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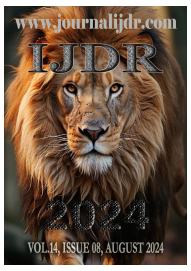

RESEARCH ARTICLE OPEN ACCESS

THE IMPORTANCE OF APPLYING BIOSAFETY IN LABORATORIES IN BRAZIL

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ABSTRACT

O Working in laboratories poses risks because they contain various agents that are harmful to the health of professionals, especially in activities that involve biological risk. Biosafety is indispensable in the daily lives of professionals working in laboratories, as it describes actions to prevent and minimize risks to human health and the environment. However, even with the existence of biosafety rules, various types of accidents still occur in laboratory environments. The aim of this study was to describe the importance of the practical application of a biosafety program in reducing accidents inherent in laboratory activities aimed at teaching, research, production, health, and the provision of services. Methods: The literature search was conducted using the following terms: "Biosafety"; "Health"; "Laboratory", and as connectors "and"; "or", in the following databases: PubMed; LILACS/BIREME and SciELO. Results: A total of 752 articles were identified in the databases, and eighteen of these studies were included in this review. Conclusion: The practical implementation of a biosafety program in laboratory environments is extremely important and necessary to increase preventive practices related to risks and consequently reduce and/or eliminate accidents inherent to laboratory activities aimed at teaching, research, production, health, and service provision.

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INTRODUCTION

Laboratories are considered risk sectors in the same way as hospitals and health centers, because in these environments there are several agents that can represent different types of risks to the health of the professionals who work in these areas (Filho *et al*., 2015), due to these factors we can understand the importance of biosafety as the set of actions aimed at preventing accidents and minimizing the risks related to laboratory activities aimed at health, teaching, research, production, development of technologies and provision of services (Wanderson *et al*., 2017). There are several definitions for the concept of risk, it represents the possibility of an adverse effect or any type of damage arising from an occurrence, such as: injuries, diseases, or damage to health, death and interference in the environment (Penna *et al*., 2010). The emergence of interest in biosafety is manifested in an increase in the number of national and international regulations to control biotechnology procedures. Biosafety has several standards that advocate reducing the exposure of workers to risks and preventing environmental contamination (Hambleton *et al*., 1992).

With the emergence of new biosafety technologies and associated guidelines, there has been a significant improvement in safety in laboratory environments, especially when it comes to managing microbiological materials. Even so, lack of attention when usine sharps, disposing of these materials in inappropriate conditions and re-sharpening needles are considered to be factors that cause accidents at work among health professionals (Bezerra *et al*., 2015). There are many concepts regarding biosafety, it is related to the prevention of accidents in occupational environments, and in the laboratory biological risk is cited as the most aggressive, physical and chemical risks also represent an important threat to health professionals, all these risks can harm the physical and mental integrity of workers, causing their temporary or even permanent withdrawal from their professional activities (Penna *et al*., 2010). For this reason, biosafety involves analyzing the risks that health and laboratory professionals face daily in their work environments. This risk assessment considers various aspects, such as those related to the procedures adopted, good laboratory practices, biological agents managed, laboratory or information infrastructure and the qualifications of the teams (Kimman *et al*., 2008). Given these facts,

we can see that biosafety is important in the daily lives of workers who work in laboratories in the areas of health, technology, research and so on. Biosafety is a set of actions aimed at preventing, minimizing, and eliminating risks in any aspect of the well-being of professionals, helping to protect the environment and raise awareness among professionals, thus guaranteeing quality of life at work. We can therefore say that biosafety actions are effective in promoting and maintaining well-being and protecting life (Piccoli *et al*., 2012). Even with all the containment measures and guides on biosafety, several types of accidents in laboratory environments involving organisms or other chemical or physical agents eventually end up occurring, because biosafety rules are not always applied correctly (Garcia *et al*., 2004). In view of all this, we highlight the importance of a greater number of studies on the applicability of biosafety. The aim of this study was to describe the importance of the practical application of a biosafety program and its rules to reduce and/or eliminate accidents inherent in laboratory activities aimed at teaching, research, production, health and the provision of services.

MATERIALS AND METHODS

A literature review was conducted with the aim of providing an overview of the relevance of the practical application of biosafety in laboratories, to reduce and/or eliminate accidents inherent in laboratory activities aimed at teaching, research, production, health and the provision of services. The bibliographical research was conducted using the following terms: "Biosafety"; 'Health'; 'Laboratory', and as connectors (Boolean operators) 'and'; 'or', in the following databases: PubMed (National Center for Biotechnology Information, U.S. National Library of Medicine), in the PUB MED module (https://www.ncbi.nlm.nih.gov/pubmed/); LILACS/ BIREME (Latin American and Caribbean Center on Health Sciences Information), in the All-Indexes module (https://lilacs.bvsalud.org/); SciELO (Scientific Electronic Library Online), in the Integrated method (http://www.scielo.br/) and the studies were selected based on predefined inclusion/exclusion criteria.

Inclusion/exclusion criteria: Manuscripts describing the importance of the practical application of biosafety in laboratories to reduce and/or eliminate accidents inherent in laboratory activities aimed at teaching, research, production, health and service provision were included. Manuscripts that did not describe the association between the practical application of biosafety in laboratories and the reduction and/or elimination of accidents inherent in laboratory activities aimed at teaching, research, production, health, and the provision of services were excluded.

RESULTS AND DISCUSSIONS

A total of 752 articles were identified in the databases and eighteen of these studies were included in this review. After reading the eighteen manuscripts included in the bibliographic survey, the following information was compiled.

Definition and Characteristics: Biosafety can be defined as a set of measures and actions focused on minimizing and preventing risks arising from laboratory activities in the areas of health, research, teaching and the provision of services, focusing on human health, the conservation of the environment and animals, as well as seeking to guarantee the quality of the results obtained from research and work carried out in laboratories (Penna *et al*., 2010). Therefore, in order to ensure worker safety, the use of Personal Protective Equipment (PPE) and Collective Protective Equipment (CPE) is essential. Good laboratory practices are made up of standards, procedures and safety precautions that aim to minimize the risk of accidents involving the activities carried out by laboratory workers, in the same way that they increase productivity and guarantee an improvement in the quality of the services provided in laboratories, as they help to keep the environment safe. The use of good laboratory practices depends on the awareness and vigilance of the personnel working in laboratories. Those responsible and team leaders must ensure and monitor the application of standard and specific rules and procedures, in order to guarantee the maintenance of a safe and reliable environment for all laboratory staff (Sangioni *et al*., 2013). The PPE can be described as a device for individual use, with the aim of protecting the health of the professional, while CPE can be described as any device that provides protection for all professionals exposed to risks in the environment (Costa, 2005). There are various types of PPE, such as PPE to protect the head and face (goggles, caps, masks and face shields), which help to protect the professional from possible irritation and contamination due to exposure to vapors, aerosols and splashes of materials with biological agents or toxic products; PPE to protect the upper limbs, such as protective gloves and sleeves; PPE to protect the lower limbs, such as waterproof protective footwear; PPE to protect the torso, such as lab coats, aprons, overalls, among others; PPE to protect the respiratory system, such as self-contained open or closed circuit masks. Examples of CPEs include safety signs in laboratories (symbols for flammable liquids, explosives, toxic products, poisons, etc.), fire extinguishers, chemical hoods, ceiling sprayers, ultraviolet light, mechanical and automatic pipettors, containers for disposing of contaminated materials and sharps, first aid kits, showers and eye washers (Simas *et al*., 2008).

Risks and Accidents in Professional Laboratory Environments: The services and activities conducted in laboratories cover different areas of knowledge and bring with them different risks. Because of this, safety regulations are needed to analyze and develop strategies to minimize risks, which is the main function of biosafety. Determining containment levels should be a priority in university laboratories because, with the emergence of modern technologies, operating procedures for handling pathogenic biological agents will have to be adapted to ensure the safety of workers (Araújo *et al*., 2004). It is important to remember that the human factor is an agent that causes accidents in laboratories, which is why it is extremely important to make an effort to address aspects of biosafety education, as they need to be present in the daily lives of laboratory workers. Some people often tend to underestimate the risks and only take the execution of activities into account, and this type of attitude cannot be allowed in any laboratory environment. For a biosafety education program to be effective, it is important that all laboratory users are properly informed about the principles of biosafety, and that they know how to apply them correctly in practice, in order to maintain a safe environment and guarantee their own safety and that of other colleagues in the team (Consiglieri *et al*., 2002). When we look at laboratory and hospital environments, we can see that there is a concentration of people and samples infected with several types of pathological agents. In addition, professionals in these areas deal with various secretions such as blood, urine and feces. All this exposure of workers to this type of material means that these professionals deal with biological risks daily, and the use of sharps such as needles and scalpels further increases the risks and severity of accidents involving biological agents (Peres, 2012).

To deal with these possible biological contaminations in laboratory and hospital environments, several types of chemical products are used to disinfect and sterilize environments and objects. Exposure to and handling of these products means that professionals are exposed to the risks of chemical contamination, corrosive products or products that may cause irritation, damage, or illness when they come into direct contact with the worker (Teixeira *et al*., 2010). Physical risks are also present in the laboratory environment and can cause various health problems for professionals, leading to partial or total interruption of their functions and activities. The following can be considered physical risks: radiation, vibrations, humidity, noise, among others. Given these facts, we can see the importance of training and educational work to raise awareness among professionals who work in laboratory environments. The clinical analysis laboratory environment is a sector with several risks for workers, an important example being biological risk, which can be seen as one of the most critical hazards in this area of activity (GOMES *et al*., 2015). The small number of professionals in the same team in a laboratory often ends up resulting in an accumulation of functions, which generates a work overload that wears out the professional and impairs

their performance, and these factors end up being some of the main aggravating factors in occupational accidents involving health professionals. In addition, inappropriate working conditions such as low pay, heavy workload, lack of training, lack of or poor use of PPE put employees in conditions where accidents occur daily (Silva and Pinto, 2012).

Scope of the Biosafety Program: The rigorous implementation of a biosafety program in laboratory environments is extremely important when seeking to minimize risks and guarantee biosafety in this type of environment. Through the concepts and foundations of biosafety, it is possible to establish a step-by-step list of actions that must be taken to practically implement an efficient biosafety program**.**

The biosafety program must cover all aspects of laboratory activities, including (Gomes, 2015; Wanderson *et al*., 2017; WHO, 2020):

- ***Risk assessment:*** Identification and characterization of the biological agents handled, determining the risk level of each one.
- ***Training in biosafety practices:*** Worker training, safe handling of biological agents, correct use of PPE, decontamination of materials and surfaces, proper waste disposal, etc.
- ***Implementation of containment barriers:*** Implementation of negative pressure laboratories, biological safety booths (BSCs) and other physical containment devices.
- ***Environmental monitoring:*** Regular environmental monitoring to detect the presence of biological agents in the air and on surfaces.
- ***Emergency management:*** Establishing contingency plans to deal with accidents and incidents, including biological agent spills, accidental exposure and containment system failures.
- ***Documentation and records:*** Keeping detailed records of all biosafety-related activities, including training, environmental monitoring, accidents, and incidents.

Implementation of the Biosafety Program:

The implementation of the biosafety program should follow the following steps (Wanderson *et al*., 2017; WHO, 2020).

1. ***Establishing a biosafety team:*** Create a multidisciplinary team made up of professionals with expertise in microbiology, biosafety, engineering, and occupational medicine. The team will be responsible for designing, implementing, and monitoring the biosafety program.
2. ***Drawing up the biosafety manual:*** Develop a complete and comprehensive biosafety manual that describes in detail all the procedures and protocols related to biosafety in the laboratory. The manual should be easily accessible to all workers.
3. ***Worker training:*** Conduct periodic and comprehensive training for all laboratory workers, covering the following topics: Basic biosafety concepts; Risks of biological agents handled; Safe working practices in the laboratory; Correct use of PPE and CPE; Decontamination procedures; Contingency plans for emergencies.
4. ***Implementing Containment Barriers:*** Design and implement the appropriate containment barriers for the level of risk of the biological agents handled, including: Negative pressure laboratories: Ensure that the air inside the laboratory is under negative pressure in relation to the external environment, preventing the escape of contaminated aerosols. Biological safety cabinets (BSCs): Use Class III BSCs for all activities involving direct handling of highly pathogenic biological agents. PPE: Provide workers with appropriate PPE, such as gloves, goggles, masks, lab coats and boots, to minimize exposure to biological agents.
5. ***Establishing Standard Operating Procedures (SOPs):*** Develop specific SOPs for each laboratory activity, describing in detail the procedures to be followed to ensure biosafety. The SOPs should include clear instructions on: Managing biological agents; Using laboratory equipment; Decontaminating materials and surfaces; Disposing of waste; Cleaning and disinfecting the laboratory.
6. ***Environmental monitoring:*** Carry out regular bacteriological, fungal and viral monitoring of the environment to detect possible contamination.

CONCLUSIONS

The human factor is one of the main causes of accidents in laboratories, which is why it is important to train professionals, and there should be an effort directed at biosafety education aspects in all companies and institutions that have teams working in laboratory environments. Understanding the basics and norms of biosafety is extremely important for teams of professionals working in laboratories because, once trained, the team itself ends up being a positive factor in reducing the risks to its own health and to the environment. The lack of practical implementation of a biosafety program means that some individuals conduct laboratory activities without caring about the risks and damage generated. The practical implementation of a biosafety program in laboratory environments is extremely important when seeking to minimize risks and guarantee biosafety in this type of environment.

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