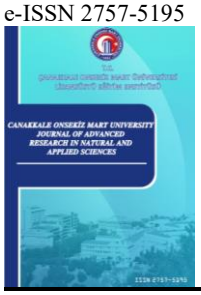
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Investigation and Comparison of Some Laboratories in Terms of Occupational Health and Safety by ELMERI Observation Method

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Abstract − Laboratories are classified as dangerous workplaces and contain various risk factors that may cause work accidents. For this reason, studies to reduce the dangers should be conducted in the laboratory by complying with the corrective and preventive activities specified in the relevant regulation. In this study, a survey was conducted for three laboratories in three different cities using the checklist of the The Ministry of Labor and Social Security. The survey data were applied with the ELMERI observation method and the safety indexes of the laboratories were created. According to the data obtained from the ELMERI safety index, the necessary measures to be taken in the laboratories were determined and recommendations were made. According to this research, average index values of laboratories according to categories; training and information 96%, diseases and accidents 94%, biological factors 86%, physical factors 82%, ergonomics 81%, machinery and hand tools 78%, personal protective equipment 75%, waste management 72%, electricity 71%, chemical factors 69%, fire-explosion and emergencies 67%, psychosocial factors 67%, storage 64% and general workplace layout 62%. Although there are occupational safety evaluation studies in the literature using the checklists published by the relevant ministry, there is almost no study to create safety indexes for workplaces by combining the relevant lists with the ELMERI observation method. It is suggested that this study will shed light on and form a source for future studies on laboratory safety and ELMERI observation method, especially in the laboratories where research was conducted.

Keywords– *Applicable observation method, elmeri safety index, laboratory safety, occupational health and safety, laboratory checklist*

1. Introduction

1.1. Laboratory Safety

Occupational health and safety, which is becoming increasingly important in the world and in our country, has become a necessity for workplaces classified as dangerous according to the NACE code, which means Statistical Classification of Economic Activities in the European Union. There are risks that may cause occupational accidents due to the use of biological, physical and chemical substances in laboratories (Yılmaz & Bilici, 2020). In addition, technical errors and personnel errors caused using equipment and materials in the laboratories cause many accidents. Laboratory safety can be defined as the employee's protection of herself and other affected employees, working environment, used machinery and equipment from all kinds of damage. Laboratory safety covers the risks and precautions that may occur as a result of operations such as the use of machines, equipment and hand tools, general & workplace order and hygiene, storage systems and waste management. In addition, fire-explosion-emergencies, electrical accidents, chemical, biological, psychosocial and physical factors are among the important factors for ensuring laboratory safety. First aid, ergonomics and the use of personal protective equipment, follow-up and examination of possible accidents and disease are among the measures. More than one layer must fail for an occupational accident to occur

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(Bansal & Selvik, 2021). The layers can be seen as procedure, instruction and control. Inadequate operating procedures, instructions, and lack of supervision increase the likelihood of an occupational accident (Paolo et al., 2021). The occupational health and safety culture to be created can be considered as one of these layers. No matter how safe the workplace is, accidents cannot be prevented unless there is a culture of occupational health and safety. Occupational health and safety culture can be created with training (Dalyan & Pişkin, 2020). Training and informing the staff about laboratory safety is also considered as a part of precautionary practices.

To ensure laboratory safety, an occupational health and safety culture should be established in the laboratory. To establish the laboratory culture, the rules to be followed before the study, during the study and after the study is completed should be determined. An occupational health and safety system, where the rules to be determined can be implemented and monitored, should be established. The installed system must be constantly controlled and monitored. In addition to the occupational health and safety system to be established, employees must be routinely trained to work safely in compliance with the rules. Trainings should be given especially before the first assignment to the laboratory and new situations where exposure may occur (OSHA, 2011).

There are also legal regulations in order to ensure safety in laboratories and to prevent occupational accidents and diseases. The legal regulations stated under the heading "general characteristics of laboratories and the rules to be followed" in the second part of the Environmental Measurement and Analysis Laboratories Qualification Regulation, published in the Official Gazette dated 25.12.2013 and numbered 28862, list the rules that employers must obey in laboratories. Checklists are available to facilitate compliance with the rules mentioned in the legislation. They are guiding in terms of taking necessary precautions against dangers by determining sources of danger with checklists in advance. A checklist for laboratories to improve the laboratory environment has been published by the General Directorate of Occupational Health and Safety of the Ministry of Labor and Social Security. The published list, with 14 categories and 234 questions, shows the issues to be considered for laboratory safety.

1.2. Elmeri Observation Method

ELMERI observation method is a proactive field observation method designed mainly for the manufacturing industry in the 1990s. ELMERI Observation Method, which was developed by a researcher named Heikki Laitinen in Finland, has been used in various sectors and an occupational health and safety competition was organized by using it in many companies between 2002-2005. The safety index, which was 68% as a result of the initial evaluation process, increased to 85% at the end of the project (Atlı, 2018). In addition, the accident costs of companies decreased by forty percent, which corresponds to an annual figure of 35 million Turkish liras (Martı, 2016). ELMERI Observation Method has been implemented first time in workplaces in Turkey between 2010-2011 under "Improvement of Occupational Health and Safety Conditions Project (ISGIP)" in a total of 103 enterprises, including 16 construction sites, 35 metal works, 37 mines, and 15 marble quarries. Especially in the metal sector, the presence of enterprises with a safety index of 80% is important in terms of being at the level of metal enterprises operating in Europe (Ergun, Karakaya & Akkaş, 2011).

ELMERI Observation Method is an easy to understand and apply method that measures the safety indexes of workplaces (Karabulut, 2016). The Elmeri observation method is based on a foundation that examines both working conditions and employee behavior (Ersoy & Yeşilkaya, 2016). Progress is being made on a scoring basis over 18 sub-headings in total (Çukurluöz, Birgören, Yalçınkaya & Orçanlı, 2020). Workplace safety indices are calculated with the mentioned scoring system. It has been determined that there is a serious link between the scoring system and occupational accident figures (Laitinen, Vuorinen, Simola & Yrjanheikki, 2013). ELMERI Observation Method is a valid proactive method in measuring occupational health and safety performance (Ongun & Bilen, 2016). It points out the potential causes of future accidents. It helps to determine the needs for improvement, to set goals and to measure the results of the work done in the field of occupational health and safety (Özdemir, 2014). For scoring, each part of the workplace or all elements in

other areas selected for observation are observed and evaluated as true or false. If the observed elements comply with the ELMERI observation rules, this element is evaluated as "correct"; otherwise, it is considered "false". If there is an item that cannot be calculated during the viewing round, or if the observer is unsure how to score any item, it is indicated as "no observation". The safety index gives the percentage value by calculating the ratio of correct elements to all observed elements. The safety index calculation method is shown in Equation 1. (Laitinen et al., 2012). Workplace safety indices are expressed as a percentage (%) and are shown between 0-100 (Yaylalı, 2016). In the workplace with a safety index of 60%, it shows that 60 out of every 100 occupational health and safety elements are good practices in terms of occupational health and safety (Laitinen & Paivarinta, 2010; Laitinen & Ruohomaki, 1996). The safety index and accident incidence are inversely proportional. The Elmeri method shows the instantaneous situations at the time of the observation, so it is necessary to routinely repeat the observation. ELMERI Observation Method aims to improve the current situation by repeating it weekly, monthly or in periods determined by the users. Thus, safety vulnerabilities detected in the previous audit are kept under constant control. The Elmeri method, which measures the effectiveness of the OHS management system with numerical data, helps to measure the corrective-preventive action steps (Sarıkaya & Altındağ, 2015). In addition, the Elmeri observation method is a system that indirectly supports OHS trainings. A direct correlation was found between the regular OHS training and the high Elmeri safety index (Sarı & Kuzupınar, 2017).

$$\frac{No.of\ correct\ items}{No.of\ correct\ items + No.of\ not\ correct\ items}.100 \quad (1.1)$$

Equation 1. ELMERİ safety index calculation method (Laitinen et al, 2012)

Laboratories contain a wide variety of hazards, and the risks associated with these hazards can result in significant losses if not properly managed. Laboratories can often be perceived as low risk and inherently safer. Therefore, laboratories are important businesses that need to be researched. Although there are various studies in the literature on laboratory safety, there are almost no studies examined by ELMERI observation method of the checklist for laboratories.

2. Materials and Methods

In the research, the "Checklist for Laboratories" published by the Ministry of Labor and Social Security was used to determine the occupational health and safety status of the laboratory. In the list, there are a total of 234 questions in 14 categories, which include General & workplace order and hygiene (28 items), Machines, hand tools and auxiliary apparatus (31 items), Chemical factors (16 items), Biological factors (14 items), Physical factors (17 items), Psychosocial factors (3 items), Fire-explosion-emergencies (22 items), Waste management (18 items), Storage (27 items), Electricity (24 items), Ergonomics (12 items), Personal protective equipment (8 items), Accidents and diseases (6 items), Training and information (8 items). The "Checklist for Laboratories" published by the Ministry of Labor and Social Security has been applied in 3 different laboratories operating in the public and private sectors of our country. The relevant list is given in Appendix 1. Laboratories are named A, B and C. Laboratory A: It is a public laboratory where soil (physical and chemical), plant (macro and micro) and irrigation water analyze are performed for agricultural purposes. Laboratory B: It is a drug quality control and analysis laboratory where in vitro and in vivo quality control analyzes of various drugs are performed. Laboratory C: It is a Chemistry Research Laboratory where studies are carried out on the synthesis, purification and characterization of new functional compounds for use in various technological applications with chemical and physical techniques. The questionnaire was applied face-to-face by answering the questionnaire with the authorized person in the laboratory and observing the laboratory environment according to the checklist. The answers are processed as "YES" if they follow the legislation, and "NO" if they are not in compliance with the legislation. ELMERI Observation Method is an

observation method that can be changed and adapted according to the sector, environmental conditions, other variables, and the work done. In order for the comparisons between laboratories to be based on numerical data, the ELMERI safety index of each laboratory was calculated. In the research, the safety indexes of the laboratories were calculated by using the "Checklist for Laboratories" items and the results were compared.

3. Results and Discussion

Laboratories have the NACE code of 86.90.10 [Services of medical laboratories (excluding the activities of forensic medicine and dental laboratories) (non-hospital)] and are included in the "Very Dangerous Work" risk category in the List of Hazard Classes Regarding Occupational Health and Safety (İş Sağlığı ve Güvenliği, 2012). In order to ensure the safety of the laboratory, the title "general characteristics of laboratories and rules to be followed" in the second part of the Environmental Measurement and Analysis Laboratories Qualification Regulation published in the Official Gazette dated 25.12.2013 and numbered 28862 should be followed. For this reason, it is essential to create working environments in the laboratory where Occupational Health and Safety legislation is applied, that do not pose a danger to employees and the environment or where risks are minimized. The number of observations to be made according to the legislation and the number of observations made in the researched laboratories are given in Table 1.

3.1. General & Workplace Order and Hygiene

In the A, B and C laboratories, it was observed that the floor was designed to prevent slipping or falling, also it was observed that the interior and exterior floors were regularly checked. Three laboratories have benches covered with waterproof and disinfectant-resistant, easy-to-clean material. Smoking is prohibited in laboratories and employees have been informed about this issue. In addition, there were no smoking personnel in the laboratory during the research. It has been observed that information and warning signs are properly hung in the laboratories.

3.2. Machines, Hand Tools and Auxiliary Apparatus

It has been observed that machinery, tools and equipment in A, B and C laboratories were procured from CE marked ones. In addition, a Turkish user manual was provided from the manufacturer company and the machines were used in accordance with the manual. It was determined that only the laboratory A user manuals were not sufficient and, in this case, no additional instructions for use were provided. In case the machine guards are opened, the deactivation of the sensors that stop the system is prevented. In addition, it has been determined that daily maintenance and periodic controls of all machines are carried out according to the manufacturer's instructions. It is ensured that the defective equipment is labeled in order not to be used in the laboratory A, while it has been observed that this practice is not applied in other laboratories.

Table 1
The number of observations to be made in categories according to the legislation and the number of observations in laboratories

Regulatory Compliant Laboratory		AL		BL		CL	
	C	C	F	C	F	C	F
General & Workplace Order and Hygiene	28	20	8	23	5	9	19
Machines, Hand Tools and Auxiliary Apparatus	31	28	3	24	7	21	10
Chemical Factors	16	10	6	14	2	9	7
Biological Factors	14	14	0	14	0	8	6
Physical Factors	17	11	6	17	0	14	3

Fire-Explosion-Emergencies	22	16	6	19	3	9	13
Waste Management	18	16	2	17	1	6	12
Storage	27	22	5	18	9	12	15
Electricity	24	17	7	21	3	13	11
Ergonomics	12	11	1	9	3	9	3
Personal Protective Equipment (PPE)	8	8	0	8	0	2	6
Psychosocial Factors	3	1	2	3	0	2	1
Accidents and Diseases	6	6	0	6	0	5	1
Training and Information	8	8	0	8	0	7	1
Total	234	188	46	201	33	126	108

AL: A Laboratory, BL: B Laboratory, CL: C Laboratory, C: Correct, F: False

3.3. Chemical Factors

It has been determined that there are properly placed gas detectors in laboratories A and B, chemicals containing oxide components are regularly renewed and materials whose shelf life has expired are disposed of. The disposal of the chemicals was done with the method and procedure in accordance with the Waste Management Regulation. When working with chemical substances, it was ensured to use a fume hood and periodic workplace environment measurement values were made. Laboratory A complied with the storage conditions for chemicals and preserved them from heat, light and other materials. Thus, it has taken measures against the risk of fire and explosion that may be caused by chemicals.

3.4. Biological Factors

In three laboratories, necessary measures have been taken to minimize the number of personnel who are or may be exposed to biological factors. Laboratory personnel were informed about possible infection risks and preventive measures, and it was determined that the program to be implemented was available. While the necessary precautions were taken when working with biological factors for laboratories A and B, it was determined that working processes and technical control measures for laboratory C were not arranged in a way to prevent the spread of biological agents.

3.5. Physical Factors

In B and C laboratories, all areas are well illuminated, natural lighting has been used sufficiently and dazzling risks arising from windows have been prevented. However, it has been stated that laboratory A has a natural lighting problem. It has been determined that three laboratories have a clean air flow and a natural ventilation system that keeps the working environment clean. The disturbing noise and vibration levels in the laboratories were prevented, and it was determined that the measurement values were below the noise and vibration exposure values. It was determined that noise and vibration exposure measurements were made periodically in the B laboratory, but not in the A and C laboratories.

3.6. Fire-Explosion-Emergencies

Emergency teams were formed in all three laboratories, and all personnel were informed about emergency teams. In addition, the evacuation plan was posted in places where the personnel can be easily seen and reached. There are enough appropriate type fire extinguishers in the laboratory and their pressure has been checked. Emergency exit routes and doors are marked accordingly. There is a fire and smoke detection and sprinkler system and periodic controls have been made. Despite the positive findings, it was determined that

the telephone numbers to be contacted in case of emergency were not hanged in the visible place in all three laboratories.

3.7. Waste Management

In laboratories A and B, the personnel were informed about the methods and procedure in accordance with the legislation for the disposal of wastes. In particular, necessary regulations were made to ensure that chemical wastes were not discharged into the sewer and mixed with domestic wastes. Hazardous chemical wastes and medical wastes have been only stored temporarily, waste containers have been classified and labeled in accordance with the legislation. Used cutting and piercing medical wastes were collected under conditions in accordance with the legislation, without mixing with other wastes. Wastes that require separate transportation and disposal were stored in different colored waste bags and disposed of.

3.8. Storage

In three laboratories, it was stated that they prevented the entry and exit of the storage areas except the officials, and the lists and hazards of chemical substances found on the refrigerators and storage shelves were written. Danger signs were hung on the doors and it was determined that there were safety data sheets of chemicals in the storage area. In B and C laboratories, all cabinets are properly fixed to the wall, shelves are mounted on the wall and each other to prevent them from falling over. In A and B laboratories, storage areas are in a different place and their control has been provided. It has been determined that the storage of flammable liquids is carried out in suitable warehouses.

3.9. Electricity

In all laboratories, the fuse boxes are closed, and the access of unauthorized persons is prevented. All portable electrical equipment has been checked periodically and indicated on their dates. It was determined that there were no cut and added electrical cables. Although working not close to electrical systems in the B and C laboratories, it is ensured that explosive and flammable materials are not kept next to electrical devices, the electrical installation is made in a locker and its base is made of insulated material. Although working not close to electrical systems in the B and C laboratories, it is ensured that explosive and flammable materials are not kept next to electrical devices, and the electrical installation is made in a locker and its base has been made of insulated material. There is grounding in the electrical system, and appropriate Personal Protective Equipment (PPE) is used in electrical equipment intervention and maintenance and repair works.

3.10. Ergonomics

In the laboratories, personnel have been prevented from working in the same position or being physically challenging for a long time, and suitable tables, chairs or support equipment have been provided. Personnel have been prevented from having to reach long distances. While a working environment was provided for the employees in laboratories A and B to move easily, it was determined that it could not be provided in laboratory C. In laboratories A and C, the personnel were informed about musculoskeletal disorders that may arise from the manual transportation of the loads and about the correct and safe lifting of the loads, but it was determined that laboratory B was not informed about this issue.

3.11. Personal Protective Equipment (PPE)

In laboratories A and B, risks were identified, and PPE in types and numbers suitable for these risks were obtained and made available for use. It was determined that the personnel were using appropriate PPE throughout the study and that the authorities made warnings to the employees on this issue. It has been determined that only PPEs in the C laboratory have CE mark and have a Turkish user manual. In addition, it

was determined that all PPE were removed when leaving the laboratory, cleaned with appropriate methods and procedure, and stored in a suitable environment. It was determined that the periodic controls of the PPE given to the personnel are carried out.

3.12. Psychosocial Factors

It has been determined that personnel in B laboratories are prevented from giving instructions other than their duties and responsibilities, but this procedure is not applied in other laboratories. Staff in all laboratories; it has been determined that they are aware of their authority, responsibility and working objectives. It has been determined that a healthy communication has been established between the personnel working in the B and C laboratories and the employer. This situation was not achieved in Laboratory A. Staff in all laboratories; It has been determined that they are aware of their authority, responsibility and working objectives. It has been determined that a healthy communication has been established between the personnel working in the B and C laboratories and the employer. This situation was not achieved in Laboratory A. It was observed that all laboratories comply with the working (article 63) and rest periods (article 68) specified in the Labor Law No. 4857 (İş Kanunu, 2003).

3.13. Accidents and Diseases

Employees in all three laboratories were inspected and checked periodically, occupational accident and occupational disease cases were reported to the Social Security Institution, and previous accidents were examined and recorded. The sources of danger were identified, and corrective-preventive actions were taken by performing root-cause analyzes in order to avoid similar accidents in the future. It has been observed that near-miss notification boxes are made that can be easily accessed by the personnel for the notification of near misses. Employees who are thought to can be affected by biological, chemical or physical factors in the laboratory environment have been vaccinated.

3.14. Training and Information

It has been determined that employees in all laboratories are given general hygiene information to reduce the risk of infection. It has been observed that the employees have the necessary training and knowledge about the work they do, as well as the safe use of the machines, tools and equipment they use. Employees are informed about the risks they may be exposed to while working with biological and chemical factors, as well as cutting, stinging, burning, etc. it was also informed about who will intervene in the injuries that may occur due to physical factors. While it is documented that the employees in laboratories A and B have received occupational health and safety training, the training certificate records of laboratory employees C could not be reached.

In this study, ELMERI method was applied to the laboratories in three different provinces to determine the safety index. In addition to the general ELMERI index, safety indexes were calculated according to the categories in ELMERI. The safety indexes of the laboratories divided by categories and the average safety indexes for 3 laboratories are given in Table 2.

Table 2
ELMERI safety index of laboratories participating in the research

	A Laboratory %	B Laboratory %	C Laboratory %
General & Workplace Order and Hygiene	71	82	32
Machines, Hand Tools and Auxiliary Apparatus	90	77	68
Chemical Factors	63	87	56

Biological Factors	100	100	57
Physical Factors	65	100	82
Fire-Explosion-Emergencies	73	86	41
Waste Management	89	94	33
Storage	81	67	44
Electricity	71	87	54
Ergonomics	92	75	75
Personal Protective Equipment (PPE)	100	100	25
Psychosocial Factors	33	100	67
Accidents and Diseases	100	100	83
Training and Information	100	100	87
ELMERİ index %	80	86	55

According to Table 2;

The general safety index of laboratory A was found to be 80%. It was determined that the subject with the lowest safety index was psychosocial factors with 33%, the subjects with the highest safety index were training and information, diseases and accidents, biological factors and personal protective equipment with 100%. The general safety index of laboratory B was found to be 86%. It was determined that the subject with the lowest safety index was storage with 67%, the subjects with the highest safety index were training and information, disease and accidents, biological factors, physical factors, personal protective equipment and psychosocial factors with 100%. The general safety index of laboratory C was found to be 55%. It was determined that the subject with the lowest safety index was personal protective equipment with 25%, the subject with highest safety index was training and information with %87.

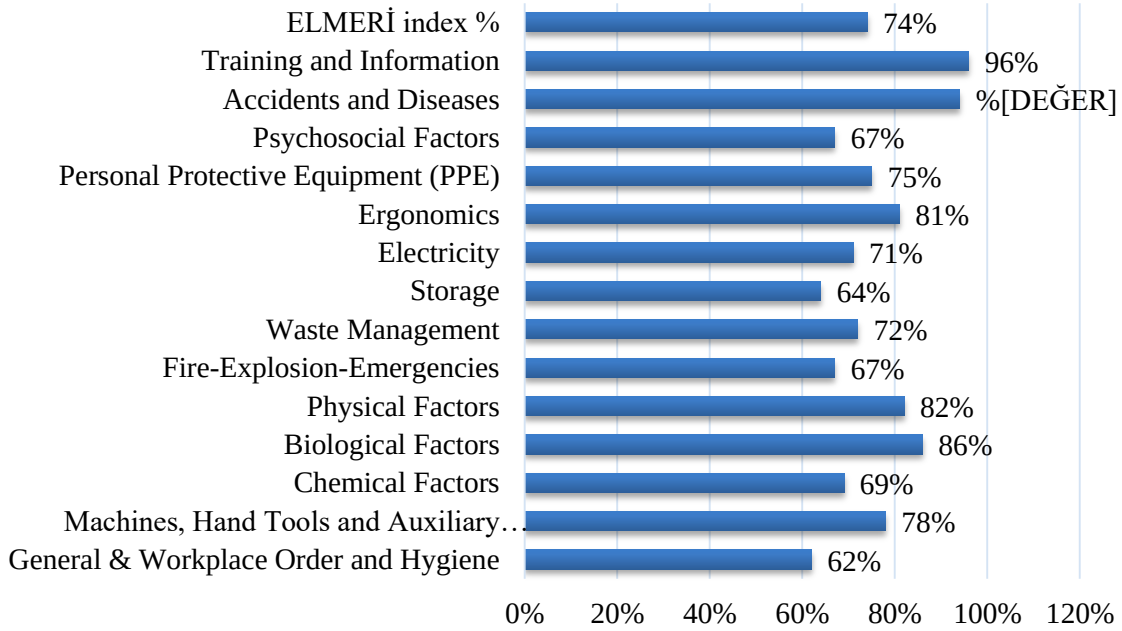


Figure 1. Average ELMERİ safety indexes by subject

According to Figure 1; The average ELMERI index value of the laboratories in the study was found to be 74%. It was determined that the subject with the lowest safety index was general & workplace order and hygiene with 62%, and the subject with the highest safety index was training and information with 96%.

In this study, the average ELMERI safety index on subject general & workplace order and hygiene has 62%. In the study conducted in the central laboratory of the Geetanjali Medical Faculty and Hospital in India, it was reported that 66.7% of the participants did not smoke in the laboratory (Shekhar, Patel, Jain, Garg & Mangukiya, 2015). In another study conducted in Ahmedabad, India, it was reported that 87.4% of the laboratory technicians did not smoke in the laboratory (Zaveri, 2012). In a study examining the laboratory safety of 335 students continuing their undergraduate program in our country during the internship period, it was reported that 75.2% of the laboratory workers did not consume any food, including cigarettes, in the laboratory (Derman & Çakmak, 2016). In this study, it was determined that smoking was prohibited in the workplace and the employees were informed about this issue. In addition, there were no smoking personnel in the laboratory during the research. In a study that examined the comparison of the laboratory safety attitudes of the students of the Chemical Technology Program in the field of school and internship, it was reported that there were warning and safety signs in the laboratories and these signs were strictly controlled. In addition, it was also reported that these controls were carried out by rule makers, 77% of whom were Class A occupational safety experts (Kerimak Öner, 2020). In this study, although it was determined that warning signs such as “slippery floor”, prohibitory signs such as “smoking is prohibited”, information signs such as “emergency exit door” were hung in all laboratories, no information was obtained about the control frequency.

In this study, the average ELMERI safety index on subject fire-explosion and emergencies has 67%. In a study conducted in our country, it was reported that emergency equipment was lacking in laboratories and that the personnel did not have information about the location of the existing equipment (Emerce & Doğan, 2017). In another study in our country where L-type risk assessment was applied in the public university food engineering laboratory, it was noted that the issue with the highest value (25) in the intolerable risk category was emergencies. In the research, it was reported that the lack of emergency plan, not determining the emergency teams and the absence of emergency drills were the hazards that received the highest value (Ersoy & Çelenk Kaya, 2019). In this study, it was observed that there were sufficient and appropriate type of fire extinguishers in laboratories. Emergency teams have been established in all laboratories and all personnel have been informed on this matter. In addition, it was determined that the evacuation plan was hanged in easily visible and accessible places for the personnel.

In this study the average ELMERI safety index on subject personal protective equipment has 75%. In a study conducted in three training hospitals in İzmir province of our country, it was reported that the rate of glove use during laboratory studies was 91.3% and that of apron was 87.4% (Aksoy, Özdemir, Usluca & Toprak Ergören, 2008). In a study conducted with 252 people in medical laboratories in Croatia, it was reported that 87.6% of the participants always wear lab coats and less than 40% use gloves daily (Dukic et al., 2015). In a study examining biosecurity practices in Pakistan, it was reported that 46.2% of the laboratory technicians did not use any preservatives (Nasim et al., 2010). In the study in the metal works workshop of Karamanoğlu Mehmetbey University Technical Sciences Vocational School in our country, it was stated that the lowest index among the categories (7.7%) was the use of personal protective equipment, and only 2 of the 26 observations were appropriate. The students in the workshop were trained on the use of personal protective equipment during the study and warning signs were posted about the subject. In the new observation made 2 weeks later, it was reported that the personal protective equipment usage index increased to 50%, and 10 out of 20 observations were appropriate (Yaylalı, 2016). In this study, it was determined that the category of personal protective equipment use has the lowest value (25%) only in laboratory C, and laboratories A and B have an index of 100%.

In this study the average ELMERI safety index on subject physical factors has 82%. In a study conducted in nine different laboratories in our country, it was noted that the ventilation conditions were good due to the portable ventilation of each employee in the private university laboratory. For this reason, it was stated that the ELMERI index of the laboratory was high (Karabulut, 2016). In a study conducted in a university college metalwork workshop in our country, it was stated that only 8 out of 13 observations made in the industrial hygiene category, which includes noise and vibration risks, were appropriate and the safety index was found to be 61.5%. In the new observation made after the improvements in industrial hygiene, it was stated that the safety index increased to 76.9% (Yaylalı, 2016). Although the existence and active use of the ventilation system in our study is provided in all laboratories, only laboratory B has an index of 100%. It has been determined that the noise and vibration measurement values made in the laboratories are measured under the exposure limit values specified by the legislation. However, it was observed that the measurements were made periodically in the B laboratory, but not in the A and C laboratories.

In this study the average ELMERI safety index on subject diseases and accidents has 94%. In a study conducted in the Ministry of Health Medicines and Medical Devices Agency laboratory in our country, it was reported that 11.9% of the employees experienced serious injury at least once during their working life, and 24.7% had an accident (Emerce & Doğan, 2017). In a study conducted in India, it was stated that 53.23% of the participants had an accident with injury in the laboratory. Only 28.78% of the injured received first aid support after the injury (Zaveri, 2012). Again, in another study conducted in the laboratory of the Geetanjali Medical Faculty in India, it was noted that 66.7% of the personnel had an accident and none of those who had an accident reported the situation to the hospital authority (Shekhar, Patel, Jain, Garg & Mangukiya, 2015). In this study, it was determined that the accidents that occurred were reported to the Social Security Institution, the accidents were examined and recorded, and necessary measures were taken to avoid similar accidents in the future.

Within the scope of the study, it was determined that the laboratories received an average of 96% ELMERI index for training and information. In an Egyptian hospital, it was reported that 60% of the participants received training in laboratory safety and waste management in a study on the knowledge, attitude and practice of laboratory technicians on laboratory safety and waste management (El-Ginay, El-Shaer, Khashaba, El-Dokroory & Omar, 2017). In a study conducted on 1782 laboratory personnel in Pakistan, it was reported that only 15% of the personnel received training on biosecurity (Nasim et al., 2010).

In a study conducted in a metalworks with twelve manufacturing parts in our country, it was reported that 73% of the participants received training, although the biggest deficiency was reported to be lack of training (Ongun, 2015). In addition, in another study conducted in our country in the Ministry of Health Pharmaceuticals and Medical Devices Agency laboratory, it was reported that it would be beneficial to provide 80.6% of the employees with regular training on laboratory safety (Emerce & Doğan, 2017). In this study, it was determined that while the subject of training and information in laboratories A and B was 100%, it was 87% in laboratories C. The category with the highest ELMERI average index of A, B and C laboratories is the training and information category.

4. Conclusion

In this study, which is one of the first to evaluate laboratory safety with ELMERI observation method, fourteen headings were examined in three different laboratories in the public and private sectors. The safety indexes of the laboratories were determined and the categories in which the deficiencies were concentrated were determined and solution suggestions were presented.

The data obtained focused on the inadequacy of general & workplace order and hygiene, which consists of 34 sub-items. This may also be due to the employer's failure to take quick action against obstacles such as collapse and deformation on the ground that may cause tripping and falling in laboratories. When the actions to be taken by the employer are implemented within the framework of a certain plan, the mentioned

problems can be solved permanently. In addition, it may be due to the fact that laboratory personnel focus too much on their work and do not pay attention to organization and order. The mentioned problem can be solved by regularly training the laboratory personnel on cleaning, organization and hygiene.

Another result of the analysis data also focused on the storage issue, which consists of 27 sub-items. This may be because most laboratories do not have a separate storage area and laboratory personnel cannot make regular storage. Creating a storage area in compliance with the legislation by the laboratories will solve the mentioned problem. In addition, it may be due to the fact that laboratory personnel are well aware of the characteristics of chemicals but are not well versed in storage rules. The mentioned problem can be solved by regularly training the laboratory staff about the storage features.

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Author Contributions

In this section, the authors' contributions to the article should be indicated for each author.

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Conflicts of Interest

The authors declare no conflict of interest.

References

4857 sayılı İş Kanunu. (2003, 10 6). Resmî Gazete (Sayı: 25134). Retrieved from: Mevzuat Bilgi Sistemi

Aksoy, Ü., Özdemir, M. H., Usluca, S., & Toprak Ergönen, A. (2008). Biosafety profile of laboratory workers at three education hospitals in İzmir, Turkey. *Bulletin of Microbiology*, *42*(3), 469-476. Retrieved from:http://www.mikrobiyolbul.org/managete/fu_folder/2008-03/2008-42-03-469-476.pdf

Atlı, B. (2018). Investigation of general occupational health and safety situation of five marble factories using elmeri method (Master's thesis). Retrieved from: https://tez.yok.gov.tr/UlusalTezMerkezi

Bansal, S., & Selvik, J. T. (2021). Investigating the implementation of the safety-diagnosability principle to support defence-in-depth in the nuclear industry: A Fukushima Daiichi accident case study. *Engineering Failure Analysis*, (123), 1 – 14. DOI: https://doi.org/10.1016/j.engfailanal.2021.105315

Çukurluöz, S., Birgören, B., Yalçınkaya, M., & Orçanlı, K. (2020). A new performance audit methodology for 6S applications in lean manufacturing. *International Journal of Engineering Research and Development*, *12*(2), 358-369. DOI: https://doi.org/10.29137/umagd.66819

Dalyan, O., & Pişkin, M. (2020). The impact of near miss noticed on occupational accidents at work-places a study from construction. *Çanakkale Onsekiz Mart University Journal of Science and Technology*, *6*(1), 133 – 143. DOI: https://doi.org/10.28979/comufbed.609675

Derman, M., & Çakmak, M. (2016). Investigation of Biology students' perception regarding laboratory safety. *Bartın University Journal of Faculty of Education*, *5*(1), 178-187. DOI: https://doi.org/10.14686/ buefad.v5i1.5000161902

Dukic, K., Zoric, M., Pozaic, P., Stracic, J., Culjak, M., Saracevic, A., & Miler, M. (2015). How compliant are technicians with universal safety measures in medical laboratories in Croatia? – A pilot study. *Biochemia Medica*, *25*(3), 386-392. DOI: https://doi.org/10.11613/BM.2015.038

El-Ginay, A., El-Shaer, S., Khashaba, E., El-Dakroory, S., & Omar, N. (2017). Knowledge, attitude and practices (KAP) of "teaching laboratory" technicians towards laboratory safety and waste management: a pilot interventional study. *The Journal of Hospital Infection*, *96*(2), 1-3. DOI: https://dx.doi.org/10.1016/j.jhin.2017.02.007

Emerce, E., & Doğan, B. (2017). Knowledge and practices of pharmaceutical laboratory workers on laboratory safety. *Turkish Journal of Public Health*, *15*(2), 106-122. DOI: https://doi.org/10.20518/tjph.341163

Ergun, A., Karakaya, F., & Akkaş, A. (2011). Türkiye'de işyerlerinde iş sağlığı ve koşullarının iyileştirilmesi projesi (İSGİP). *İş Sağlığı ve Güvenliği Dergisi*, *11* (52), 58-59.
Retrieved from: https://www.csgb.gov.tr/isggm/dergiler/52.pdf

Ersoy, M., & Yeşilkaya, L. (2016). Comparison of the occupational safety applications in marble quarries of Carrara (Italy) and Iscehisar (Turkey) by using Elmeri method. *International Journal of Injury Control and Safety Promotion*, *23*(1), 29 – 63. DOI: https://doi.org/10.1080/17457300.2014.945464

Ersoy, S., & Çelenk Kaya, E. (2019). A Risk Analysis Implementation of a State University Food Engineering Department's Laboratories. *Gümüşhane University Journal of Health*, *8*(4), 411-423.
Retrieved from: https://dergipark.org.tr/tr/download/article-file/913326

İş Sağlığı ve Güvenliğine İlişkin İşyeri Tehlike Sınıfları Tebliği. (2012, 26 12). Resmî Gazete (Sayı: 28509).
Retrieved from: Mevzuat Bilgi Sistemi

Karabulut, M. (2016). Determination of ohs risks of employees in chemistry laboratories of universities and solution suggestions for chemical exposure (Occupational Health and Safety Thesis).
Retrieved from: meryemkarabulut.pdf (ailevecalisma.gov.tr)

Kerimak Öner, M. N. (2020). Laboratory safety culture placement in chemistry education. *İSG Academic*, *2*(1), 15-25.
Retrieved from: https://dergipark.org.tr/tr/pub/isgakademik/issue/55400/751261

Laitinen, H., & Paivarinta, K. (2010). A new-generation safety contest in the construction industry-a long-term evaluation of a real-life intervention. *Safety Science*, *48*(5), 680 – 686. DOI: https://doi.org/10.1016/j.ssci.2010.01.018

Laitinen, H., & Ruohomaki, I. (1996). The effects of feedback and goal setting on safety performance at two construction sites. *Safety Science*, *24*(1), 61 – 73. DOI: https://doi.org/10.1016/S0925-7535(96)00070-7

Laitinen, H., Vahapassi, A., Campbell, S., Ersan, E., Birgören, B., Özesen, M., Matisane, L., Şimşek, C., Atlı, K., Demirkol, D., & Rodoplu, S. (2012). KOBİ'ler için İş Sağlığı ve Güvenliği Yönetim Rehberi: Risk Değerlendirmesi, İSG Performans İzleme ve Sağlık Tehlikeleri-Metal Sektörü. Ankara: Çalışma ve Sosyal Güvenlik Bakanlığı.
Retrieved from: Microsoft Word - Metal YENİ (ailevecalisma.gov.tr)

Laitinen, H., Vuorinen, M., Simola, A., & Yrjanheikki, E. (2013). Observation-based OHS outcome indicators-validity of elmeri+ method. *Safety Science*, 54, 69-79. DOI: https://doi.org/10.1016/j.ssci.2012.11.005

Martı, D. (2016). Evaluation of dust and silica exposure in brick and tile production sector and determining thermal comfort conditions (Occupational Health and Safety Thesis).
Retrieved from: dogamarti.pdf (ailevecalisma.gov.tr)

Nasim, S., Shahid, A., Mustufa, M., Kazmi, S., Siddiqui, T., Mohiuddin, S., Sheikh, M., & Usman, S. (2010). Practices and awareness regarding biosafety measures among laboratory technicians working in clinical laboratories in Karachi, Pakistan. *Applied Biosafety Journal*, *15*(4), 172-179.
DOI: https://doi.org/10.1177/153567601001500403

Ongun, A. (2015). Occupational health and safety in Turkey and Finland's manufacturing industry comparison and elmeri with OHS-YSD methods an application (Master's thesis).
Retrieved from: https://tez.yok.gov.tr/UlusalTezMerkezi

Ongun, A., & Bilen, K. (2016). Analysis and an application of Elmeri Method. İş Sağlığı ve Güvenliği Genel Müdürlüğü (Eds.), 8. *International conference on safety & health* (pp. 574-583). İstanbul, Turkey.
Retrieved from: untitled (ailevecalisma.gov.tr)

OSHA. (2011). *Laboratory Safety Guidance*. U.S.: Occupational Safety and Health Administration U.S. Department of Labor. Retrieved from: Laboratory Safety Guidance (osha.gov)

Özdemir, B. (2014). Evaluation of occupational health and safety conditions in textile ateliers by using multi-criteria decision-making method (Occupational Health and Safety Thesis).
Retrieved from: burakozdemir.pdf (ailevecalisma.gov.tr)

Paolo, F., Gianfranco, F., Luca, F., Marco, M., Andrea M., Francesco, M., Vittorio, P., Mattia, P., & Patrizia, S. (2021). Investigating the role of the human element in maritime accidents using semi-supervised hierarchical methods. *Transportation Research Procedia*, 52, 252-259. DOI: https://doi.org/10.1016/j.trpro.2021.01.029

Sarı, M., & Kuzpınar, H. G. (2017). Application of Elmeri OHS observation Method for Quarries around Aksaray city. Altıner, M., Özdemir, A. C., & Yılmaz, M. (Eds.). *International Symposium on Occupational Health and Safety in Mining'2017 Reported Book* (pp. 412-427). Adana, Turkey.
Retrieved from: https://www.maden.org.tr/resimler/ekler/8d3eefe2cdb3628_ek.pdf

Sarıkaya, H., & Altındağ, R. (2015). Application of Marble Factory Method of Elmer. Gülsün Kılıç, M., Önel, Ö., Başarır, H., Karadeniz, M., & Torun Bilgiç, E. (Eds.). *Proceedings Book of the 24th International Mining Congress of Turkey* (pp. 90-96). Antalya, Turkey.
Retrieved from: https://www.maden.org.tr/resimler/ ekler/5adcde510c66d4c_ek.pdf

Shekhar, H., Patel, M., Jain, C., Garg, N., & Mangukiya, K. (2015). Awareness to hazards and biosafety precautions among laboratory technicians working in tertiary-care center in Rajasthan, India. *International Journal of Medical Science and Public Health*, *4*(1), 15-18. DOI: https://doi.org/ 10.5455/ijmsph.2015.020920143

Yaylalı, Ç. (2016). The Elmeri Method of performance monitoring at occupational health and safety and an application in metal workshop of Karamanoğlu Mehmetbey University vocational school. Young Scholars Union (Eds.). *II. International Multidisciplinary Congress of Eurasia* (pp. 589-602). Odessa, Ukraine.
Retrieved from: Önceki Kongreler (imcofe.org)

Yılmaz, Ş., & Bilici, M. (2020). Occupational health and safety in laboratories located in the faculty of engineering. *OHS Academy*, *3*(2), 102-113. DOI: https://doi.org/10.38213/ohsacademy.745723

Zaveri, J. (2012). Knowledge, attitudes and practice of laboratory technicians regarding universal work precaution. *National Journal of Medical Research*, *2*(1), 113-115.
Retrieved from: https://www.bibliomed.org/mnsfulltext/78/78-1334080140.pdf?1624805948