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RISK MANAGEMENT IN MICROBIOLOGY LABORATORY

KENALI PENYAKIT IKAN DALAM MAKMAL

PLOGGING: A NEW TREND IN ENVIRONMENT?

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BIORISK MANAGEMENT IN MICROBIOLOGY LABORATORY

By

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Microbiology studies all living organisms that are too small to be visible to the naked eye. This includes bacteria, archaea, viruses, fungi, prions, protozoa, and algae, collectively known as 'microbes.' It began with the hobby of developing a microscope by Antoine Van Leeuwenhoek, a Dutch draper, and provided proper documentation of his observation. The field is concerned with the structure, function, and classification of such organisms and with ways of both exploiting and controlling their activities. These microbes play vital roles in nutrient cycling, biodegradation/biodeterioration, climate change, food spoilage, the cause and control of disease, and biotechnology. However, microbes are also versatile, like making life-saving drugs, manufacturing biofuels, cleaning up pollution, and producing/processing food and drink. Conventional microbiology is a laborious, expensive, and time-consuming exercise. However, modern and applied microbiology research has been. It continues to be central to meeting many current global aspirations and challenges, such as maintaining food, water, and energy security for a healthy population on habitable earth. There are techniques that define microbiology as a scientific field of study. It has been estimated that less than 1% of bacteria can be grown in a culture in a laboratory. Microbiologists culture bacteria by providing them with food, water, and other growth requirements in an environment with a constant and comfortable growth temperature. These requirements vary depending on the natural growth conditions for the microbial populations under study. To ensure that a microbiologist will only culture the specific bacteria they want and nothing else from the environment, microbiologists use a set of strict aseptic techniques, which protects them from the bacteria in the cultures, and protects the cultures from contaminants in the environment. These standard methods will be official, and specific laboratory rules must be followed to contain microbial cultures in the laboratory for the safety of all. Mainly to control laboratory-acquired infection (LAI) in the outside world.

"Biorisk management" is the effective management of risks posed while working with infectious agents and toxins in laboratories; it includes a range of practices and procedures to ensure the biosecurity, biosafety, and biocontainment of those infectious agents and toxins.

Biosafety involves preventative measures undertaken to eliminate pathogenic microbes and their contagious toxins. Microbial laboratory-acquired infections are serious biohazards for laboratory workers and public health in general. While **biosecurity** is the process employed to ensure biological agents are appropriately safeguarded against theft, loss, diversion, unauthorized access, or use/release.

However, the overall objective of **biocontainment** is to confine or prevent the unintentional release of an infectious organism or toxin, thereby reducing the potential for exposure to laboratory workers or persons outside the laboratory and the likelihood of accidental release to the environment. Biosafety measures designed to ensure the safety of laboratory workers include the use of various primary and secondary barriers, many of which are due to the advent of new materials science and engineering technologies. The **primary barriers** in the laboratory are techniques and equipment that guard against the release of biological material; they may also be referred to as primary containment. They provide a physical barrier between the worker and the environment and the hazardous material. The **secondary barrier** contains the agent within the room or facility if an agent escapes from the primary barriers.

ELEMENTS IN MICROBIAL CONTAINMENT

The containment of microbes is composed of three elements: safety equipment, best laboratory practices and techniques, and facility design.

i. **Safety equipments**: It's also called the primary barrier, which includes biosafety cabinets (BSC) and a variety of other enclosed containers such as animal caging systems (IVCs), centrifuges, fermenters, and other specialized laboratory equipment. The biosafety cabinet is beneficial for containing infectious aerosols generated while performing microbiological procedures. The biosafety cabinets contain biohazards with an inward airflow to provide **personnel** protection; a filtered exhaust air provides **environmental** protection, and the supply air filter provides **product** protection. The BSC is categorized into Class I, Class II, and Class III biosafety cabinets. Class I and II biosafety cabinets are open-fronted biological safety cabinets; thus, they only offer partial containment. Class III biosafety cabinets provide maximum protection to laboratory personnel and the environment. Other than biosafety cabinets, some additional equipment, such as gloves, lab coats, shoe covers, lab gowns, face shields, respirators, boots, and safety glasses, provide extra protection to lab personnel.

ii. **Best laboratory practices and techniques**: Standard laboratory training and practices are essential for the containment of microbial organisms in the laboratory. Lab personnel should know the potential hazards of infected materials and agents they must work with. They must be taught standard practices and microbiological techniques for handling and maintaining such materials. The lab director has a vital role to play when it comes to choosing appropriate training for lab personnel. Moreover, when the safety measures and training are not sufficient to contain the spread of infectious agents, they are required to select additional practices to minimize/eliminate hazards associated with contagious materials/agents. Additionally, at least one biosafety operation manual should be available in all labs explaining the dangers associated with each infectious agent and the procedures to minimize the risks.

Figure 1. Laboratory equipment and animal changing.

A lab expert or scientist trained in using laboratory techniques and aware of lab safety measures and hazards associated with an infectious agent must direct such lab activities. There are several Biosafety Operational Manual commonly used in Microbiology Laboratory such as The WHO Laboratory Biosafety Manual, The US NIH handbook on Biosafety in Microbiological and Biomedical Laboratories, The CWA 15793: Laboratory Biorisk Management, SIRIM Malaysian Standards MS 1042: 3 Code of Practice for Safety in laboratories. Biocontainment and Biosafety Practices for Microbiology Laboratories, The National Biosafety Board Guidelines for Contained Use Activity of Living Modified Organism (LMO), and many more depends on the laboratory activities.

Figure 2. Laboratory Biosafety Manual

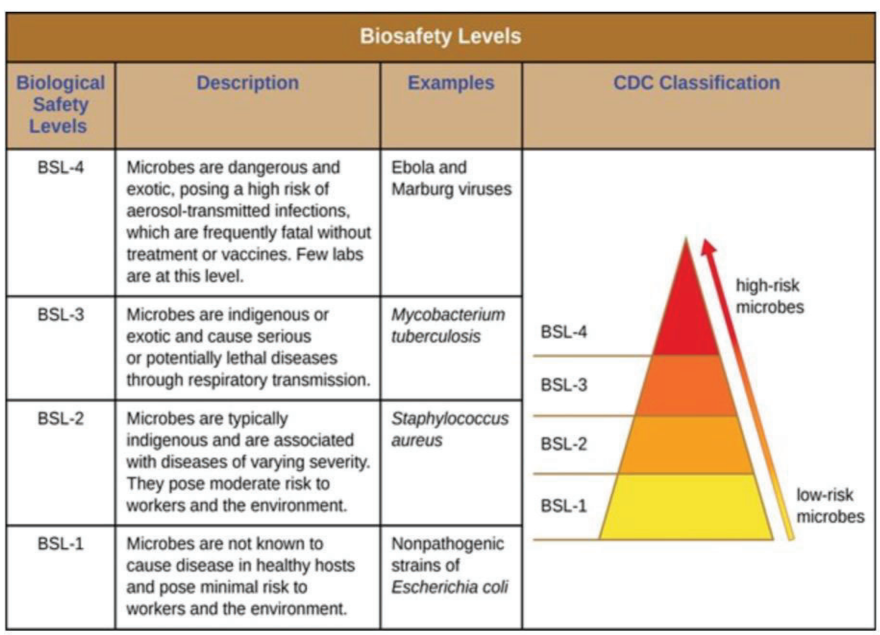
iii. **Facility design:** Appropriate facility design and engineering must supplement lab personnel's efforts, techniques, and best safety practices for proper containment and safety of people, inside or outside the labs. It serves as an additional barrier against the spread of infectious agents. Based on the containment level, the facility design is of three types. The first type is the **Basic laboratory**; this will include the space created for working with viable infectious agents or materials that are not infectious or potentially have low hazard levels, with biosafety level 1 and level 2 facilities. At the same time, the **Containment laboratory** contains some specialized engineering features to deal with potential hazards and protect lab personnel, the environment, and the community. It's described as a biosafety level 3 facility. Followed by the **Maximum Containment laboratory** has unique engineering and containment systems. It permits the safe handling of infectious agents that can be extremely dangerous to lab workers or cause epidemic diseases. This level of facility is described as biosafety level 4. The lab should be built in isolated areas within the building or in a separate building. It has secondary barriers to protect the environment from hazardous materials. The barrier can be airlocks or liquid disinfectant barriers, sealed entrances to the laboratory, a treatment system to eliminate contaminants from exhaust air, and a clothes-change room and a shower room adjacent to the laboratory ventilation system.

Table 1. Relation of Biosafety level, Laboratory practices, and safety equipment.

BIOSAFETY LEVEL	LABORATORY TYPE	LABORATORY PRACTICES	SAFETY EQUIPMENT
Basic – Biosafety Level 1	Basic teaching, research	GMT	None; open bench work
Basic – Biosafety Level 2	Primary health services; diagnostic services, research	GMT plus protective clothing, biohazard sign	Open bench plus BSC for potential aerosols
Containment – Biosafety Level 3	Special diagnostic services, research	As Level 2 plus special clothing, controlled access, directional airflow	BSC and/or other primary devices for all activities
Maximum containment – Biosafety Level 4	Dangerous pathogen units	As Level 3 plus airlock entry, shower exit, special waste disposal	Class III BSC, or positive pressure suits in conjunction with Class II BSCs, double-ended autoclave (through the wall), filtered air

BIOSAFETY LEVELS

Biosafety levels are divided into four levels based on their combination of safety equipment, laboratory techniques, best practices, and appropriate laboratory facilities to perform operations, control hazards by infectious agents, and run lab activities safely. The combination of elements designed and fit into these four levels decide the extent or degree of protection the labs provide to lab personnel, the environment, and the community. The following is a brief overview of all four protection levels in ascending order.



Biosafety Levels

Biological Safety Levels	Description	Examples	CDC Classification
BSL-4	Microbes are dangerous and exotic, posing a high risk of aerosol-transmitted infections, which are frequently fatal without treatment or vaccines. Few labs are at this level.	Ebola and Marburg viruses	
BSL-3	Microbes are indigenous or exotic and cause serious or potentially lethal diseases through respiratory transmission.	*Mycobacterium tuberculosis*	
BSL-2	Microbes are typically indigenous and are associated with diseases of varying severity. They pose moderate risk to workers and the environment.	*Staphylococcus aureus*	
BSL-1	Microbes are not known to cause disease in healthy hosts and pose minimal risk to workers and the environment.	Nonpathogenic strains of *Escherichia coli*	

Figure 3. Biological safety Levels (Source: BSL Autoclaves for Biosafety Sterilization, June 6, 2017)

Figure 4. Malaysia Biosafety and Biosecurity Association

BIOSECURITY

Biosecurity refers to measures designed to protect microbiological agents from loss, theft, misuse, or intentional release and to protect research-related information from loss, theft, or misuse. This can be accomplished by limiting access to facilities, biological materials, and research-related information. Sufficient security for the biological materials in use may already be in place for laboratories that do not handle select agents, exempt levels of toxins on the select agent list, or exempt strains of select agents. These security measures include access controls and training requirements outlined for BSL-1 and BSL-2 laboratories. The risk assessment conducted as part of the biosafety program gathers information on the type of organisms handled, the location of work, and the personnel handling these agents.

Based on this information, the potential for the use of these agents for harmful purposes can be assessed. If such a threat is identified, a Biosecurity program should be implemented to protect against possible misuse of these agents. Such a program should involve participation from PIs, biosafety officers, laboratory staff, information technology staff, law enforcement agencies, and building security staff. In Malaysia, we have the "Malaysian Biosafety and Biosecurity Association" (MBBA), a registered non-profit organization established in June 2011. MBBA promotes Biosafety and Biosecurity practices in organizations that handle biological agents and toxins, provides a platform for training on biosafety and biosecurity, and develops networking with other regional and international Biosafety/Biorisk associations.

"MBBA also encourages the implementation of biorisk management in BSL2 laboratories in Malaysia and promotes sustainable and efficient biorisk management in laboratories in Malaysia."

In conclusion, microbiology laboratories dealing with infectious agents that may pose a threat to laboratory personnel require biosafety measures. These measures include information on standard microbiological practices and procedures, safety equipment, and biosafety facilities. However, not all microbes pose the same threat to humans after exposure. Therefore, according to the level of danger posed to the public by an infectious agent, four biosafety levels are created for the safety of lab personnel, the community, and the environment. Considering the history of people contracting diseases, safety measures are necessary for microbial labs. And following these rules, standard procedures, and standard operating procedures (SOPs) will help not only the people working in labs but also the people, animals, environment around them, and the whole community.