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Compliance with Standard Precautions Reduces the Infection Risks among the Clinical Laboratory Workers of Bio Safety Level 2

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Abstract: *Laboratory workers who directly handle the hazardous biological agents from clinical specimens and cultures are at risk of exposure to a variety of infectious agents. Hence, they are more prone to laboratory acquired infections. Despite the detailed biosafety procedures available, most of the workers do not consistently follow standard precautions while handling the biological fluids in the laboratory. Inadequate compliance is associated with increased exposure and thus predisposing the laboratory workers to transmission of blood borne pathogens. Human immunodeficiency virus (HIV), hepatitis B and hepatitis C are the major infectious viral agents. While Neisseria meningitides, Mycobacterium tuberculosis, Shigella sp., Brucella sp., Salmonella sp., Escherichia coli, Clostridium difficile* and *Klebsiella sp. are the major bacteria that cause infection in diagnostic laboratory workers of biosafety level 2. Most of them are preventable by adhering to the practices of standard precautions. Lack of awareness and decreased rate of reporting the infections make it difficult to know the precise number of incidences. This article discusses some guidelines on the standard precautions that is necessary to mitigate the risks associated with the basic diagnostic laboratory procedures of biosafety level 2.*

Keywords: *Biosafety level, biological safety cabinets, hepatitis B, hepatitis C, Human immunodeficiency virus*

1. INTRODUCTION

Laboratory workers are consistently handling clinical specimens and cultures such as viruses, bacteria, fungi, parasites and prions. Hence, they are at higher risk for exposure to infectious agents. Microbiology technicians handling the culture/ drug susceptibility testing and smear microscopy are more prone to get tuberculosis [1]. Among the bacteria *Neisseria meningitides, Mycobacterium tuberculosis, Shigella sp., Brucella sp., Salmonella sp. Escherichia coli, Clostridium difficile* and *Klebsiella sp.* can cause infection to laboratory workers [2]. Aerosolization is the major cause for transmission of meningococcal disease**,** tuberculosis and brucellosis [3-5]. Human immunodeficiency virus (HIV), hepatitis B and hepatitis C are the major infectious viral agents and most of them are preventable. Comparing the hepatitis and HIV, hepatitis B is found to be more infectious than HIV. Decreased rate of reporting the infections make it difficult to know the precise number of incidences. Despite the report regarding the annual risk of tuberculosis infection among young nursing trainees in South India, an up to date published reports are scant among the laboratory workers in India [6].

A nested case control study among the health care workers in South India showed that workers in the Microbiology laboratories with body mass index <19 kg/m^2 are at high risk for acquiring tuberculosis (OR: 5.65 with 95% CI: 1.74-18.36) [7]. Study conducted among the laboratory technical assistance who screen tuberculosis infection in sputum samples of designated microscopy centres (DMCs) in Northern Kerala, South India showed that only 29% had knowledge and 45% followed infection control practices. However, facilities for infection control were available in 61% of the centres [8]. Despite the detailed biosafety procedures available, most of the workers do not consistently follow standard precautions while handling the biological fluids in the laboratory. Such inadequate compliance is associated with increased blood exposure and thus predisposing the laboratory workers to transmission of blood borne pathogens. The hazardous agents in the laboratory can be transmitted by inhalation, inoculation, or through the skin [9]. Nasal mucosa, conjunctivae and less frequently the

mouth, are susceptible portals of entry for respiratory viruses [10]. Lack of awareness, low vaccination coverage and high rates of needle stick injuries contribute the increased risk for viral hepatitis infections. Furthermore, most of the laboratories have practices of allowing trainees to work in without adequate training. Therefore, prevention of occupational infection should be the priority for the infection control. Biosafety encompass the suitable facility design, access restrictions, availability and use of personal protective equipment (PPE) and safety equipment, safe work practices of managing infectious materials, professional expertise and training. This article provides some guidance on the requirements that is necessary to mitigate the risks associated with the laboratory procedures.

2. FACILITY DESIGN

A well designed initial planning should be in place to ensure the suitability for the work undertaken and also to protect the workers from infective microorganisms while set-up a laboratory. Laboratories are classified by World Health Organization (WHO) based on the infection risk to laboratory personnel and the environment into 4 biosafety levels (Table 1) [11]. Human pathogens encountered in basic clinical laboratory are mostly belonging to risk group 2 biological agents (Figure 1). According to the specimens handled in basic diagnostic laboratory, they need biosafety Level 2 (BSL-2) requirements [12]. A well designed initial planning includes location and layout of laboratory, ample space, air flow (directional airflow from the corridor into the lab) and ventilation requirements, material of work surfaces with respect to type of work and disinfection considerations and sanitation and hand washing facilities.

Table1. *Classification of laboratories based on biosafety level*

Risk groups	Types	Details	Requirements
1	Biosafety level 1	Basic teaching and research laboratory working with agents with minimal potential hazard to laboratory personnel and the environment.	Work can be performed on open-bench with good laboratory practices
2	Biosafety level 2	Diagnostic and research laboratory working with agents that pose moderate hazards to personnel and the environment. Non-respiratory, non-lethal agents are handled.	Autoclaves and biological safety cabinets (BSC). Safe waste disposal measures and aseptic techniques are mandatory
3	Biosafety level 3	Clinical, special diagnostic and research purpose, or production facilities where work is performed with agents that may cause serious or potentially lethal disease through inhalation, to the personnel and may contaminate the environment.	In addition to the requirement for BSL 2, the laboratory personnel must receive specific training in handling pathogenic and potentially lethal agents. Scientists competent in handling infectious agents and associated procedures must supervise the lab.
4	Biosafety level 4	Working with dangerous and exotic infectious agents that pose a high individual as well as environment risk of life-threatening disease, aerosol transmission, or a related agent with unknown risk of transmission	In addition to the specific training in handling pathogenic and potentially lethal agents, personnel have to wear mandatorily work wearing positive pressure BSL-4 suits. BSC class III and double ended autoclave, facility for filtered air exhaust.

Kao et al. reported that inadequate isolation procedures in laboratories where very large number of tuberculosis suspected specimens handle can increase the risk for infection [13]. Exhaust ventilation should be provided above the exterior door of the autoclave to remove the heat and steam, when the door is opened. Biological safety cabinets should be placed away from walking areas, out of cross currents from doors and ventilation systems. A stand-by generator is needed for a reliable electricity supply to support the safety equipments. Facility for storing outer garments, personnel items and rest room for the workers (where the personnel can eat and/or drink) should be set outside the lab working areas. Hand-washing basins/sink with running tap water, antiseptic-containing liquid soap and paper

towel should be provided preferably near the exit door of each lab room. First aid room/areas should be available and readily accessible.

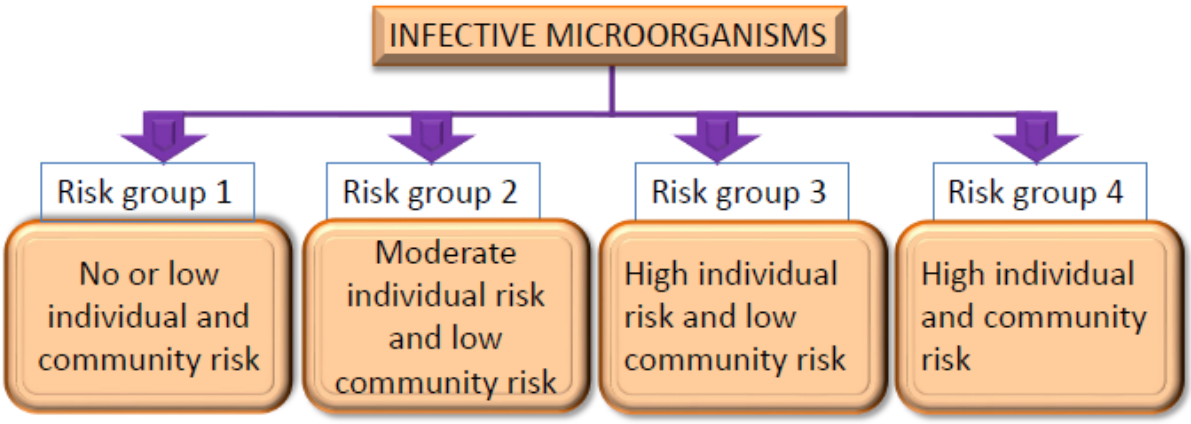

Figure1. *Classification of infective microorganisms by WHO based on the risk of infection*

3. PERSONAL PROTECTIVE EQUIPMENT AND SAFETY EQUIPMENT

All blood/body fluids and visible blood contaminated materials should be treated as infectious materials. The PPE are specialized clothing or equipment worn by an employee for protection. This includes gowns, gloves, masks, face shields, eye shields, or other protective equipment. Herwaldt reported that bare handed work can increase the parasitic infection [14]. Safety equipment selected should be based on the nature of work performed that should minimize the risk of exposure to aerosols, splashes and accidental inoculation. For example wear goggles and face shields for work with potential splashes, opening of culture and centrifuges.

The specialized lab equipments are not just a supplement to the appropriate procedures. The containment equipments include biological safety cabinet (BSC) (Class I, II and III), decontamination autoclaves and centrifuges with sealed buckets. Use BSC (Class I or II) for laboratory (BSL2 and 3) procedures that may give rise to infectious aerosols. Therefore, BSC must be available for mycobacteriological and mycological work [15]. The centrifuge should be fitted with either sealed rotors or safety cups and opening of such safety cups must always be inside a BSC. All the containment equipments shall be maintained, disinfected and stored properly. Inventories and maintenance records shall be kept. Colony count from the BSC should be monitored at least once in a week. Furthermore, BSC must be certified at least annually to ensure that filters are functioning properly and the air flow rates meet specifications. The sterilizers for discarding the specimen should be periodically evaluated using chemical or biological indicators.

4. SAFE WORK PRACTICES

Follow the good microbiological techniques which are fundamental to the biosafety measures in a diagnostic lab. All the laboratory workers should aware about the procedure for dealing the spillage of specimens and cultures. For this, a biosafety manual shall be developed, adopted and regularly reviewed. Transportation of biological materials should be in a triple packaging system with absorbent kept around the primary sample container. Biohazard warning sign must be displayed on the outer container while transporting the samples from the primary collection centers to the lab and also in all areas where such procedures are doing. Maintaining personal hygiene, use appropriate precautions when performing microbiological manipulations, especially when undertaking aerosol generating procedures. Airborne plus contact precautions are recommended for respiratory viruses, *M. tuberculosis*, *S. pneumonia* and *S. aureus* (MSSA or MRSA). Hence the use of eye/face protection, if aerosol-generating procedure performed or contact with respiratory secretions anticipated. It is recommended to not to touch skin, eyes, nose, or other exposed membrane with the gloved hands. Sodium hypochlorite (with 1% available chlorine) is recommended to disinfection of material contaminated with blood and body fluids in well ventilated areas [16]. Alcohol (70%) is recommended for surfaces on which bleach cannot be used [16]. All the PPE should be removed when contaminated or when their use is no longer required, with proper decontamination before re-use or disposal. The lab personnel must wash their hand after handling infectious materials before they leave

the laboratory working areas. The PPEs are prohibited to be used outside the laboratory and should keep apart from uncontaminated clothing or equipment. The lab doors must be kept closed. Entry to the laboratory working area should be restricted to people other than the concerned laboratory personnel.

Proper decontamination and appropriate disposal of infectious materials should be ensured according to the Environmental Protection Act. An observational study conducted in old Raipur district of Chhattisgarh showed that 63.89% of DMC's neither decontaminate before disposal nor dispose properly as per the guidelines which will be dangerous to staff and community [17]. All the potentially infectious materials must be disposed of in specially marked bags and/or containers. Plastics, non-plastics contaminated with blood, body fluids, secretions and excretions and infectious laboratory wastes should be decontaminated by autoclaving. After autoclaving the material, they must be placed in transfer containers for transport to incinerator. Monitoring of staff health including immunization and medical surveillance is inevitable.

5. PROFESSIONAL EXPERTISE AND TRAINING

All staff including the clerical and domestic workers should be trained to foster the right attitudes and understanding of safe working practices before the commencement of work. The laboratory supervisors should provide the training and continuing education to maintain staff awareness for the safety implication of changing technology and improvements in safety practices. This includes inhalation risk during taking blood/sputum samples, centrifuging, streaking agar plates, making smears, opening cultures, etc. Hence, training on personal hygiene, appropriate use of PPE with good microbiological techniques, safe use of equipment, recognition of hazards risks and consequences shall be given before commencement of work to prevent the acquired infections.

6. CONCLUSION

Laboratory workers are consistently exposed to infectious microorganisms while doing routine laboratory procedures on clinical specimens and cultures. Steps to reduce the occupational exposures to infectious in a clinical laboratory are depicted in table 2. HICPAC/CDC recommends standard precautions which include a group of infection prevention practices such as hand hygiene, use of gloves, gown, mask, eye protection/face shield regardless of suspected or confirmed infection status as the primary strategy for the prevention of transmission of infectious agents to the laboratory personnel. Vaccines, safer devices and safer procedures are necessary. Frequency of training and education about the epidemiology and pathogenicity of the microorganisms is inevitable. Institutional safety climate and leadership support further influence the biosaftey measures and curtail the rate of infection. It is the responsibility of the laboratory Director to ensure the safety of all employees and patients/visitors to the laboratory. A safety coordinator should be appointed to assist the laboratory Director for monitoring the safe work practices as well as working environment in the laboratory. In addition to this, infection control committee is required for the development of prevention and control of infection policies and oversees the implementation of the programme. Overall, there should be a periodic safety audit conducted by an internal or external person using a well planned audit check list.

Table2. *Easy ten steps procedure to reduce the occupational exposure to various infectious agents in a clinical laboratory.*

Sl. No	Steps
1	Adherence to standard precautions and use of safety devices are the primary means of preventing exposures to infection.
2	Vaccination. E.g. Hepatitis B
3	Pre-placement health checkup is necessary and recorded the person's medical history.
4	Training on safe handling and transportation of samples, disposal of sharps, spillages of specimens and segregation and disposal of infectious samples.
5	Individual staff members should follow the documented safety procedures described in the safety manual.
6	Potentially infectious materials must be stored in a secure location and locked with access only to the designated staff.
7.	Facility of the early detection of infection. All accidents/ incidents could be promptly reported to the lab supervisor/safety coordinator by a reporting mechanism that shall be made known to all

	laboratory staff. Medical surveillance to monitor staff sickness through reporting and recording of illness and their absence in duty.
8	Post-exposure prophylaxis (second line of defense)
9.	Implement preventive measures with a continuous improvement programme.
10	Safety auditing and maintenance of various safety records (Table 3).

Table3. *Records to be maintained for biosafety*

Sl. No	Records
1	Training (induction and continual).
2	Inventory and maintenance of safety equipments.
3	Staff health including immunization and sickness.
4	Safety inspection and audit using checklist.
5	Accidents and incidents report.
6	Updated inventory of specimens and isolates in storage.

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