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The Level of Awareness and Knowledge Sources of Safety and Security Procedures in School Laboratories among Science Teachers and Laboratory Technicians in Public Education Schools

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Abstract:

The present study aimed to investigate the level of awareness of safety and security procedures in school laboratories and their knowledge sources among science teachers and laboratory technicians, as well as to identify the significance of differences according to certain variables. To meet such an end, the study adopted the descriptive methodology. The researcher designed a scale to measure awareness of laboratory safety and security procedures, which was administered to a study sample of (348) male and female teachers and laboratory technicians. The findings revealed that the overall level of awareness regarding laboratory safety and security procedures among the study sample was lower than the acceptable standard. Furthermore, the results indicated no statistically significant differences between male and female teachers attributed to the variables of gender, experience, specialization, and academic qualification. Similarly, no statistically significant differences were found among male and female laboratory technicians attributed to the variables of gender, experience, and academic qualification. Conversely, the findings demonstrated statistically significant differences regarding the job variable in favor of the (laboratory technician) position. The results also showed that university education, external reading, the Internet, and the teacher's manual ranked as the primary knowledge sources of laboratory safety and security procedures from the perspective of the sample members. The study recommended the necessity of designing courses and training programs on laboratory safety and security for pre-service and in-service teachers, in addition to developing websites for the same purpose.

Keywords: Awareness, Safety and Security Procedures, School Laboratory, Laboratory Technician.

1. Introduction

The school science laboratory is considered one of the most important educational resources for teaching scientific subjects in the modern school. This is due to the learning experiences it provides for students, as well as the scientific and practical skills, and positive attitudes towards science and scientists, that it instills in them. It is deemed the appropriate environment where the scientific experimentation approach can be applied, utilizing the available apparatuses, tools, and materials that students use to achieve practical results that complement the theoretical aspects of the studied scientific subject (Al-Maarefa Magazine, 1433 AH). This enables them to adopt the methodology of scientists in research, experimentation, and knowledge acquisition.

From the 1950s to the present day, interest in science laboratories in middle and high schools has increasingly grown. They have been regarded as a crucial focal point for the study of science and a vital component of modern science curricula within most developmental programs and projects for science instruction (Trowbridge et al., 2004, p. 295). Consequently, the science laboratory has remained the beating heart of the science teaching process (Al-Shuaili & Al-Maamari, 2006, p. 165). It acts as the fundamental feature that distinguishes the field of science from other domains of human knowledge and contributes to its advancement over them.

Parallel to the focus on the educational role of science laboratories in the modern school, there has been an emphasis on ensuring safety and security requirements for all users of this school facility. The laboratory encompasses numerous hazards that could potentially harm both the teacher and the student if they lack awareness of safety rules and procedures, whether concerning the protocols for conducting experiments or handling the various materials and equipment housed within it.

A report issued by the Science Education Section in Hong Kong (2013) regarding science laboratory accidents in local high schools revealed that 97% of the incidents were primarily caused by a lack of knowledge regarding safety and security procedures and the negligence of laboratory users towards them. Furthermore, a report by the US Chemical Safety Board (2013, p. 8) indicated that since 2001, accidents have occurred in the laboratories of more than 120 American universities, resulting in fatalities, numerous injuries, and damages, in addition to millions of dollars in losses affecting students, teachers, researchers, and staff. This underscores the importance of fostering preventive awareness among all users of these laboratories, foremost among them being students, teachers, and laboratory technicians.

The science teacher is considered a fundamental pillar in laboratory work through their roles in supervision, guidance, monitoring, and raising awareness during the implementation of the science lesson in the laboratory with their students. Safety in this environment is the primary responsibility of

the science teacher; therefore, the teacher's awareness and comprehension of safety and security standards within the laboratory are crucial elements and essential competencies that serve to protect both the teacher and the students from potential hazards. Likewise, laboratory technicians play a significant role in educating and disseminating awareness among teachers and students regarding safety and security procedures when utilizing the laboratory, operating under the assumption that they possess a solid cognitive and skill-based background, given that this lies at the core of their profession.

The findings of several studies that addressed this topic regionally and internationally, such as the study by Ali (2013) in Algeria, Al-Habeel and Ayesh (2012) in Palestine, Al-Shuaili and Al-Maamari (2006) in the Sultanate of Oman, Julius and Thomas (2014) in Nigeria, Zaveri and Karia (2012) in Pakistan, and Schroder et al. (2015) in the United States, have demonstrated a low level of awareness concerning laboratory safety and security procedures among academics, teachers, and laboratory technicians across various scientific disciplines. Similarly, the study by Iman Abdullatif (1432 AH) and the study by Al-Mudaifer (2005) in the Kingdom of Saudi Arabia also revealed a low level of awareness of these procedures among female science teachers and female laboratory technicians.

Over the past few years, science curricula in the Kingdom of Saudi Arabia have witnessed a developmental leap in their content, substance, and implementation mechanisms. This was manifested in the Mathematics and Natural Sciences Development Project, adopted by the Ministry of Education in its endeavor to develop science and mathematics education and to benefit from the experiences and expertise of successful countries in this domain.

Perhaps the most prominent distinguishing feature of the developed science curricula is their profound attention to the applied domain and their focus on conducting activities and experiments within every topic of the textbook. This is evidenced by the allocation of a supplementary manual accompanying the student's textbook to assist them in executing various experiments and activities, the majority of which are conducted in the school laboratory. As an indication of the importance of implementing these activities and experiments, these manuals included instructions and rules directed at both the teacher and the student, which must be adhered to when handling laboratory materials and equipment. This highlights the curricula's attention to safety and security standards in the laboratory and their emphasis on the necessity of disseminating awareness of these standards among all users of this vital space within the school.

1.1. Statement of the Problem:

Based on the aforementioned, and in parallel with the general trend among educational authorities in the Kingdom toward emphasizing the achievement of safety and security standards in educational institutions as a requisite for the quality of the educational process, a trend activated through a number

of practical measures, including the Ministry of Education's establishment of the General Administration for School Safety and Security in 1433 AH. This step aligns with the developments witnessed in the Kingdom's school curricula, including science curricula, and the emphasis these curricula place on various safety and security standards, particularly concerning the school laboratory. The laboratory hosts diverse scientific activities requiring the use of potentially hazardous tools and materials for both the teacher and the student. Given that the teacher is the leader and guide of the instructional process within the laboratory, assisted by the laboratory technician, it is imperative that both are knowledgeable and aware of all safety and security precautions, as well as proper conduct procedures in situations that may arise in the laboratory. Therefore, the present study seeks to reveal the level of awareness among science teachers and laboratory technicians in our schools regarding safety and security procedures inside the laboratory, as well as their sources of acquiring this awareness. Consequently, the research problem is defined by the following main question:

What is the level of awareness and the sources of knowledge regarding safety and security procedures in science laboratories among science teachers and laboratory technicians in public education schools?

1.2. Research Questions:

The following sub-questions branch out from the preceding main question:

1. What is the level of awareness of safety and security procedures among science teachers and laboratory technicians?
2. Are there statistically significant differences in the level of awareness of safety and security procedures between male and female science teachers attributed to the gender variable?
3. Are there statistically significant differences in science teachers' level of awareness of safety and security procedures according to their specialization?
4. Are there statistically significant differences in science teachers' level of awareness of safety and security procedures according to their practical experience?
5. Are there statistically significant differences in science teachers' level of awareness of safety and security procedures according to their academic qualification?
6. Are there statistically significant differences in the level of awareness of safety and security procedures between male and female laboratory technicians attributed to the gender variable?
7. Are there statistically significant differences in laboratory technicians' level of awareness of safety and security procedures according to their practical experience?

8. Are there statistically significant differences in laboratory technicians' level of awareness of safety and security procedures according to their academic qualification?
9. Are there statistically significant differences in the level of awareness of safety and security procedures among the sample members attributed to the job variable?
10. What are the knowledge sources of safety and security procedures in the laboratory among science teachers and laboratory technicians?

1.3. Objectives of the Study:

The current study aimed to:

1. Determine the level of awareness of safety and security procedures in school laboratories among science teachers and laboratory technicians.
2. Identify the significance of differences among the sample members according to the study's variables.
3. Determine the knowledge sources of safety and security procedures in school laboratories among science teachers and laboratory technicians.

1.4. Significance of the Study

The significance of this study stems from the fact that it:

1. Seeks to determine the level of awareness of safety and security procedures in school laboratories among science teachers and laboratory technicians.
2. Provides stakeholders involved in developing science curricula, the Safety and Security Administration at the Ministry of Education, and other relevant government entities with a clear picture of the state of teachers' and laboratory technicians' knowledge regarding safety and security procedures in school laboratories.
3. Offers recommendations and proposals to enhance this vital pedagogical aspect.

1.5. Delimitations of the Study

- Human Delimitations: The study included a sample of male and female science teachers and laboratory technicians in the Al-Madinah Al-Munawwarah and Qassim regions.
- Objective Delimitations: The study addressed the awareness of science teachers and laboratory technicians regarding safety and security procedures in school laboratories in light of the scale developed for this purpose.

1.6. Definition of Terms:

Awareness: Linguistically, as stated in *Lisan al-Arab*, it means "to comprehend something; to grasp a speech thoroughly, to preserve, understand, and accept it, making one 'aware.' Saying someone is

more aware than another means they possess greater retention and understanding. In the Hadith, the Prophet Mohammad “peace be upon him” stated, ‘May Allah gladden a man who hears something from us, so he conveys it as he heard it.’" (p. 396).

Terminologically, Laila Hussam El-Din (2000) defines awareness as "an individual’s perception based on sensation and knowledge, comprising both cognitive and affective dimensions" (p. 127).

Ahmed (1413 AH) defines it as "a concept founded on knowledge (the acquisition of information), understanding the meaning of knowledge, and developing a positive attitude toward knowledge. Cognitive awareness entails the availability of information regarding a specific phenomenon or subject, whereas affective awareness involves the formation of inclinations and attitudes" (p. 22).

The researcher operationally defines it as the familiarity of teachers and laboratory technicians with safety and security procedures in their utilization of the school laboratory. This is achieved through acquiring the relevant concepts, facts, and skills, and its impact on cultivating sound attitudes. It is measured here by the score the teacher or technician obtains through their performance on the scale developed for this purpose.

School Laboratory: Defined by Collins and Nancy O’Brien (2008) in the *Greenwood Dictionary of Education* as "a room or building equipped for performing scientific experiments, investigative procedures, or teaching science using specific equipment and procedures, with a designated time period allocated for laboratory work" (p. 527).

Security: Defined by Al-Malki (1435 AH) as "a human feeling of safety and tranquility, and the absence of causes of fear for one’s life, the necessities of survival, and acknowledged interests, thereby encompassing the security of the individual, the community, and the nation" (p. 79).

Safety: Defined by Al-Dandani (2013, p. 11) as a set of approved procedures and methods that ensure the protection of lives and properties prior to the occurrence of an accident, and contribute to providing a safe working environment.

Safety and Security Procedures in the School Laboratory: Based on the aforementioned, the researcher defines them as the practices and rules relevant to the school laboratory aimed at preventing accidents and hazards resulting from chemical, physical, and biological factors present within it. These are associated with risk management, the safety of practices, and first aid skills, providing protection for the student, the teacher, and every user of this educational environment, which necessitates knowledge and awareness thereof.

Laboratory Technician: A specialized technician responsible for laboratory affairs in schools, entrusted with coordinating with the school’s science teachers to execute the practical experiments

prescribed in the academic curricula. The technician bears the bulk of the responsibilities for organizing the laboratory, ensuring its complete operational readiness, and verifying the availability of safety and security requirements within it (Al-Maarefa Magazine, 1433 AH).

2. Theoretical Framework:

2.1. The School Science Laboratory (Its Objectives, Types, and Specifications):

Experimentation is considered a fundamental component in science education, as the science laboratory plays a crucial role in testing hypotheses, verifying their validity, and translating theories and laws into tangible state. This process, namely, experimentation, is the characteristic that distinguishes natural sciences from other branches of knowledge and science, to the extent that it is often referred to as "experimental sciences," a metonymy encompassing its various branches (Physics, Biology, Chemistry, and Earth Science).

Therefore, the laboratory has acquired a central role in modern science curricula. As Doran (p. 95) elucidates, it is not merely a medium for conducting demonstrations and verification experiments, but rather the focal point of the science learning process and an effective environment for developing and enhancing students' higher-order cognitive and performance skills.

Since the 1960s, laboratory activities, as Khataybeh (2005, p. 445) notes, have become an integral part of science curricula from kindergarten through the university level. This is linked to the curriculum renewal movement and various science development programs and projects, which established laboratory work as a cornerstone in the teaching and learning of science.

Today, the school laboratory has become an essential part of the educational environment, occupying significant space within educational facilities across all levels of education. It is also considered one of the indispensable elements of modern educational technology in teaching science. These scientific laboratories have become the environment where the student develops, as they provide diverse and multiple sensory experiences that form the foundation for understanding numerous facts, information, concepts, and phenomena present in their environment (Samiha Sulaiman, 1430 AH).

The importance of laboratory work in science education is highlighted by the objectives we strive to achieve in students through its practice. This constitutes a common denominator among all science curricula worldwide. These objectives, as cited by (Al-Ayasrah, 2012, p. 168; Khataybeh, 2005, p. 440; Hala Bakhsh, n.d., p. 171; Al-Khalili et al., 1996, p. 307), consist of:

1. Understanding the nature of science.
2. Acquiring science processes.
3. Forming direct learning experiences.

4. Acquiring new scientific knowledge and information.
5. Discovering the relationship between causes and effects.
6. Training students in precise observation.
7. Assisting students in acquiring appropriate practical skills.
8. Training students in the correct use of scientific apparatus to attain accurate experiences.
9. Forming, acquiring, and developing scientific attitudes towards science.
10. Verifying the studied principles and theories.

Al-Nimrah (2004, p. 18) identifies the functions and activities conducted in school laboratories, which must be considered during their design, and they comprise:

1. Presenting and delivering lessons related to science and its fields.
2. Utilizing educational technologies, such as scientific films and various projectors, to display educational materials to students.
3. The teacher conducting experiments in front of the students.
4. Students conducting experiments themselves through working groups, which include experiments related to the fields of physics, chemistry, and biology.

The conceptualization of the school laboratory has remained largely associated with that designated room within the school building, equipped with tables, chairs, diverse materials, and physical, chemical, and biological apparatuses, predominantly focused on teaching scientific subjects. However, with the evolution in science education and the concomitant technological advancements, which have impacted the nature, role, and equipment of the school laboratory, other models have emerged. These models strive to achieve the same objectives while attempting to overcome the difficulties and problems associated with the traditional laboratory. The currently existing laboratory models can be categorized as follows:

- **The Stationary Laboratory:** This is the most common and widespread traditional model in schools and educational institutions. It is considered an essential part of any educational facility and consists of a hall or room within the building designated for this purpose, designed and equipped according to specific standards. A prerequisite for this laboratory is the provision of safety and security factors for its users. An educational facility may encompass more than one laboratory.
- **The Mobile (Micro) Laboratory:** In light of the problems accompanying the use of the stationary laboratory, such as the shortage of materials and equipment, and the high density of student numbers, the mobile (micro) laboratory emerged as a solution to overcome these issues. As Hala Bakhsh (n.d.,

p. 178) mentions, this type is a miniaturized laboratory distributed to students, consisting of a small box containing a set of small, alternative equipment made of plastic, such as tubes, burettes, and stands, along with some non-hazardous chemical materials. The primary purpose of utilizing this type is to overcome the aforementioned problems, provide safety for the learner, individualize instruction, connect the learner with science, and enhance their practical skills.

- **The Virtual Laboratory:** This model emerged as a result of the development of computer applications and their uses in the educational process. It is an interactive virtual educational environment through which various experiments are conducted in a manner simulating real laboratory experiments. The learner feels as if they are in the laboratory through their control of the apparatuses, as though they were present at the experiment site (Sharaf, 2006, p. 31). It employs computer programs and applications designed on disks, and there are also websites on the Internet that achieve the same objective. The importance of this type of laboratory lies in enabling learners to conduct laboratory experiments that cannot be performed under normal circumstances, providing them with the opportunity for self-learning. It also mitigates the risks arising from handling certain hazardous materials and equipment in a real laboratory and is economical in terms of cost and effort. Consequently, its prevalence and utilization in schools are increasing.

The design of the stationary school laboratory must observe several technical specifications, standards, and requirements that are imperative to adhere to when constructing the educational facility, with safety requirements placed at the forefront of these specifications. Al-Dandani (1434 AH, p. 28), Al-Nimrah (2014, p. 22), Iman Al-Abdullatif (1432 AH, p. 700), Al-Rifai (1426 AH, p. 6), and Al-Mudaifer (2005, p. 26) mention some of these specifications, including:

1. The laboratory should be located on the ground floor.
2. The space available and allocated for each student in the laboratory must be sufficient for their movement (2 square meters per student).
3. A working area of no less than one meter should be maintained around each apparatus or workbench.
4. Sub-aisles with a width of no less than one meter and a main aisle with a width of no less than 1.5 meters must be maintained inside the laboratory.
5. Storage cabinets should not exceed eye level, and an area for movement of no less than one meter must be left in front of them.
6. The laboratory must be equipped with two emergency exits, one of which opens onto a spacious area.

7. Emergency exit doors must open outward and be equipped with a horizontal push bar that opens the door upon pressure.
8. The fire resistance of the emergency exit doors must not be less than one hour.
9. Fire extinguishers and fire blankets should be hung near the exits at a height of one meter from the floor.
10. Laboratories must be equipped with a robust ventilation system and adequate cooling means.
11. Laboratory floors must be made of non-slip materials and be resistant to chemicals.
12. The upper half of the laboratory doors must be made of shatter-resistant glass to facilitate monitoring of activities inside the laboratory.
13. The presence of an automatic fire alarm system.
14. The presence of an automatic fire extinguishing system.
15. School laboratories should be connected to an alarm system linked directly to the relevant safety and security administration (Civil Defense).

2.2. Hazards in School Science Laboratories:

School science laboratories encompass numerous hazards arising from the neglect of adherence to safety and security procedures within the laboratory by teachers, laboratory technicians, and students. These hazards, as mentioned by Omayma Al-Mughni (2006, p. 41) and Al-Dandani (1434 AH, p. 37), can be classified into:

1. Physical Hazards: Represented by the risks of electricity, radiation, noise, and heat.
2. Chemical Hazards: Represented by poisoning, chemical burns, gases, and the inhalation of toxic gases and vapors.
3. Biological Hazards: Represented by infection with bacteria, viruses, fungi, contamination, stings, and bites.
4. Mechanical Hazards: Represented by cuts, wounds, falls, slips, and collisions.
5. Fire Hazards: Represented by thermal, chemical, and electrical fires.

2.3. Requirements for Safety and Security in the School Science Laboratory:

The school laboratory is considered one of the most dangerous places within the school building due to the materials, apparatuses, and tools it contains. Negligence in handling them could lead to a catastrophe within the school, with damage extending beyond the physical components to the human personnel interacting with them.

Laboratory workers are the individuals most vulnerable to these hazards, particularly if they are unaware of the preventive measures that must be taken during work. This is usually due to improper handling of apparatuses or chemicals inside the laboratory (Al-Shuaili & Al-Maamari, 2006, p. 166).

Therefore, it is imperative to pay close attention to the availability of safety and security means, procedures, and requirements in these laboratories, and to ensure that their users are knowledgeable about and provided with these procedures. This must be accompanied by an endeavor to raise the level of awareness by focusing on the training domain and utilizing various safety programs (Al-Habeel & Ayesh, 2012, p. 4). The responsibility for this matter lies with the authorities specialized in safety and security, in collaboration with educational institutions. The requirements for safety and security in science laboratories consist of three crucial aspects that must be present among the users of this educational environment:

First: The Preventive Aspect (Risk Management):

The fundamental element for achieving safety and security in laboratories is the awareness of the hazards present within them by the personnel working there and knowing how to prevent them. The preventive aspect pertains to the potential hazards in the laboratory and how to deal with them. This is known as "risk management," which is a crucial requirement that must be possessed by teachers, laboratory technicians, and students, as the knowledge and observance of these preventive precautions represent the first stage of safety and security requirements in laboratory work.

Risk management aims to prevent and minimize the hazards to which individuals and properties are exposed, reduce the magnitude of losses, and strive to prevent the recurrence of their causes (Abdul Moneim et al., 2008, p. 6). The most prominent hazards found in school laboratories, as explained by Allan et al. (1422 AH, p. 20), include fires, explosions, gas leaks, chemical liquid spills, electrocution, falls, collisions, and slips. These hazards may result in burns, wounds, poisoning, fractures, explosions, and diseases.

Therefore, the entity responsible for the laboratory in the school must identify activities with high-risk rates for teachers, familiarize them with apparatuses and materials that may be hazardous, and educate them about the expected injuries resulting from the misuse of these materials and apparatuses (Jo et al., 2000, p. 7).

These hazards arise due to two types of causes, as clarified by Al-Rifai (1426 AH, p. 8), which are:

1. Causes related to an unsafe working environment: This includes poor storage, lack of ventilation, improper electrical wiring, poorly manufactured apparatuses, lack of safety tools, and negligence in their maintenance.

2. Causes related to the performance of laboratory workers: This includes non-compliance with the instructions for using the facility, disregarding safety procedures and personal protective equipment, and failing to follow the correct steps during work.

The study by Iman Al-Abdullatif (1432 AH) indicated that preventive awareness of safety and security procedures among female teachers and female laboratory technicians was low, in addition to shortcomings in safety and security procedures in public school laboratories in the Kingdom. This issue is not limited to the Kingdom but extends to numerous countries, as confirmed by the study of Julius and Thomas (2014) in Nigeria, Hackling (2009) in Australia, and Mogopodi et al. (2015) in Botswana. Despite this, providing complete, hazard-free laboratories is insufficient on its own; it requires educating the workers within them about safety and security procedures and prevention methods that contribute to reducing material and human losses (Al-Habeel & Ayesh, 2012, p. 84).

Second: The Practical Aspect (Laboratory Practices):

Laboratory practices refer to all the applied activities conducted by the teacher, laboratory technician, or students inside the laboratory, which are usually linked to the science curriculum. The safety of laboratory practices is an important requirement, as the core of laboratory work lies in these practices, which necessitate the availability of a set of skills among teachers and laboratory technicians, as well as their possession of a cognitive background regarding the aspects of those practices. Most hazards that occur in laboratories result from incorrect practices and behaviors, the majority of which stem from ignorance and poor intention on the part of those performing the work, whether they are students, teachers, or laboratory technicians.

Workers in the laboratory bear the significance of adhering to safety instructions in terms of proper conduct, executing work steps accurately, following safety guidelines during implementation, and providing a safe and sound practical environment (Al-Habeel & Ayesh, 2012, p. 85).

As Al-Mudaifer (2005) mentions that the improper practice methods are considered among the most important causes of laboratory accidents. For this reason, it is necessary to build awareness of safety procedures and follow appropriate practices in the laboratory among students and teachers, so that it becomes like an ethical charter that everyone adheres to when conducting laboratory experiments (American Chemical Society, 2012, p. 6).

Third: The Remedial Aspect (First Aid):

The hazards resulting from errors in laboratory practices cause material and human losses. Proper conduct and addressing the errors caused by these practices is a matter of utmost importance, directly linked to first aid as the initial procedure to be undertaken when any injuries occur in the laboratory.

First aid is defined as the immediate preliminary care provided to the injured person before the arrival of the ambulance and medical assistance (Mansoura University, 2009, p. 2).

In the school laboratory, the probabilities of its users being exposed to various injury risks increase, occurring suddenly without prior warning. This necessitates that these users possess full knowledge and awareness of how to act and handle these emergency situations, where timely and successful intervention leads to rescuing the injured and preserving their life. Therefore, school teachers must possess a level of knowledge and skill in first aid principles that enables them to act properly in critical situations to save their students (Nairat, 2014, p. 2223).

2.4. Sources of Knowledge of Safety and Security Requirements in School Laboratories:

There are numerous and diverse knowledge sources regarding safety and security procedures and requirements in laboratories, aiming to improve awareness among the users of these laboratories in schools, including teachers, laboratory technicians, and students, so they can conduct their experiments safely (Science Education Section, 2013, p. 4). In the United States of America, educational programs on laboratory safety and security have been approved and are taught either as independent programs or within scientific subjects to assist teachers and students in elementary, middle, and high schools. This is in addition to various publications, manuals, and specialized books in this regard (American Chemical Society, 2010).

Omayma Al-Mughni (2006, p. 35) mentions sources of knowledge of safety and security requirements, including lectures, printed publications, and films, as well as training programs, which are considered an important source for hazard prevention. They acquaint laboratory users with safe working methods, rendering them more capable of predicting accidents, as they can identify danger zones and understand their consequences.

Furthermore, the internet currently serves as an important source of information on laboratory safety and security, containing many reliable websites and pages that can be depended upon to educate the users of these environments (American Chemical Society, 2010, p. 40). Social media networks, such as Facebook, have begun to be included among these sources, having proven their effectiveness in improving awareness of laboratory safety and security among university students, as demonstrated by Daclan's study (2013).

The study by Ali (2013) revealed that previous university education, teacher's manuals, publications accompanying chemicals, and the textbook are considered, in this order, the best sources of knowledge of laboratory safety procedures among teachers. The responsibility of familiarizing teachers, students, and laboratory technicians with these rules and procedures lies with the individuals and entities specialized in safety and security within the educational administration, through training courses,

lectures, and publications. Additionally, the laboratory technician within the school bears the responsibility of introducing and disseminating awareness of these procedures among teachers and students, as Schroder et al. (2015) confirm the positive impact of laboratory technicians on their colleagues.

3. Literature Review:

Numerous studies have been conducted addressing the aspects of safety and security in laboratories and the extent to which their users possess awareness and understanding of these aspects. Schroder et al. (2015) conducted a survey study in the United States aiming to identify the state of practices and attitudes toward laboratory safety among workers in three types of laboratories (academic, industrial, and government). The study sample comprised (991) workers in academic laboratories, (120) workers in industrial laboratories, and (133) workers in government laboratories. The results revealed that the risk assessment rating present in laboratories was lower among academics compared to those working in industrial and government laboratories. Furthermore, the compliance rate with laboratory practice rules and safety requirements was highest among workers in industrial laboratories, followed by government laboratories, and then academic laboratories. The findings disclosed that 25% of the total sample had not received any training on laboratory safety procedures. Additionally, the results demonstrated a positive impact of laboratory technicians on their colleagues.

Mogopodi et al. (2015) conducted a study aiming to assess the level of awareness and safety and security practices in middle school laboratories in Gaborone, Republic of Botswana. The scale was administered to a sample consisting of 30 teachers in these laboratories across ten schools. Additionally, safety procedures in these laboratories were observed and monitored. The study yielded several results, most notably a lack of awareness and knowledge of safety and security procedures among teachers, as well as distinct shortcomings in the safety and security procedures within these laboratories.

The study by Can et al. (2015) in Turkey revealed that the awareness and attitudes of students and pre-service science teachers were positive toward laboratory safety procedures. The study adopted the descriptive methodology, and the sample consisted of 135 pre-service student teachers. No statistically significant differences were found among individuals in their attitudes toward school laboratory safety procedures attributed to the variables of gender, region, and academic stage.

In Nigeria, Julius and Thomas (2014) conducted a descriptive study aiming to identify hazards and safety procedures in school laboratories in Ekiti State, Nigeria. To achieve this objective, they employed the descriptive survey methodology. The researchers designed a questionnaire for hazard analysis and safety in the science laboratory, which was distributed to a random sample of teachers

comprising (120) science teachers and (200) students in science classes. The study concluded that science laboratories encompass numerous hazards and that security precautions in these laboratories are minimal and non-existent in some aspects. The results indicated that the level of awareness among physics teachers was the highest compared to chemistry and biology teachers, and the same applied to the students. Hypothesis testing showed significant differences among teachers in their awareness of safety and security procedures according to specialization.

Ali (2013) conducted a study aiming to identify the level of understanding of laboratory safety and security rules and procedures among teachers in Algeria, as well as the sources of their knowledge of these rules. The researcher designed a scale for safety and security rules, consisting of a test administered to a sample of 170 male and female high school teachers. The results clarified that the level of understanding among teachers in Algeria regarding laboratory safety and security rules and procedures was below the required standard. They also indicated no significant differences in teachers' knowledge of these rules attributed to the variables of gender and experience, whereas the differences were significant for the specialization variable in favor of physics teachers. Furthermore, the sources of teachers' knowledge of safety and security rules and procedures were concentrated in two sources: previous university education and laboratory documents and manuals accompanying the textbooks.

In Turkey, Daclan (2013) conducted a study aiming to determine the impact of using social networks (Facebook) based on health education in disseminating awareness of laboratory safety and security procedures. The researcher employed the quasi-experimental methodology using an experimental and control group design. The sample consisted of sixteen students, distributed as ten students in the experimental group and six students in the control group. Educational material regarding laboratory safety and security was presented to them via a Facebook page (experimental group) and through traditional lectures (control group). The study instruments comprised tests to measure awareness of laboratory safety procedures. The results revealed a positive impact of the social network in improving awareness of laboratory safety and security.

The study by Al-Habeel and Ayesh (2012) aimed to evaluate the effectiveness of occupational and health safety and security procedures in scientific laboratories at Palestinian universities. The researchers relied on the descriptive-analytical methodology and designed a four-domains questionnaire, which was administered to a stratified random sample of (217) workers in these scientific laboratories. Personal interviews were also utilized to answer some of the study's questions. The study's results revealed a lack of training for workers in these laboratories regarding safety and security procedures, necessitating the establishment of safety and security units to enhance their awareness and develop their skills.

To investigate the knowledge, attitudes, and practices of laboratory technicians toward precautionary procedures during laboratory work, Zaveri and Karia (2012) conducted a study on a sample of laboratory technicians in several private hospitals in Pakistan, totaling (154) cases. The results revealed a low level of knowledge regarding these precautions among the sample members. The results also demonstrated the presence of several unsafe practices among laboratory technicians, such as smoking, eating, and using laboratory refrigerators to store water and food, among other hazardous actions. It recommended the necessity of training laboratory workers and familiarizing them with laboratory safety precautions.

The study by Shuhara et al. (2011) aimed to analyze the safety and security factors in university scientific laboratories in Japan and the sources of acquiring these factors, by identifying four main factors contributing to achieving safety: planned safety education, self-protection, practice procedures, and a sense of enjoyment. The study instrument consisted of a questionnaire following a Likert scale encompassing a number of questions, which was administered to a sample of 406 students in scientific universities and colleges. The study yielded several results, most notably that the planned safety education factor was the primary source for acquiring awareness of laboratory safety and security procedures. The study recommended the necessity of developing training programs on laboratory safety and security procedures.

In Saudi Arabia, Iman Al-Abdullatif (1432 AH) conducted a study aiming to identify the safety and security procedures in school laboratories in the Riyadh region schools affiliated with the Ministry of Education, and to determine the shortcomings, if any, and methods to address them. The researcher gathered her information through a set of forms, questionnaires, and field visits. The study reached several conclusions, including: there are distinct shortcomings in the safety and security aspects of school laboratories, and the security awareness among female teachers, female students, and female laboratory technicians regarding laboratory safety and security aspects was generally low.

A study by Nasim et al. (2010) found a distinct low level of awareness of biosafety and security procedures among laboratory technicians in Karachi hospitals, Pakistan. A survey study was administered to (253) cases of male and female laboratory technicians, and interviews were also conducted with them. The results demonstrated the presence of several erroneous practices performed during laboratory work. The study recommended the necessity of conducting intensive training courses for them.

Hackling (2009) conducted a survey study in Australia aiming to identify the state of laboratory technicians in high schools in Australia. The study sample comprised 824 laboratory technicians and 607 school principals. The instrument consisted of a multi-domains questionnaire, in addition to

conducting interviews. The study reached several results, most notably that 25% of laboratory technicians in high schools require further training on laboratory safety and security precautions, and that 36% of schools require support regarding those precautions. The study recommended the necessity of providing diverse training programs and utilizing the Internet and other technologies to disseminate awareness among laboratory technicians.

The study by Al-Shuaili and Al-Maamari (2006) aimed to reveal the level of understanding of laboratory safety and security precautions among university students in Colleges of Education (Chemistry major). The sample consisted of 54 male and female fourth-year students. A test comprising 55 items, distributed across five domains and prepared by the researchers, was administered to them. The results revealed a low level of understanding among the sample members, falling below the pedagogically acceptable standard, and the absence of significant differences attributed to the gender variable or academic achievement in chemistry, except for the domain of (using chemical materials) in favor of students with a "Very Good" grade. The study recommended the necessity of including an educational unit on laboratory safety and security precautions and making this topic a part of the practical aspect examinations in chemistry courses.

The study by Al-Mudaifer (2005) aimed to identify the effectiveness of occupational and technical safety and security systems in the scientific laboratories at the Girls' Colleges in Riyadh. The researcher employed the descriptive-analytical methodology and designed two study instruments, consisting of two questionnaires: one directed at the female laboratory supervisors and the other at the female students. The study reached several results, most notably the weak level of knowledge among female students and female laboratory supervisors regarding the safety and security means and systems in these laboratories, and the lack of availability of these safety and security means and systems in the anticipated manner.

In Jordan, Al-Tarawneh (2005) conducted a study to identify the level of knowledge among students of scientific colleges regarding safety and security principles in chemistry laboratories at Mutah University. The study sample consisted of (258) male and female students, to whom a test on safety and security principles was administered. The study concluded that the students' level of knowledge of these principles was weak. It also found significant differences in favor of the female gender, and significant differences in favor of the specialization variable.

3.1. Discussion of Previous Studies:

Through reviewing the previous studies that the researcher was able to access, which were utilized in constructing the theoretical framework upon which this study is based, it became evident to the researcher that most of these studies revealed a deficiency in the level of awareness and understanding

of safety and security procedures in laboratories among the study samples of teachers, students, and laboratory technicians. This is exemplified in the study by Ali (2013), Schroder et al. (2015), Mogopodi et al. (2015), Iman Al-Abdullatif (1432 AH), Zaveri and Karia (2012), Nasim et al. (2010), Al-Shuaili and Al-Maamari (2006), Al-Tarawneh (2005), and Al-Mudaifer (2005).

Furthermore, some of these studies, most notably the study by Schroder et al. (2015), Ali (2013), Daclan (2013), Shuhara et al. (2011), and Hackling (2009), revealed the existence of diverse sources of knowledge regarding safety and security procedures. Some are traditional, such as publications, manuals, education, and continuous training, while others are modern and align with the information age, such as social networks (Facebook).

Additionally, laboratory technicians have an effective role as a source for educating their colleagues. Most of these previous studies agreed on the weakness of safety and security procedures in school laboratories, as seen in the study by Julius and Thomas (2014), Iman Al-Abdullatif (1432 AH), Al-Mudaifer (2005), and Mogopodi et al. (2015).

With the exception of Daclan's study (2013), in which the researcher employed the experimental methodology, the remaining studies adopted the descriptive survey methodology by utilizing scales and questionnaires that focused in their content on laboratory safety and security procedures. This approach will be followed in the present study, which distinguishes itself from the other previous studies by identifying the main domains of awareness of safety and security in the school laboratory (risk management, laboratory practice, first aid), in light of which the scale's items were constructed.

4. Methods:

The study adopted the descriptive survey methodology, which is defined as the approach that relies on describing the studied phenomenon in terms of its nature and existence through surveying all members of the research population or a sample thereof (Al-Assaf, 1421 AH, p. 191).

4.1. Population and Sample of the Study:

The study population consisted of all male and female science teachers and laboratory technicians in public education schools in the Kingdom. The study procedures were administered to a random sample of male and female science teachers and laboratory technicians in the Al-Madinah Al-Munawwarah and Qassim regions.

The total sample of teachers amounted to (n = 215 male and female teachers) representing a percentage of (61.8%), and the total sample of laboratory technicians amounted to (n = 133 male and female technicians) representing a percentage of (38.2%). Table (1) presents a description of the study sample.

Table 1. Description of the Study Sample

Job	Gender		Total	Percentage
	Male	Female		
Teacher	129	86	215	61.8%
Laboratory Technician	33	100	133	38.2%
Overall Total	**162**	**186**	**348**	**100%**

4.2. Study Instrument:

The study instrument consisted of a scale for awareness of safety and security procedures, prepared by the researcher. It is a multiple-choice test distributed across three dimensions:

- Risk management inside the laboratory, comprising 15 questions.
- Safety of laboratory practices, comprising 13 questions.
- First aid, comprising 10 questions.

The researcher prepared the scale after reviewing numerous specialized manuals, books, and research papers that addressed aspects of laboratory safety and security. The instrument was refined, and its validity and reliability were verified as follows:

- Validity: The research instrument was presented to specialized experts in education, science, and laboratories to ascertain the scale's validity regarding the scientific accuracy of the items' content and the extent of the items' correlation with the main dimensions. Some modifications were made to a number of items, and several were deleted, resulting in the final version of the scale upon which it was administered, comprising (38) items. The jury members were also requested to determine the criterion score for the acceptable level of performance on the scale to be used as an indicator for judgment after administration. The acceptable level of performance on the scale was determined as a percentage of (75%), which is equivalent to a score of (28.5) out of the scale's total score of (38).

- Reliability: The scale's reliability was verified by administering it to a pilot sample comprising (30) cases. The Cronbach's Alpha coefficient for the scale as a whole amounted to (0.82), a value indicating a good, dependable reliability coefficient.

4.3. Statistical Methods:

The study utilized a number of statistical methods, including arithmetic means, standard deviations, frequencies, percentages, the *t*-test, Analysis of Variance (ANOVA), and Spearman's rank correlation coefficient. Data processing and analysis were conducted using the Statistical Package for the Social Sciences (SPSS).

5. Results:

- Results Related to the First Research Question: What is the level of awareness of safety and security procedures among science teachers and laboratory technicians?

To answer this question, the researcher calculated the mean and standard deviation for the study sample's level of awareness of laboratory safety and security procedures. A one-sample t-test was conducted to examine whether the sample mean differed significantly from the criterion score, as shown in Table 2.

Table 2. Descriptive Statistics and t-Test Results for Participants' Level of Awareness of Safety and Security Procedures

Sample	N	Mean	Standard Deviation	*t*-value	Level of Significance
Female Teachers	86	27.8	6.1	-1.06	0.293
Male Teachers	129	25.2	4.9	-7.59	0.000*
Female Lab Technicians	100	30.4	3.1	6.07	0.000*
Male Lab Technicians	33	27.8	4.3	-0.956	0.346
Total	**348**	**27.6**	**5.2**	**-3.34**	**0.001***

** A statistically significant differences at the significance level (0.05).*

The preceding table shows that the t-value for the study sample's overall level of awareness of safety and security procedures was -3.34, which was statistically significant at the 0.05 level. This indicates the presence of significant differences between the sample's performance score on the scale and the specified criterion score. Referring to the arithmetic mean of the total sample's performance on the study scale, we find it amounted to (27.6), a value lower than the criterion score set at (28.5). This signifies that the overall performance of the sample members was below the acceptable level determined in the study. Consequently, the level of awareness regarding safety and security procedures in the school laboratory among the study sample was low.

When detailing the sample according to each category, we find that the *t*-test value for the performance of female teachers and male laboratory technicians was not significant, indicating no differences between the mean performance for each category and the scale's criterion score. Conversely, the *t*-test value for the performance of male teachers and female laboratory technicians was significant; the performance of male teachers was below the acceptable level, and in a general comparison, it was the lowest among all categories, with a mean of (25.2).

Meanwhile, the performance of female laboratory technicians exceeded the acceptable level, indicating that their awareness of laboratory safety and security procedures was the highest, with a mean performance of (30.4). The researcher attributes this superiority among female laboratory technicians to their possession of prior cognitive and skill-based experiences regarding laboratories. This may have been refined and developed by the female nature, which is characterized by seriousness at work, diligence, and a desire for continuous learning and excellence compared to males.

This result aligns with the study by Mogopodi et al. (2015), Schroder et al. (2015), Iman Al-Abdullatif (1432 AH), Al-Shuaili and Al-Maamari (2006), Al-Tarawneh (2005), and Al-Mudaifer (2005), all of which concurred on the low level of awareness of safety and security procedures among users of this environment, including students, teachers, laboratory technicians, and academics.

- Results Related to the Second Research Question: Are there statistically significant differences in the level of awareness of safety and security procedures among science teachers according to gender?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the teacher sample members (male and female) on the scale. An independent samples *t*-test was utilized to determine the significance of differences, if any, as illustrated in Table (3):

Table 3. Science Teachers' Level of Awareness of Safety and Security Procedures by Gender

Gender	N	Mean	Standard Deviation	*t*-value	Level of Significance
Male	129	25.2	4.9	-3.46	0.193
Female	86	27.8	6.1		

Table (3) illustrates that the *t*-test value amounted to (-3.46), and this value is not statistically significant at the (0.05) significance level. This indicates the absence of significant differences in performance on the study scale between male and female teachers attributed to the gender variable.

The researcher attributes this result to the similarity of conditions related to the mechanisms for educating and training teachers of both genders concerning safety and security procedures in school laboratories, which remains deficient based on the sample's performance in the current study. Furthermore, there is a lack of interest among teachers of both genders in this knowledge, relying instead on their previous experiences. This occurs amidst a noticeable reluctance among teachers in the Kingdom to utilize laboratories in teaching science, relying more heavily on traditional methods, a fact confirmed by numerous studies conducted in this area, as mentioned by Al-Jabr (2009, p. 116). This contradicts the recent developments witnessed in science curricula in the Kingdom, which

emphasized the aspect of practice, application, and knowledge construction by students under the supervision of teachers, where work in the school laboratory plays a crucial role in achieving these objectives.

This result agrees with the study by Can et al. (2015), Ali (2013), and Al-Shuaili and Al-Maamari (2006), where no effect of gender was observed. Conversely, it differed from the study by Al-Tarawneh (2005), in which females outperformed males in the knowledge of safety and security principles.

- Results Related to the Third Research Question: Are there statistically significant differences in science teachers' level of awareness of safety and security procedures according to their specialization?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the teacher sample on the scale of awareness of laboratory safety and security procedures according to specialization, as illustrated in Table (4):

Table 4. Science Teachers' Level of Awareness of Safety and Security Procedures by Specialization

Specialization	N	Mean	Standard Deviation
Physics	63	26.4	5.02
Chemistry	50	27.2	5.2
Biology	83	25.9	6.3
Science	19	24.4	4.7

It is evident from the preceding table that the mean performance of the teacher sample members on the scale whose specialization is (Chemistry) was the highest, amounting to (27.2), followed by the (Physics) specialization with a mean performance of (26.4), then the (Biology) specialization with a mean performance of (25.9), while the lowest performance means were for the (Science) specialization, amounting to (24.4). To determine the level of significance and the significance of differences among the means, an Analysis of Variance (ANOVA) test was utilized, as illustrated in Table (5):

Table 5. Analysis of Variance for Science Teachers' Performance by Specialization

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Level of Significance
Between Groups	116.527	3	38.842		
Within Groups	6588.756	211	31.226	1.244	0.295
Total	6705.284	214			

It is evident from the preceding table that the calculated (F) value equals (1.244), which is not statistically significant at the (0.05) level. This signifies the absence of statistically significant differences among teachers in the level of performance on the scale of awareness of laboratory safety and security procedures attributed to the specialization variable.

This result can be explained by looking at the convergence in performance on the scale among the sample members across all specializations. This may reflect the similarity in the conditions of preparing male and female teachers at the university level across all scientific disciplines, and the ineffectiveness of the university courses related to laboratories in their current state in familiarizing students with safety and security procedures when working in the laboratory.

This result differs from the study by Julius and Thomas (2014), Ali (2013), and Al-Tarawneh (2005), which demonstrated the presence of significant differences attributed to the specialization variable in favor of the (Physics) specialization.

- Results Related to the Fourth Research Question: Are there statistically significant differences in science teachers' level of awareness of safety and security procedures according to their practical experience?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the teacher sample members on the scale of awareness of laboratory safety and security procedures according to experience, as illustrated in Table (6):

Table 6. Science Teachers' Level of Awareness of Safety and Security Procedures by Experience

Experience	N	Mean	Standard Deviation
Less than 5 years	26	26.6	5.2
5 to 10 years	65	26.5	5.8
More than 10 years	124	25.9	5.6

It is evident from the preceding table that the mean performance of the teacher sample members on the scale according to their experience was largely converging. The mean performance for those possessing experience of (less than 5 years) was the highest, amounting to (26.6), followed by individuals possessing experience of (5 to 10 years) with a mean performance of (26.5), and finally the mean performance for teachers possessing experience of (more than 10 years) which amounted to (25.9).

To determine the level of significance and the significance of differences among the means, an Analysis of Variance (ANOVA) test was utilized, as illustrated in Table (7):

Table 7. Analysis of Variance for Science Teachers' Performance by Experience

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Level of Significance
Between Groups	15.892	2	7.946	0.252	0.778
Within Groups	6689.392	212	31.554		
Total	6705.284	214			

It is evident from the preceding table that the calculated (F) value equals (0.252), which is not statistically significant at the (0.05) level. This signifies the absence of statistically significant differences among teachers in the level of performance on the scale of awareness of laboratory safety and security procedures attributed to the experience variable. The interpretation of this result is linked to what was previously discussed regarding the variables of gender and specialization, specifically, the weak relationship of teachers in general with the laboratory as an educational environment. This is a consequence of factors, some of which are attributed to the teacher, and others to the role of the authorities supervising school laboratories within the Ministry of Education. It is also noteworthy here that the newly experienced teachers performed better on the scale than those with extensive experience. This can be associated with their recent graduation and potentially their benefit from university studies, which the results indicated is considered the primary source of knowledge regarding laboratory safety and security procedures among the sample members. This result aligns with the study by Ali (2013), where experience had no effect on performance.

- Results Related to the Fifth Research Question: Are there statistically significant differences in science teachers' level of awareness of safety and security procedures according to their academic qualification?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the teacher sample members on the scale of awareness of laboratory safety and security procedures according to the qualification variable, as illustrated in Table (8):

Table 8. Science Teachers' Level of Awareness of Safety and Security Procedures by Qualification

Qualification	N	Mean	Standard Deviation
Diploma	4	22	3.3
Bachelor's	200	26.4	5.4
Master's	11	25.5	8.2

The preceding table presents the mean scores for science teachers' level of awareness of laboratory safety and security procedures according to academic qualification. Teachers with a bachelor's degree

had the highest mean score (M = 26.4), followed by those with a master's degree (M = 25.5), and then those with a diploma (M = 22.0). To determine whether these differences were statistically significant, a one-way analysis of variance (ANOVA) was conducted, as shown in Table 9.

Table 9. Analysis of Variance for Science Teachers' Performance by Qualification

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Level of Significance
Between Groups	81.056	2	40.528		
Within Groups	6624.227	212	31.246	1.297	0.275
Total	6705.284	214			

It is evident from the preceding table that the calculated (F) value equals (1.297), which is not statistically significant at the (0.05) level. This signifies the absence of statistically significant differences among teachers in the level of performance on the scale of awareness of laboratory safety and security procedures attributed to the qualification variable. It is noteworthy here that the mean performance of teachers possessing a (Bachelor's) qualification was the best compared to those with (Master's) and (Diploma) qualifications. This may be due to the fact that most teachers holding a Bachelor's qualification are still practicing the teaching profession and maintain a connection with utilizing and interacting with the laboratory. This is in contrast to holders of other qualifications, some of whom work as supervisors (Master's) or in the lower grades of elementary school (Diploma), where their utilization of the laboratory is minimal.

- Results Related to the Sixth Research Question: Are there statistically significant differences in the level of awareness of safety and security procedures between male and female laboratory technicians attributed to the gender variable?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the laboratory technician sample members (male and female) on the scale. An independent samples *t*-test was utilized to determine the significance of differences, if any, as illustrated in Table (10):

Table 10. Laboratory Technicians' Level of Awareness of Safety and Security Procedures by Gender

Gender	N	Mean	Standard Deviation	*t*-value	Level of Significance
Male	33	27.8	4.3	3.77	0.068
Female	100	30.4	3.1		

Table (10) illustrates that the *t*-test value amounted to (3.77), and this value is not statistically significant at the (0.05) significance level. This indicates the absence of significant differences in

performance on the study scale between male and female laboratory technicians attributed to the gender variable.

The researcher attributes this result to the similarity of conditions related to the mechanisms of preparing and training laboratory technicians of both genders. This occurs in light of the competent administration for school laboratories within the Ministry of Education focusing on the material aspects related to these laboratories, while neglecting the technical and awareness aspects pertaining to the users of this environment, including technicians and others. Foremost among these neglected aspects is the provision of effective training programs related to safety and security. Furthermore, there is a reluctance among male and female laboratory technicians to attend such training programs, which necessitates resorting to alternative methods to achieve this objective. The most important of these methods is utilizing modern technologies and communication channels, which have proven their effectiveness, as confirmed by Daclan's study (2013).

- Results Related to the Seventh Research Question: Are there statistically significant differences in laboratory technicians' level of awareness of safety and security procedures according to their practical experience?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the laboratory technician sample members on the scale of awareness of laboratory safety and security procedures according to experience, as illustrated in Table (11):

Table 11. Laboratory Technicians' Level of Awareness of Safety and Security Procedures by Experience

Experience	N	Mean	Standard Deviation
Less than 5 years	55	30	3.2
5 to 10 years	22	29.9	3.6
More than 10 years	56	29.4	3.9

It is evident from the preceding table that the mean performance of the laboratory technician sample members on the scale according to their experience was converging. The mean performance for those possessing experience of (less than 5 years) was the highest, amounting to (30), followed by individuals possessing experience of (5 to 10 years) with a mean performance of (29.9), and finally the mean performance for technicians possessing experience of (more than 10 years) which amounted to (29.4).

To determine the level of significance and the significance of differences among the means, an Analysis of Variance (ANOVA) test was utilized, as illustrated in Table (12):

Table 12. Analysis of Variance for Laboratory Technicians' Performance by Experience

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Level of Significance
Between Groups	10.418	2	5.209		
Within Groups	1689.372	130	12.995	0.401	0.671
Total	1699.789	132			

It is evident from the preceding table that the calculated (F) value equals (0.401), which is not statistically significant at the (0.05) level. This signifies the absence of statistically significant differences among laboratory technicians in the level of performance on the scale of awareness of laboratory safety and security procedures attributed to the experience variable. Referring to the mean performance, this result corroborates what was previously mentioned regarding teachers: newly minted professionals, those closest to their university studies, possess cognitive and skill-based experiences regarding laboratory safety and security procedures. This may be a residual effect of those studies, influencing their performance on the scale, despite the lack of significant variance among the sample members of technicians. This finding underscores the necessity for the competent administration for school laboratories within the Ministry of Education to develop continuous training mechanisms for in-service personnel, ensuring that laboratory technicians maintain full awareness and understanding of their job requirements.

- Results Related to the Eighth Research Question: Are there statistically significant differences in laboratory technicians' level of awareness of safety and security procedures according to their academic qualification?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the laboratory technician sample members on the scale of awareness of laboratory safety and security procedures according to qualification, as illustrated in Table (13):

Table 13. Laboratory Technicians' Level of Awareness of Safety and Security Procedures by Qualification

Qualification	N	Mean	Standard Deviation
Diploma	122	29.9	3.2
Bachelor's	11	28	6.5

The preceding table presents the mean scores for laboratory technicians' level of awareness of laboratory safety and security procedures according to academic qualification. Laboratory technicians with a diploma had the highest mean score (M = 29.9), followed by those with a bachelor's degree (M

= 28.0). To determine whether the differences between the means were statistically significant, a one-way analysis of variance (ANOVA) was conducted, as shown in Table 14.

Table 14. Analysis of Variance for Laboratory Technicians' Performance by Qualification

Source of Variance	Sum of Squares	Degrees of Freedom	Mean Square	F	Level of Significance
Between Groups	36.175	1	36.175	2.849	0.094
Within Groups	1663.615	131	12.699		
Total	1699.789	132			

It is evident from the preceding table that the calculated (F) value equals (2.849), which is not statistically significant at the (0.05) level. This signifies the absence of statistically significant differences among laboratory technicians in the level of performance on the scale of awareness of laboratory safety and security procedures attributed to the qualification variable. It is observed from the preceding result that obtaining a higher qualification (Bachelor's) for laboratory technicians did not positively impact the sample members' level of performance on the scale. This may be attributed to the fact that the courses studied during the Bachelor's degree did not have a strong correlation with laboratory safety and security procedures. This underscores the necessity of reconsidering and developing the current academic programs and courses in universities related to the preparation of laboratory technicians, in parallel with the development of science curricula in the Kingdom.

- Results Related to the Ninth Research Question: Are there statistically significant differences in the level of awareness of safety and security procedures among the sample members attributed to the job variable?

To answer this question, the researcher calculated the arithmetic mean and standard deviation for the performance of the sample members on the scale. An independent samples *t*-test was utilized to determine the significance of differences, if any, as illustrated in Table (15):

Table 15. Differences in Participants' Level of Awareness of Safety and Security Procedures by Job

Job	Number	Mean	Standard Deviation	*t*-value	Level of Significance
Teacher	215	26.2	5.6	6.46	0.000*
Laboratory Technician	133	29.7	3.6		

**Indicates the presence of statistically significant differences at the significance level (0.05).*

It is evident from Table (15) that there are statistically significant differences at the significance level of (0.05) attributed to the job variable in favor of the (laboratory technician) position. The mean performance for individuals whose job is (laboratory technician) amounted to (29.7) compared to the

study's criterion score of (28.5), whereas the mean performance for individuals whose job is (teacher) amounted to (26.2).

This result may be attributed to the fact that the sample members (laboratory technicians), by virtue of their current profession and previous studies that are directly related to the school laboratory, possess knowledge and skills pertaining to safety and security to a degree surpassing that of teachers. The latter's knowledge of these procedures perhaps relied on personal endeavors, coupled with limited experiences from university studies.

- Results Related to the Tenth Research Question: What are the knowledge sources of safety and security procedures in the laboratory among science teachers and laboratory technicians?

Frequencies and percentages were calculated for the sample members' responses regarding their knowledge sources of safety and security procedures in the laboratory. Furthermore, these options were ranked for each category, and the correlation (Spearman's coefficient) between the ranking of choices by teachers (male/female) and laboratory technicians (male/female) for these sources was studied separately, as illustrated in Table (16).

Table 16. Ranking of Participants' Sources of Knowledge about Safety and Security Procedures

Sources	Female Teachers			Male Teachers			Female Lab Techs			Male Lab Techs			Total		Overall Rank
	F	%	R	F	%	R	F	%	R	F	%	R	F	%	
Teacher's Manual	34	14.1	3	49	14.2	3	11	4.7	9	3	6	6	97	11.1	4
Laboratory Technician	18	7.4	7	28	8.1	6	24	10.2	4	5	10	4	75	8.6	6
Colleagues	29	12	5	26	7.5	7	22	9.3	5	2	4	8	79	9	5
Educational Supervisor	9	4	9	10	2.9	10	13	5.5	7	5	10	5	37	4.2	9
Training Programs	10	4.1	8	12	3.5	9	22	9.3	6	2	4	9	46	5.3	8
Publications & Booklets	6	2.4	10	7	2	11	9	3.8	10	3	6	7	25	2.9	11
External Reading	36	15	2	51	14.7	2	44	18.6	2	8	16	3	139	15.9	2
University Education	43	18	1	74	21.4	1	25	10.6	3	12	24	1	154	17.6	1
Media	22	9	6	33	9.5	5	13	5.5	8	1	2	10	69	7.9	7

Social Networks	5	2	11	14	4	8	8	3.4	11	0	0	11	27	3.1	10
Internet Websites	30	12	4	42	12.1	4	45	19.1	1	9	18	2	126	14.4	3
Total	**242**	**100**		**346**	**100**		**236**	**100**		**50**	**100**		**874**	**100**	
Spearman (r)	$r_s = 0.92$						$r_{s=}0.77$								

F = frequency; R = rank

The value of Spearman's correlation coefficient between the choices of female and male teachers amounted to (r = 0.92). This value indicates a high consensus in ranking the knowledge sources of safety and security procedures between male and female teachers. The correlation value for female and male laboratory technicians amounted to (r = 0.77), which is also a significant value indicating convergence in ranking the knowledge sources of those procedures. Referring to the preceding table, it is evident that the ranking of the top four options for the (male and female teachers) category was identical, as the sources (university education, external reading, teacher's manual, Internet websites) appeared in this order at the top ranks as their knowledge sources of laboratory safety and security procedures.

The table also reveals that the sources (university education, Internet websites, external reading, laboratory technician) were the primary sources in ranking for the (female and male laboratory technicians) category. It is observed that there is a consensus among everyone that (university education, Internet websites, external reading) were the primary sources in their knowledge of laboratory safety and security procedures.

The table further shows that the primary knowledge source of safety and security procedures among (male and female teachers) and (male laboratory technicians) was (university education), which obtained the highest percentage of selection among these categories and achieved the first rank in the overall ranking with a frequency of (154) and a total percentage of (17.6%). Meanwhile, the primary knowledge source of these procedures among (female laboratory technicians) was (Internet websites), which came third in the overall ranking with a frequency of (126) and a percentage of (14.4%).

The table also demonstrates that the sources (publications and booklets) and (social networks) came in the lowest ranks in the overall ranking as knowledge sources of the procedures among the sample members.

This result highlights the importance of university education as a specialized stage that contributed to imparting a portion of the sample members' knowledge regarding laboratory safety and security procedures. This aligns with the study by Ali (2013), which reached the same conclusion. Furthermore, the result demonstrates the importance of Internet websites as a significant knowledge source for

laboratory safety procedures in this era, wherein this global network and its contained potential have become an essential cognitive source for acculturation, teaching, and learning through its diverse mediums, such as forums and social networks. This was demonstrated by Daclan's study (2013) regarding the positive impact of the (Facebook) network in developing awareness of laboratory safety and security procedures, which contradicted the result of the current study, wherein the sample members considered such networks not to be among the fundamental sources of their knowledge of these procedures.

6. Recommendations and Proposals:

In light of the preceding findings, the current study recommends the following:

1. Activating safety and security procedures within the content of science curricula by urging and monitoring the implementation of these procedures by science teachers and laboratory technicians during the instructional delivery of science lessons in the laboratory.
2. Conducting specialized training courses for science teachers and laboratory technicians regarding laboratory safety and security procedures on a continuous and periodic basis.
3. Intensifying and activating awareness-raising efforts concerning safety and security procedures in school laboratories through the issuance of specialized manuals and publications, alongside monitoring their implementation by the competent authorities within the Ministry of Education and educational directorates.
4. Establishing an interactive website dedicated to school laboratory safety and security under the supervision of the competent authority within the Ministry of Education.
5. Incorporating specialized courses on school laboratory safety and security into university academic programs at the Colleges of Science and Education for science teachers and laboratory technicians.
6. Engaging specialized scientific colleges in universities and Civil Defense administrations in organizing training programs and workshops focused on laboratory operations and safe practice methods, as well as conducting field visits for science teachers and laboratory technicians to acquire practical expertise.
7. Conducting further educational research on the current state of school laboratories in the Kingdom, the attitudes of science teachers and laboratory technicians toward laboratory work, and the extent of their adherence to and implementation of safety and security procedures while working therein.

7. Declarations:

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