Reform on Knowledge and Skills of Clinical Laboratory Biosafety and Biosecurity Among Chinese Medical Students

Yu Li¹, Li-yuan SUN¹ and Ming-cheng Li²,*

¹Associated Hospital, Beihua University, Jilin, Jilin, China
²School of Laboratory Medicine, Beihua University, Jilin, Jilin, China
*Corresponding author

Keywords: Laboratory biosafety and biosecurity, Medical laboratory, Theory and practice, Teaching reform.

Abstract. Laboratory workers deal with clinical specimens, the threat of exposure to occupational hazards, emerging infectious agents, and antimicrobial-resistant microbes. During student training, it is necessary to strengthen their knowledge and skills in the laboratory. Education covers a range of biosafety and biosecurity principles and practices. 642 medical students from different medicine professions were classified into two groups as research objects and controls to explore the teaching reform of laboratory biosafety, biosecurity theory and experimental courses. Teacher designed program-based learning (PBL) covered microbiology laboratory biosafety incidents, laboratory training, and the methods used in man-machine interactions in clinical practice. From a four stage reform of laboratory biosafety theory and experimental teaching, the protective awareness of biosafety of the students was strengthened. Students could also run standardized, timely detection protocols and treat laboratory biological factors arising from emergencies and accidents in clinical practice. These increased the competency and proficiency among BSL laboratory users and guarantee adherence to stipulations on biosafety and biosecurity.

Introduction

Laboratory medicine is a discipline that has developed rapidly. It is an applied subject teaching the diagnosis of clinical disease, and has efficient evaluation and prognosis evaluation as its main targets. This forces government, society, and academe to pay more attention to the cultivation of medical laboratory personnel as well as public health security and microbiology laboratory biosafety, especially after the occurrence of emergent public health events such as SARS, avian influenza, and so on [1, 2].

Clinical practice is the principal channel for the practical teaching of laboratory specialisms and is also an extension of the theoretical teaching in the cognate area. Hospital laboratories are departments that are prone to iatrogenic infection. The staff will not only come into contact with patients on a daily basis, but also with their blood, urine, faeces, bodily fluids, secretions and pathological tissues. Meanwhile, medical students will also encounter patients face-to-face with infectious specimens frequently interchanging during the internship, or the tenure of their studies.

The results of the survey showed that interns in a medical laboratory specialty had a higher awareness of the concepts of prevention of hospital acquired infections, such as disinfection and sterilization and a higher awareness of the available technology. However, all newcomers had a lower awareness of microbiology laboratory biosafety, standard prevention and treatment of occupational hazards, post-exposure controls and medical wastes [3, 4, 5]. Therefore, it is necessary to take effective protective measures and strengthen the biosafety education of medical laboratory students at a realistic stage.

We achieved perfect results through strengthening the biosafety education of medical laboratory students through creating multi-channel full range laboratory biosafety theoretical knowledge, teaching reform based on practical application, real case studies, and laboratory simulation training,
all of which occurred during the medical laboratory students’ basic courses, specialized courses, and practice stage.

Materials and Methods

Students Groups
During five years from 2010-2014, two professional grades including six hundred and forty-two medical students were designed to participate in the reform. One group in three hundred and twenty students belonging to clinical medicine were conducted in traditional teaching form, and another group in three hundred and twenty-two students belonging to laboratory medicine were conducted in the reform assay.

Opening Up Laboratory Biosafety Courses to Strengthen Theoretical Study
According to the lectures in microbiological laboratory biosafety theory, we have divided the programme into four stages. Interspersing biosafety theoretical knowledge into different courses and systematically lecturing on all aspects from theory to performance.

The first stage is the learning stage (i.e. basic courses in medicine). This stage mainly uses medical microbiology courses to teach basic theory to laboratory biosafety students, explaining the theoretical knowledge of microbiology laboratory biosafety. The lectures mainly include biosafety-related knowledge and biological risk factors in microbiology laboratories, such as microbial aerosols and laboratory biohazard sources, while emphasizing the significance of biohazards and biosafety.

The second stage is for professional course learners, which mainly covers lectures on the classification of hazards, safety barriers, and the requirements for biosafety in the study of clinical microbiology and diagnostic courses.

The third stage is the recess internship stage. This stage uses the content which they have learned in clinical laboratory management courses and combines it with the content previously seen in the teaching of microbiology laboratory safety systems, microbiology laboratory bio-security measures and operational procedures, proper handling of laboratory accidents caused by biological factors, and the use of biological safety equipment.

Simulation of Pathological Experiments
What the experiments focus on is that students should fully grasp the basic experimental techniques of microbiology and establish bacterial concepts and biosafety protection awareness, so that aseptic techniques can be implemented. It also requires students to control the identification method of bacterial morphology as well as isolation and culturing methods. An acquaintance with serological identification and application of molecular biology techniques that are used in bacteriological inspections is also required.

Deepening Pre-workplace Education in Practice
It is necessary for a laboratory director to conduct post-early schooling of students. The director should also introduce the basic information about the laboratory, services, and work flow before they enter a clinical laboratory. It is also obligatory to introduce various regulations and job demands as well as to explain the operations manuals used in microbiology. It is important to master the six steps of hand-washing, treatment after occupational hazard exposure, and other preventive measures. It is essential that we should enhance bio-security awareness and ability, so that we should not be contaminated and the environment remain unpolluted as well. Students who enter a clinical microbiology laboratory must be checked on their theoretical knowledge of biosafety and practical operations, only those that pass the exam can be permitted to practice.
Establishing the Analysis of Biosafety Incidents

In practice, we have developed PLA courseware for biosafety accident case studies from a microbiological laboratory, which includes relevant cases from the major sources of biohazards in the laboratory. Specific sources include the inhalation of microbial aerosols, needle-stick injuries, glassware cuts, contamination of skin and mucosa, ingestion, and cases involving bites from infected animals. We must analyse them with respect to their causes, hazards, warnings, and precautions.

Selecting cases that are reported by a number of domestic hospitals and involve laboratory biosafety incidents: for example, front-line hospital staff, including doctors, nurses, and inspection personnel for whom the infection rates of Hepatitis B virus and Mycobacterium tuberculosis are significantly higher than in second-line staff. There are also many unexplained cases of laboratory-associated infections. This makes students realise that the risk of being infected with pathogenic microorganisms is significantly higher among clinical diagnostic laboratory personnel than the general population and that laboratory pathogenic microorganisms may also infect non-laboratory personnel.

In addition, we have also established a simulation training experiment on microbiology laboratory biosafety and the blood, body fluids, and other clinical specimens which are to be used in the experiments are from patients and are potentially infectious. The experiment assesses students, linking each of the laboratory techniques which include specimen collection, specimen preservation and handling, inspection procedures and equipment operation.

Results and Discussion

Through two rounds of exploration and practice, we have offset the lack of theoretical lessons by making biosafety theoretical knowledge more mainstream and have embedded it into a different course. It can develop effects on the review of learning and practice, intensifying and consolidating knowledge, because similar theory has been taught at different times. Teaching reforming focused on the combination of biosafety theory and practice in clinical testing. Furthermore, it has avoided boring theoretical biosafety lectures. Putting it into practice, students could cultivate their ability to make timely discoveries and handle, in a quasi-emergency situation, those accidents caused by laboratory biological factors.

Through careful and comprehensive safety education, students could establish safety awareness, develop good habits around laboratory biosafety issues, adapt to a clinical laboratory environment as soon as possible, and master a variety of standardised operating procedures for laboratory experiments. Specimens such as blood, and body fluids may cause communicable diseases. Medical tutors must therefore be reliable, confident, and trained. Trainees should be reminded to wear overalls, work caps, and when necessary they should also wear laboratory gowns, shoes, masks and gloves, and should execute aseptic operating procedures. Venous blood collection must be done by a single person. One needle, one tube, one towel, one belt, must be drummed into their practice and laboratory personnel must wash their hands or disinfect their hands before each operation, and when facing each patient. Practice has proved that this is the key to prevent the occurrence of biological hazards, since we have educated students to establish appropriate bio-security awareness and foster standardised experimental techniques.

It is necessary for everyone to avoid using contaminated hands when making and receiving calls or operating a computer keyboard in the middle of the experiment, and neither should students wear contaminated clothing in a rest room, nor use make-up, drink and smoke in the laboratory. It is proposed that students should be reminded to distinguish clean areas, buffer zones, semi-polluted and contaminated areas in the laboratory, and disinfect the air, surfaces, and the floor, daily. It is emphasised that operations which may result in aerosol pollution should be done in a biological safety cabinet, for example, when opening sample bottles, liquid samples may overflow. We need to use padded pieces of gauze or paper, and then use forceps to pick up broken pieces of glass, then
disinfection is carried out without direct involvement of hands during the clean-up, when there is breakage of specimen tube during an operation, or centrifugation process.

Clinical laboratory work often involves contact with infected blood, urine, faeces, etc. Students may not observe samples carefully as they are timid, afraid of dirt, and some even miss the obvious anyway. Medical tutors should take the opportunity to inculcate in their students the virtues of loving their work, pride, and dedication during the process. Besides this, it is necessary to develop an attitude of earnestness and one of truth-seeking from data, as well as a spirit of not being afraid of dirt, so that they will know, promote, and embody, the status of medical tests in clinical diagnostic work and its vital function [6].

Once it is found that students are not paying attention to infections that are caused by occupational exposure, the medical tutor should intensify the training, as far as possible to avoid the occurrence of occupational infections and improve student self-awareness. Tutors should always remind students that clinical laboratory work mainly involves coming into contact with a number of clinical specimens, which are infectious. It will lead to environmental pollution and self-infection if students neither strictly execute aseptic techniques in the operation, nor have standardised skills in biosafety.

We set up a universal biosafety laboratory with the purpose of not only supplying an experimental site to protect teaching staff and medical students, but also to be able to carry out laboratory biosafety education. Such a laboratory must be partitioned clearly, and should include uncontaminated areas, buffer zones, semi-polluted, and contaminated areas. It is necessary to limit the area of activity, number of laboratory personnel, and to define the flow direction of goods, so that the work area and processes can be standardised. Furthermore, a level 2 biosafety cabinet should be configured at the same time. It is necessary to establish a reliable laboratory biosafety management system as well as develop procedures and bio-security measures.

Only when we have a certified biosafety laboratory, and go through standardised systematic education on laboratory biosafety (both theoretically and experimentally) can we cultivate qualified, skilled, medical laboratory personnel with solid a theoretical knowledge of laboratory biosafety, qualified skills in biosafety, who can adapt to jobs engaging in teaching, research, and various type of laboratory work.

Summary

During the four years administering the training programme, we developed a proficient set of courses that combined theoretical training with practical training to cover the knowledge and skills needed in biosafety and biosecurity for ensuring safe operation within the laboratory. These increased the competency and proficiency among BLS laboratory users and guaranteed adherence to stipulations on biosafety and biosecurity.

Acknowledgement

This research was financially supported by the Teaching Guiding Committee for College of Medical Technology Majors under the Ministry of Education in China (JX2016-Y026).

References


