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Enhancing Laboratory Safety Practices to Minimize Risk

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ABSTRACT

A vital component of scientific research, laboratory safety protects both the integrity of experimental findings and the health of researchers. The attitudes and behaviors related to laboratory safety are examined in this essay. Like any other sector, laboratories use similar risk management techniques, such as making a process map to help employees better understand how the process works. After identifying potential mistake sources and evaluating their impact according to severity, chance of occurrence, and detectability, controls and checks are put in place to stop and identify errors before they endanger patients. In order to minimize mishaps and preserve ethical standards in scientific research, the conclusion emphasizes the necessity of ongoing instruction and reinforcement of safety procedures in laboratory settings.

Keywords: Laboratory Safety, Hazardous Agents, Product Protection, Decontamination.

Introduction

The term "clinical laboratory stewardship" aptly explains the vital role that laboratory medicine plays in healthcare and highlights the need to advance a new vision for the field that emphasizes and focuses on some innovative concepts. Promoting diagnostic and therapeutic networks is necessary to turn laboratory data into useful information and to enhance patient-centered and end-to-end assistance in clinical pathways. Research in the literature emphasizes how critical it is for physicians to employ diagnostic testing more effectively and to have faith in the accuracy of laboratory data that is provided to them. Compliance with the aforementioned requirements requires the sharing of important concerns. Clinicians must have a comprehensive awareness of the instruments used and implemented in the laboratory, while laboratory workers

must be made aware of the impact laboratory results have on the patient in order to decrease errors and increase the quality of care (Schiff et al., 2018).

Compared to other disciplines like emergency and critical care medicine, laboratory medicine is still seen as a low-risk specialty in the healthcare system. This is due to the fact that laboratory medicine's primary functions are precisely defined and easier to manage than emergency department operations, which heavily rely on medical personnel. However, because laboratory errors include multiple processes, multiple providers, and a longer time lag between testing, physician intervention, and patient result, they are typically more subtle and challenging to spot right away (Plebani et al., 2020).

A key component of scientific research is laboratory safety, which includes a variety of procedures and guidelines meant to reduce mishaps, harm, and exposure to dangerous materials. Following safety protocols is crucial for both the validity and dependability of experimental results as well as the researchers' health. Upholding a high standard of laboratory safety is crucial at the master's level, when students work with sophisticated equipment and conduct advanced research projects (Keckler et al., 2019).

The majority of errors are caused by a failure to design safe processes, even though they are typically attributed to the shortcomings of healthcare personnel. As a result, the laboratory director is now responsible for developing a safer medical laboratory. Understanding and managing the possible dangers associated with errors is now crucial in the patient-centered laboratory; simply identifying, analyzing, and monitoring errors is no longer sufficient. The methodical procedure for determining and controlling the real and possible risks connected to laboratory testing is known as "clinical risk management." It is becoming a crucial part of corporate culture, a vital part of the quality management system, and a major factor in guaranteeing high-quality services (Aita et al., 2017).

Identifying and interpreting laboratory dangers may be impacted by the personal views, knowledge, education, training, attitudes, and experiences of the laboratory management and workers who create, record, and carry out laboratory processes. A consistent approach to risk assessment is challenging since laboratory risk assessments are intricate and vary greatly from one laboratory to another. However, risk management can be enhanced by measuring employee views of laboratory safety. These are strong arguments for the need for public health laboratories to better integrate safety and quality management (Keckler et al., 2019).

Literature review

An assessment of the medical laboratory's service based on efficacy criteria has become increasingly important in recent years due to the expansion of laboratory medicine's role in patient management and the increased focus on cost containment. A number of quality improvement initiatives have been implemented to support sustainable outcomes based on systematic and organizational criteria. In this context, improvements in quality control techniques have been observed, ranging from improvements in the analytical phase to the promotion and development of quality

assurance systems for the entire analysis process. Since laboratory medicine is becoming more widely acknowledged as an essential part of patient care, laboratory personnel are being asked to increase their clinical and analytical proficiency (Sciacovelli et al., 2016).

Safety and health management have had difficulty assessing the risks and hazards associated with the many substances found in laboratories. There are several major, occasionally fatal risks and mishaps associated with the substances and equipment that students and lab staff utilize. It is the duty of laboratory managers to shield their staff and students from physical, biological, and chemical risks (Ozdemir et al., 2017).

There are several published works on risk management in the fields of pharmaceutical manufacture, medicine distribution, in-vitro diagnostics production, healthcare process management, and health information protection. Risk management is a crucial part of patient safety programs in developed countries. In clinical laboratories, risk management is a crucial quality improvement task that requires an assessment of every testing procedure. Laboratories must perform this recurring preventive measure at least once a year (Jayamani et al., 2022).

A survey of the literature on the health and safety of laboratories in higher education institutions has shown numerous instances involving equipment malfunctions, fires, and explosions that resulted in fatalities and severely crippling injuries. Prior research on health risks has documented both acute and long-term poisonings after being exposed to different chemicals in lab settings. Furthermore, dangerous substances found in laboratory effluent have been deemed a serious environmental hazard. nearly 18% of workplace accidents at US higher education institutions involved laboratory settings, and students were the primary casualties in nearly one-third of these incidents. Accidents have been caused by a lack of knowledge about numerous health and safety risks, including those involving hazardous chemical and equipment handling procedures in labs (Chartres et al., 2018).

1. Risk definition

The procedure of testing patient samples in a lab is intricate. Any stage of the testing procedure is susceptible to errors. Therefore, laboratories need to take action to guarantee that correct and dependable results are generated. In order to identify and stop errors before they have an impact on test findings, the laboratory must assess its procedures for flaws or potential dangers. Mapping the testing procedure or guiding a sample through the preanalytical, analytical, and postanalytical phases of testing while assessing each stage for the possibility of possible risks are two ways to accomplish this (Ozdemir et al., 2017).

The possibility of experiencing harm or loss is known as risk. The likelihood of harm occurring and the seriousness of that harm can be combined to evaluate risk. One can never attain zero risk; there is a range of risk from extremely low to extremely high. Higher risk events are those that happen more frequently and those that inflict more damage (Ozdemir et al., 2017).

In essence, risk is the likelihood that a mistake will be made in the lab that could cause injury. In addition to harming the patient, a laboratory error may also result in harm to the technician, the laboratory director, the doctor, or even the entire organization.

Detectability, which aims to identify and stop mistakes before they leave the lab and come into contact with a patient, is another way to quantify risk (Ozdemir et al., 2017).

2. Containment of Hazardous Agents

The ability of high-containment biological laboratories (HCBLs) to combat the three forms of biological insecurity—natural outbreaks, deliberate abuse, and unintentional dissemination—has made them an essential component of many national security initiatives. The safest setting for identifying and studying these infections is offered by the HCBLs. They play a key role in stopping and controlling natural epidemics and provide promise for a more effective response to the bioterrorism threat (Maehira & Spencer, 2019).

Figure 1. Laboratory containment (Maehira & Spencer, 2019).

Safe techniques for controlling infectious pathogens in a lab setting are referred to as containment. Reducing exposure to potentially dangerous substances and preventing their escape into the surrounding environment are the goals of containment for laboratory personnel and others. The three components of confinement are facility design, safety equipment, and laboratory practice and method. Adherence to conventional microbiological protocols and techniques is the most crucial component of containment. People who work with infectious agents or infected materials must be knowledgeable about the risks involved and skilled in the procedures and methods needed to handle them safely. Additional precautions involving safety equipment and facility design may be required when regular laboratory practices are insufficient to control the hazard associated with a specific agent or laboratory operation (Maehira & Spencer, 2019).

Figure 2. Opening a jar under a protective hood (Zhang et al., 2020).

An integral component of biotechnology research and applications is the laboratory handling of organisms, especially microbes. It is essential to handle potentially harmful microbes responsibly and safely in order to protect the environment, community, and laboratory staff (Zhang et al., 2020).

3. Personnel Protection

The National Bio-Protective Engineering Center (NPEC) developed an intelligent detection platform that simulates human walking, standing, squatting, and other everyday actions using robots in order to assess the protective effectiveness of positive pressure suits. The assessment of positive pressure suits' dynamic protective aspects was completed. By modeling normal operations, Chinese researchers have conducted a thorough comparison between the positive pressure suit and comparable foreign items. The findings demonstrated that there was no discernible difference between the positive pressure suit and foreign brands in terms of performance or experience. The suit's design satisfied the high containment laboratories' operational criteria (Hao et al., 2019).

The NPEC's positive pressure hood has a flexible, completely transparent design, maximizes the protective structure, features a novel inflatable seal structure around the neck, and significantly enhances the head's protective effect. The positive pressure hood successfully avoids fogging at the face screen by means of a well-designed air distribution. Additionally, the research team created essential technologies for positive pressure suits, including noise reduction, air distribution, zipper seals, structural seals, and stable pressure air supplies (Hao et al., 2019).

3.1 Personal protective technical support equipment

Technical assistance for the regular use of personal protective equipment, such as gaseous/vapor disinfection chambers, chemical showers, and laboratory life-support systems, is the primary function of personal protective technical support equipment. In order to guarantee that laboratory workers are kept apart from the outside environment and that they have access to clean, breathable air, life-support systems primarily supply a steady source of positive pressure gas for positive pressure suits. Chemical shower equipment primarily employs washing and a variety of disinfectant sprays to eliminate biological pollutants from the surfaces of positive pressure suits. Gaseous/vapor disinfection chambers for protective equipment are primarily used to clean protective masks, positive pressure hoods, and other PPE (Hao et al., 2019).

3.2 Laboratory ventilation and filtration equipment

One of the most crucial components of secondary barriers in containment laboratories is laboratory ventilation and filtration equipment, which primarily consists of airtight isolation dampers and HEPA filtration devices. Biological aerosols released from the laboratory are effectively filtered by HEPA filtration equipment to keep them out of the surrounding environment. The primary purpose of airtight isolation dampers is to keep laboratory ventilation systems and biosafety protection equipment isolated from the outside world (Zhang et al., 2020).

4. Product Protection

In order to properly apply controls, the laboratory risk assessment should essentially be carried out for each work job and function as well as for particular specialized laboratory environments. In chemical laboratories, health, safety, and risk management experts have faced difficulties in obtaining thorough and objective data about risks and hazards. Defining an assessment project with a knowledgeable team is necessary before planning a risk assessment. The first stage in determining the magnitude of a threat's impact is predicting and identifying hazards (Fatemi et al., 2022).

5. Decontamination and disinfection equipment

In order to prevent the spread of infectious agents to laboratory personnel, the public, and the environment, decontamination and waste treatment equipment is primarily used for the disinfection and sterilization of solid and liquid wastes, surfaces, objects, and areas in containment laboratories. In particular, autoclaves, liquid effluent treatment equipment, gaseous/vapor disinfection equipment, animal carcass treatment equipment, and so forth are examples of decontamination and waste treatment equipment. Autoclaves, which are frequently employed in medical care facilities, scientific research facilities, and pharmaceutical manufacturing companies, use saturated-pressure steam to quickly sterilize items (Zhang et al., 2020).

6. Regulatory Compliance

All laboratory workers, including academics, staff, and students, should get laboratory standard training since awareness and training are crucial in lowering exposures,

accidents, and injuries. Chemical safety programs, chemical emergency response plans, and laboratory security plans must to be included in the training courses. Following the training sessions, it should be made sure that the laboratory staff members are aware of the proper use of personal protective equipment, when and by whom to use it, how to use emergency supplies like eyewashes and safety showers, where SDSs are stored, and how to handle spills and chemical waste. In order to improve awareness, safety, and security culture among laboratory workers and enable them to differentiate what to do before, during, and after emergencies, the earlier studies suggested periodic training courses for laboratory staff and approved the laboratory safety and security curriculum in the majority of faculties (Simmons et al., 2016).

Additionally, the other checklist items with the highest rates of non-compliance in this study were emergency preparation, the overall work environment, and the information needed for chemical laboratories. In addition to increasing the safety risk by converting one room of the chemistry lab into a chemical warehouse, the arrangement of the chemicals did not follow safety guidelines or best practices (Simmons et al., 2016).

7. Professional Competence: Education and Skill

Laboratory professionals must acknowledge that they are part of a multidisciplinary team in order to increase the visibility of laboratory medicine's involvement in patient care. Increased visibility through committees, rounds, consulting, knowledge display, and self-promotion will be evaluated primarily based on the clinical benefits they provide. To emphasize the role that laboratory data plays in patient care, laboratory personnel need to acquire new skills. Even familiarity with less conventional fields is necessary, as this will introduce fresh perspectives and methods from other fields (Plebani et al., 2020).

Furthermore, laboratory personnel need to understand that ongoing developments in fields like computerization, technology, clinical decision tools, information media, and artificial neural networks will have a significant impact on the degree of recognition attained. The clinical field of laboratory medicine is always changing, and new issues necessitate updating and improving operational procedures to improve patient care's quality and safety. To perform laboratory services effectively and efficiently, laboratory workers need to keep up a high level of skill (Plebani et al., 2020)

Incorporating laboratory organization, quality, safety, and clinical governance into training has also made it possible for laboratory medicine specialists to function as clinical leaders who can assist and revolutionize healthcare systems. The new generation of laboratory professionals and leaders are thus expected to integrate particular technical abilities into a wider view of healthcare and of patients' demands, given the recent changes in the nature of laboratory services and their position in the healthcare process (Jassam et al., 2018).

Conclusion

The practice of risk management was created in manufacturing or industrial environments. To introduce risk management concepts to the clinical laboratory, new recommendations have been released. Risk management can guarantee test result

dependability and reduce the likelihood of errors. According to risk management recommendations, laboratories should take the initiative to reduce the possibility of errors by creating customized quality control plans (QCPs) to handle the unique risks associated with laboratory analysis. To find flaws at every stage of the testing process, laboratories should map it out. The laboratory chooses suitable control procedures to identify hazards and stop mistakes from happening. A QCP provides a summary of all the risks and control procedures. To guarantee that patient findings are accurate and residual risks are kept to a clinically acceptable level, the effectiveness of the laboratory's QCP should be regularly reviewed and updated as new mistakes are discovered.

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