicators, the study suggests several solutions, including equipping laboratories with automatic fire alarm and extinguishing systems, providing regular fire extinguishing training, connecting devices to grounding wires, adhering to safety standards in electrical panels, and implementing an occupational health and safety management system with proper oversight. In addition, the study found that the emergency response management index for all laboratories was at a moderate-to-weak level and received the lowest score among the safety indicators. To improve this index, several precautions should be taken in laboratories, including installing danger signs and emergency contact

numbers, providing proper training, conducting emergency maneuvers, and preparing comprehensive emergency plans and instructions. Future studies are recommended to explore these weaknesses in greater detail by thoroughly examining the emergency response index, allowing for the development of more effective and comprehensive solutions to enhance the overall safety level of laboratories. This study demonstrated that the ELMERI monitoring method effectively assesses overall laboratory safety and offers improvement solutions. It is suggested that future studies assess the effectiveness of control measures both before and after implementation by utilizing the results of the ELMERI index.

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Ethics code

The Medical Ethics Committee of Isfahan University of Medical Sciences approved the study protocol under the ethical code IR.MUI.RESEARCH.REC.1402.070.

Conflict of interest

There are no conflicts of interest.

Authors' contributions

Ehsanollah Habibi: Study design, edited the article; Motjaba Nakhaeipour: Writing, Data analysis, and Interpretation; Seyed Mahdi Mousavi: Data collection and writing; Hossein Ebrahimi: Data collection and edited the paper.

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