QATAR UNIVERSITY

COLLEGE OF HEALTH SCIENCES

EVALUATING THE SAFETY OF QATAR UNIVERSITY'S EDUCATION LABS IN BIOMEDICAL LABORATORY SCIENCES BY RISK MANAGEMENT PROCESS

BY

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ABSTRACT

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Title: Evaluating the Safety of Qatar University's Educational Labs in Biomedical Laboratory Sciences by Risk Management Process

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Background: Safety in the educational biomedical science laboratory is the most crucial topic because the students lack full knowledge of the hazards around them and lack of commitment. The hazards can be chemical, biological, physical, ergonomic, and radiation. Despite the category of hazards, all-hazards need to be identified, evaluated, and controlled, which is known as the process of risk management (RM). Hazard identification is considered the most crucial step in the RM process. The risk evaluation is the estimation likelihood of occurrence and severity of each risk. The Risk Priority Number (RPN) classify identified risks into four categories depending on the multiplication score, which are high-RPN (16-25), warning- RPN (12-15), medium-RPN (8-10), and low-RPN (1-6). According to the category of RPN, the hierarchy of control is selected. The hierarchy of control includes elimination (highest level), replacement, engineering control, administrative control, and personal protective equipment (lowest level). This study was conducted to evaluate the safety of the microbiology and the hematology labs, identifying potential hazards and determining the actions or controls required to eliminate or reduce any risks to the Biomedical Sciences (BMS) students, teaching assistants, lab technicians, faculties and other related workers, following an RM process. **Materials and method:** A prospective and retrospective cross-sectional study was conducted from January to

March of 2020 in Laboratories of the Department of Biomedical Science (BMS) at Qatar University (QU). The study sample consists of two BMS education laboratories, which were microbiology (BIOM 322) and hematology (BIOM 451) labs. During the inspection process, checklists, data collection sheets (hazard identification sheets, and hazard evaluation sheets) were used. Then, each identified risk was evaluated in terms of severity and likelihood of occurrence. The RPN was calculated for each risk. The control measure was divided into two categories adopted and recommended control measures. These measures were evaluated per each lab, and a comparison between both labs was performed. A Comparison was carried out between the adopted and the recommended control measure for each lab and between the two selected labs. **Results:** Chemical, physical, ergonomic hazards have the highest percentages in the microbiology laboratory, with an equal percentage of 25% of each hazard. Chemical and ergonomic hazards have the highest percentage in the hematology lab with 31% each. Both microbiology and hematology labs do not have radiation hazards. The total number of hazards that were identified“ were thirteen (n=13) hazards in the hematology lab and sixteen (n=16) hazards in the microbiology lab. There is a significant difference between adopted and recommended control measures per each lab in terms of likelihood, severity, and RPN. **Conclusion:** Almost a quarter of the identified hazards in both labs is for chemical and ergonomic hazards. The recommended control measure can reduce the severity, likelihood of occurrence, and the RPN for the identified hazards in both labs.

DEDICATION

I dedicate this humble research to the generous parents, my brother, and to everyone who has spared no effort in helping me.

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1. INTRODUCTION

Biomedical Sciences (BIOM) is considered one of the essential medical specialization, which is concerned with examining patients, diagnosing the causes of injury, and dispensing appropriate treatment. The biomedical sciences laboratories include research and development (R&D) laboratories, clinical and medical laboratories, education laboratories, and others. Despite the type of laboratory, safety is the most crucial issue (Stack & Harrington, 2011). These critical issues of safety and risk management, especially in educational laboratories, and this is because students differ from employees who have experience in dealing with different hazards. The safety issue is particularly importance since students lack full knowledge of the hazards around them, how to deal with risks, lack of commitments, and adherence to the rules of security and safety.

Furthermore, students generate a curiosity motivation in dealing with all materials and equipment in the laboratory (Barbato, De Lillo, La Torre, Cardoni, & De Giusti, 2019). The hazards can be chemical, biological, physical, and radiation. It is more likely that these hazards become a risk if they are not handled properly, and the effect may affect the student, laboratory personnel, and cleaners in the laboratory, which may also extend to outside the laboratory. Hence the importance of risk management in the educational laboratories to protect workers inside the laboratory and the surrounding environment as well.

Safety and health within the laboratories are the responsibility of everybody working in the laboratory, including lab assistants, teaching assistants, housekeeping, and students (Stack & Harrington, 2011). Therefore, all workers in this field must abide by following safety and security guidelines. The nature of experiments inside

the laboratory varies with different levels of education, and therefore security and safety means and standards differ from one place to another(Mendias & Ross, 2001).

Nevertheless, there are general rules that guarantee the safety and security of students within the Biomedical Sciences Laboratory, the most important of which is not to enter the laboratory except with the teacher or supervisor, not to deal with any of the chemicals and equipment (Van Ness, 2001).

Noticeably, the vast expansion in laboratory services and the abundance of education laboratories make it is difficult to monitor from the degree of safety for workers and students in those laboratories and the individuals surrounded by them and the environment in general(Rajczi, 2008). During the past decades, there have been several incidents of diseases such as *Salmonella species, Neisseria meningitides, Brucella species, Mycobacterium tuberculosis* associated with hospital medical laboratories(Singh, 2009). This is what it is called Laboratory-Acquired Infection.

Similarly, education laboratories are the primary sources of infection with various types of pathogenic microbes that may affect either laboratory personnel (students and workers) or may affect those around them from individuals and families(Tun, 2017). The daily handling of eight hours with fluids, tissues, and blood of sick patients and even normal subjects makes this job the most dangerous occupational and more susceptible to diseases(Parks, Yetman, McNeese, Burau, & Smolensky, 2000). Experts assure that about 90% of injuries accidents during laboratory work are due to human errors that can be avoided and that only 10% are due to mistakes in equipment and laboratory machines (Kuselman, Pennecchi, Fajgelj, & Karpov, 2013; Smith, 2011).

There are several ways the microbe enters the body of laboratory workers in the event of these human errors(Johnson, Bidez, & Delucas, 2012). First and most

dangerous by acupuncture or wound of the skin with sharp materials such as scalpels or broken glass remains contaminated(Marusic, Markovic-Denic, Djuric, Protic, & Dubljanin-Raspopovic, 2017). Secondly, through the mucous membranes have been inhaled and finally swallowing(Singh, 2009).

In addition to injury inside the laboratory, there is the possibility of infection by microbial infections outside the laboratory when individuals are exposed to hazardous medical waste from these laboratories due to negligence and lack of proper disposal(Burd, 2005). In the late eighties, awareness increased worldwide on the dangers of what is known as medical waste, and studies increased to search for safe ways to get rid of such waste for the safety of health workers and the individuals surrounded and the environment in general because of the damage and rapid epidemics that could spread(Liao & Ho, 2014).

1. Concept of Risk management

At the beginning of the nineteenth century, risk management function appeared, as one of its most important activities was to provide security for project employees and also provide security for the property of these projects, since that date to the world's interest in using scientific methods to confront risks (Boudia & Jas, 2007).

Risk management is an essential part of the broader discipline of project management. Risk management is defined as a complete willingness to face the problems that will occur in the future, so every problem that arises in the future is a danger at present (Boudia & Jas, 2007). The students, the instructors, laboratory personal (technician and technologist) may encounter threats during working in the lab. Risk management focuses mainly on facing threats before they occur. Risk management can also be defined as "an administrative activity that aims to control risks and reduce them to acceptable levels." RM is the process of identifying,

measuring, controlling, and reducing risks facing a laboratory." (Heilig, Kushner, & Thomasma, 2001) The risk management process is one of the essential concepts that some people do not know or do not realize how important it is (Aita, Padoan, Antonelli, Sciacovelli, & Plebani, 2017).

There is a vast difference between risk management and risk assessment. Risk assessment is the process of identifying sources of risk and analyzing them in the light of the severity of the damage and the likelihood of it occurring(Ushakov, Davydov, & Turzin, 2002). Subsequently evaluating the means of control and their effectiveness and indicating the degree of risk (Aita et al., 2017). On the other hand, risk management is a process that includes the business as a whole and begins with a risk assessment and then implementation of the identified risk management plan by either blocking the source of the risk and applying appropriate control methods with continuous monitoring, and review of risks and the effectiveness of the control methods.

Although the term hazard and risk are used interchangeably, there is a vast difference between them. The risk (ISO 14971) is the probability of harm and the severity of the injury caused by exposure to Hazard (Canadian center for occupational health and safety, 2017).

The harm (ISO/ IEC Guide 51) is physical damage or injury to the health of people. The severity (ISO 14971) is a measure of the possible consequences of a hazard. However, Hazard (ISO/ IEC Guide 51) is the cause of injury or damage to life, property, or both such as chemicals, fire, physical, mechanical, and electricity. For example, bleach is considered a hazard and not risk, but when the bleach is mishandled, it becomes a risk (Canadian center for occupational health and safety,

2017). Usually, there is action or exposure needed to convert hazard to risk(Sanchez Lopez, Cambil Martin, Villegas Calvo, & Moreno Martin, 2019).

2. Strategic objectives of risk management:

Risk management aims to set the most appropriate policy to meet expected losses at the lowest possible costs. Usually, this position is assumed by a person called the risk manager. The risk manager's tasks are limited to the followings: discovering the risks specific to each activity separately(Rid, 2014), whether this activity is an individual or a project, analysing each of the risks that have been found and knowing its nature and its causes and its relationship to the risks to another, measuring the degree of severity and probability of an accident and estimating the size of the loss, choosing the most appropriate way to manage each of the risks that exist with the individual or project, according to the degree of safety and the necessary cost(Aita, Padoan, Antonelli, Sciacovelli, & Plebani, 2017).

Several systems can be used to estimate each risk by linking two factors together, the first factor represents the possibility (Likelihood) of the risk table 1, and the other factor represents the severity of the risk and its impact when it occurs, as follows:

Table 1. The five levels of likelihood of occurrence.

Likelihood	Level	Occurrence criteria
Frequent	5	Likely to occur many times per year
Moderate	4	Likely to occur once a year
Occasional	3	Might occur once in 3 years
Remote	2	Might occur once in 5 year
Unlikely	1	Might occur once in 10 years

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

Table 2. The five levels of severity.

Severity	Level	Occurrence criteria
Critical	5	Fatal/ permanent injury; Poison/ Infection with unknown cure; Spill outside campus; > $10 million damage; > 1 year downtime
Very serious	4	30 days MC/hospitalization; Infection with known cure; Spill outside building; > $1 million damage; > 3-month downtime
Serious	3	10 days MC/hospitalization; Injury with 1-month recovery; Spill outside Lab/room; $100,000 damage; > 1-month downtime
Marginal	2	3 days MC; Very mild exposure; Spill outside workplace; > $10,000 damage; > 5 days downtime
Negligible	1	First aid treatment only; mild / no exposure; Spill within workplace; < $5,000 damage; No significant downtime

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

The risk matrix is a colour map using the factors mentioned above, the risk probability factor that is digitally represented, the risk impact factor when it occurs and is represented by letters, and three colours have been adopted to indicate the risk level as shown in table 3. RPN is calculated across the table 3. The possibility (Likelihood) of the risk: Frequent (5), moderate (4), Occasional (3), Remote (2), Unlikely (1). The harm of the risk: Critical (A), Very series (B), Serious (C), Marginal (D), and Negligible (E).

Table 3. Risk matrix (5×5).

	Critical (A)	Very serious (B)	Serious (C)	Marginal (D)	Negligible (E)
Frequent (5)	Operation not permissible (5,A) 25	Operation not permissible (5,B) 20	High priority (5,C) 15	Review at appropriate time (5,D) 10	Risk acceptable (5,E) 5
Moderate (4)	Operation not permissible (4,A) 20	Operation not permissible (4,B) 16	High priority (4,C) 12	Review at appropriate time (4,D) 8	Risk acceptable (4,E) 4
Occasional (3)	High priority (3,A) 15	High priority (3,B) 12	Review at appropriate time (3,C) 9	Risk acceptable (3,D) 6	Risk acceptable (3,E) 3
Remote (2)	Review at appropriate time (2,A) 10	Review at appropriate time (2,B) 8	Risk acceptable (2,C) 6	Risk acceptable (2,D) 4	Risk acceptable (2,E) **2**
Unlikely (1)	Risk acceptable (1,A) 5	Risk acceptable (1,B) 4	Risk acceptable (1,C) 3	Risk acceptable (1,D) 2	Risk acceptable (1,E) 1

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

In the case of ideal risk management, prioritization is followed so that risks with high losses and a high probability of occurrence are addressed first, while risks with fewer losses and less probability of occurrence are discussed later. In practice, this process may be complicated, and the balance between high-risk and low losses versus low-risk risks and high losses may be poorly managed.

3. Type of risks:

Although the goal for all laboratories is to optimize their risk management, risks are distributed among the three phases of testing: pre-analytic, analytic, and post-

analytic (Orme et al., 2015). Some risks may primarily affect the laboratory itself, but others can affect larger institutions and even the general public if they are not handled correctly (Klein et al., 2018).

3.1.Biological hazards:

Their seriousness is a concern in laboratories that deal with microorganisms or contaminated materials(Park et al., 2018). These risks are usually found in clinical and infectious disease research laboratories but may be found in other laboratories as well(Orme et al., 2015). The assessment of the severity of biological materials requires consideration of several factors, including the organism that is treated and the activities that will be carried out on this organism.

3.2.Health risks:

These are the risks that threaten the health and performance of individuals working at the university as a result of the work environment surrounding them and may cause harm to them that requires direct medical intervention, or are those risks that cause chronic diseases (Monafo, Tandon, Bradley, & Condict, 1976) These include:

3.2.1. *The risk of infection from epidemics and biological wastes and their spread:*

There are several risk-reduction policies such as correct disposal of biological (biological) waste, non-accumulation of biological (biological) waste, disposing of waste in cooperation with specialized institutions in this field, specify places for collection of these (biological) waste that meet the required conditions (temperature and ventilation) (Orme et al., 2015). Also, imposing annual vaccinations on all medical personnel (workers in the health centre and pharmacy and nursing laboratories) (Monafo et al., 1976). Also, Health awareness of the dangers of these

epidemics. Finally, conduct periodic preventive inspections of the places where biological (biological) waste is preserved.

3.2.2. *Public health risk:*

This type of risk can be tackled using the following methods: report cases that have been contaminated with biological (biological) waste and handle the accident incident model. Perform immediate treatment according to the place where the pollution was exposed. Transferring the injured person to the health centre and documenting the case (Monafo et al., 1976). End danger and get rid of the damage it caused: Immediate treatment of first aid cases at the site of the injury, then refer the injured person to the health centre. Control the source of infection through various sterilization and disinfection methods, and by type of contamination. Provide a first aid kit to carry out the first aid operation in the event of injuries(Klein et al., 2018). An ambulance is available to transport the injured. Establish safety awareness guidelines for laboratory and health centre personnel. Establishing guidelines for the safe use of devices in laboratories and health centres.

3.2.3. *The risk of chronic diseases*

The risk reduction policy for risk of the chronic illness includes safe transportation and use of hazardous materials, use personal protective tools that are appropriate to the nature of work or training, availability of first aid kits (sterile wound, cotton, gauze, medical wrapping, …..etc.) (Monafo et al., 1976). In all training and workplaces, training in performing first aid in the event of wounds and burns and ensure public hygiene places to work and training to prevent diseases that occur due to lack of hygiene.

3.3.Chemical risks:

Chemical risks are the risks property or personnel face in scientific laboratories during experiments or throughout the transportation, handling, and storage of chemicals(Raja & Sultana, 2012). These include the risk of a chemical spill, fire hazard from flammable chemicals, the risk of chemical explosions, hazardous chemical waste dumped in containers and sanitation facilities, the risk of a fall, leak and blast of a compressed gas cylinder; and the risk of mixing incompatible chemicals during transport, use, storage or disposal(Klein et al., 2018).

3.3.1. *The risk of a chemical spill:*

The risk reduction policy includes: read carefully the information on the public safety card for the materials handled in the laboratory, know the properties of the materials that will be use, keep the workplace clean and get rid of clutter in the lab, examine the procedures established for the safe use of chemicals in the workplace(Raja & Sultana, 2012); and place the name of the material and its hazard marks on the secondary container to which the material is transferred. Also, be familiar with the general safety procedures and requirements in the laboratory before conducting any new experiment: development and periodic review of written instructions to respond to spills in the laboratory. Take precautions to prevent spillage, gas emissions, and plan how to deal with it. Knowing the best way to clean and sterilize any chemical that will deal with when it is spilled.

3.3.2. *Fire hazard from flammable chemicals:*

The risk reduction policy includes: learn about the properties of flammable materials by looking at the Chemical Safety Card, Storing flammable materials in suitable special tanks, and storing no more than four liters of them outside the cabinet, never leave dust of flammable solids in the form of powders on the floor and surfaces and clean them immediately(Raja & Sultana, 2012). Also, provide appropriate fire

extinguishers and fire blankets in the laboratory and access them when needed, and check them periodically as there should be a sand bucket on site. Regular training is on how to use extinguishers in case of fire, providing the appropriate conditions for storing or dealing with flammable materials so that the room's air renews periodically to prevent the accumulation of volatile fumes. Dimensions of all sources of ignition when dealing with flammable materials, and it is strictly forbidden to use direct flame stoves. Place flammable materials in suitable containers that prevent spillage opportunities while transporting quantities of them. Separate flammable materials from other materials by barriers or in separate rooms, especially if their quantities are large. Finally, replacing more dangerous solvents with less dangerous ones and use appropriate vehicles during transport to prevent spillage.

3.3.3. *The risk of chemicals exploding.*

The risk reduction policy includes: The necessity of identifying the characteristics of explosive chemicals when handling them, from public safety cards, handle these materials with extreme caution, and avoid friction, electric shock or sparks, or heat when handling them. Also, store small quantities of explosive materials in their safes(Raja & Sultana, 2012). Take into account the extent of the incompatibility of some substances whose reaction may cause explosions when stored and transported. The necessity of having contingency and evacuation plans at the university. Sufficient to store small quantities and as needed. Wear personal protective equipment (glasses, masks, gloves).

3.3.4. *The danger is of dumping chemical waste into containers and sanitation facilities.*

The risk reduction policy includes place warning signs to raise awareness of the dangers of dumping chemical waste into containers(Raja & Sultana, 2012).

3.3.5. *The risk is of gas cylinder fall, leakage, and explosion.*

The risk reduction policy includes make sure the cylinders are safe and ready before turning them on. Store cylinders are in an upright position away from corridors and emergency exit places in a well-ventilated area and away from corrosive materials, salts and vapours. Attach the cylinders to an appropriate chain or belt and secure it to the wall or a suitable place. Air regulator uses the cylinder to know the pressure rating, the cylinder must be closed, and the regulator disconnected when not in use, Large quantities of cylinders are not stored in the laboratory, and the principle of chemical incompatibility must be taken into consideration. The content of the cylinders when storing (storing gases with similar chemical hazards near each other). Always ensure that the cylinder is at least four meters away from flammable and incompatible materials. The instruction that does not completely discharge the gas from the cylinder, and a portion of the gas must be left inside the cylinder to ensure that the pressure inside the cylinder is larger than the outside so that air does not enter the cylinder. It is preferable to use the lowest volume of compressed gas cylinders. Special vehicles are used to move the cylinders from one place to another. They know the nature of the gas before use(Klein et al., 2018).

3.3.6. *The risk is of mixing incompatible chemicals during transport, use, storage, or disposal.*

The risk reduction policy includes: Inventory all the chemicals and make a statement showing their name, quantity, and nature. Provide a public safety card for all materials in the laboratory and put it in an accessible file when needed(Asiry & Ang, 2019). View the general safety card for the materials handled in the laboratory and identify incompatible materials. For the material is being dealt with and not allowing compatible materials to be in close proximity to each other during

transportation and storage(Raja & Sultana, 2012). In the case of returned materials, care must be taken to collect them in special packages according to the principle of chemical incompatibility.

3.4.Fire risk:

Fire risk may threaten the lives of students and workers at the university and cause damage to the university's property as a result of the absence of security and safety precautions or the lack of necessary equipment to warn and combat or the lack of required training(Litton et al., 2018). These include poor storage of flammable materials; and bad electrical connections.

3.4.1. *Fire risk resulting from poor storage of flammable materials* (explained in 4.3.2)

3.4.2. *Fire risk from bad electrical connections:*

The risk reduction policy includes: The wires should be suitable and the electrical voltage suitable. Avoid passing wires under carpets and furniture(Klein et al., 2018). Do not use an electric heater that does not have the advantage of disconnecting the electric current when it falls. Not to load the electrical circuits or the overheating or overloading, especially the multi-opening switch, so placing several plugs in one fuse constitutes an overload on the electrical circuit. Failure to replace the three-headed socket with two heads through connections, which leads to the non-utilization of the grounding system. Never allow equipment to pass over electrical wires(Litton et al., 2018). Notify the engineering, maintenance, and services department in the event of a feeling of heat in the sockets or wires of the equipment when used. Notify the engineering, maintenance, and services department immediately of the devices that cause electrical charges when dealing with it (short circuit).

3.5. Physical risk:

Some operations in the laboratory pose a threat to employees due to the materials or equipment used(Asiry & Ang, 2019). The risks include the following: compressed gases, high-pressure reactions, electrical hazards, microwave risks, and radio frequencies. In addition, workers face general hazards related to the workplace, which result from their activities inside the laboratory, such as falls and slips, and wounds, and health problems caused by frequent routine movement.

4. Risk management process:

The risk management process is a sequential process that is based on specific criteria by the ISO standards. The risk management process must be an integral part of the organizational processes; it must also be part of the decision-making process(Njoroge & Nichols, 2014). The risk management process steps are as follows: preparation, risk identification, risk evaluation, risk control, and record-keeping and reviewing(Aita et al., 2017) as shown in table 4.

Table 4. Risk management process.

1 Preparation	**2 Hazard identification**	**3 Risk evaluation**	**4 Risk control**	**5 Recordkeeping & Review**	**6 Back to step 1**
-Gathering information	-Identify hazards -Identify potential accidents	-Estimate the risk level -Prioritize hazards to be controlled	-Formulate control measures -evaluate residual risks	-keep risk registry (3 years) -review periodically or when necessary	

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

4.1. Preparation:

Planning for the risk management process, mapping the scope of work, the basis, and criteria upon which it will be based, as well as defining a framework for the process and its analysis agenda (Njoroge & Nichols, 2014).

4.2. Hazard identification:

Risk identification is the second step in preparing proactive risk management(Nichols, 2011). For startups and others, the ability to identify risks that pose a threat to the laboratory is an essential component of strategic planning. It is imperative that seriously consider the types of potential risks facing the laboratory rather than just focusing on apparent concerns such as a fire(Miida, 2010). Although it is difficult to manage the risks by 100%, it is possible to identify the most prominent risks mentioned in the future within the laboratory and work to avoid them(Fabbretti, 2010).

4.2.1. *Methods of identification of Hazards:*

It is self-evident that the risks are first identified so that they can be addressed before they occur, and the methods for identifying the risks are not counted on the fingers of the hand and can be categorized into retrospective and prospective methods(Fabbretti, 2010). The retrospective method includes safety audit reports and incident reports, while the prospective method includes checklists and brainstorming(Geerts, De Koning, De Smet, Van Solinge, & Egberts, 2009).

4.2.1.1. *Brainstorming:*

One of the essential methods used to determine risks. It is assumed that every laboratory holds periodic meetings on a weekly or bi-monthly basis, and in each meeting(Kobo-Greenhut, Reuveni, Ben Shlomo, & Megnezi, 2019). The time of meeting must be devoted to brainstorming in which all attendees participate to

determine any possible risks that occur for any reason. Also, brainstorming sessions should be activated in meetings that occur at the beginning and end of each stage(Geerts et al., 2009).

4.2.1.2. *Job Safety Analysis (JSA):*

One of the oldest methods used to define risks is that the project or stage is divided into several activities,(Thepaksorn et al., 2017) then each activity is studied separately to extract risks from it as possible and study them(Ahlin & Weiss, 2007).

4.2.1.3. *The scenario of achieving the goal:*

The risk can be known from the goal, where the scenario used to achieve this goal is studied, and all the risks that might prevent it from being achieved are explored, (Ahlin & Weiss, 2007)as well as opportunities that help achieve the goal in time or at a lower cost(Lippi & Guidi, 2007).

4.2.1.4. *List of previous risks (retrospective method):*

This method is used when the current risk is similar to a risk that occurred in the past. It can be determined whether the current danger occurred in the past or not by returning to the old records(Sciacovelli, Secchiero, Zardo, D'Osualdo, & Plebani, 2007).

4.2.1.5. *Field Tours:*

Using this technique will make noticing any mistakes that will help to extract risks quickly.

4.2.1.6. *Teamwork posts:*

It is imperative that the team get motivated to inform about the potential risks in the project(Sciacovelli et al., 2007). The team is practicing the required work, and therefore, it will surely discover risks that the manager of the project, cannot quickly know.

4.2.1.7. *Ask the experts:*

The experts are not working with the team who have much experience in such projects, and indeed, the size of their experience will add many risks that risk managers have never thought about.(Gan, 2019)

4.3. Risk evaluation

When identifying the risks is completed, the evaluation has to be done. The risk assessment stage is an essential stage of the laboratory safety management plan, which gives a comprehensive view of the risks and their severity. Control it when it cannot be eliminated permanently. By assessing risks, it will be easy to make decisions, and then determine the necessary measures that must be taken to get rid of harm or reduce it effectively(Njoroge & Nichols, 2014). The risk assessment process also helps in raising awareness of the risks surrounding laboratory, determining the type of risk, knowing if the preventive measures are sufficient to solve the problem and reduce the risks, determine the priority of risks and control measures, and meet the legal requirements when necessary. Several methods can be used to analyse risks such as "Failure Mode and Effects Analysis (FMEA)," "structured what-if technique (SWIFT)," and Data Mining.

4.3.1. *"Failure mode and effects analysis (FMEA)"*

FMEA is a proactive tool of risk assessment tools that are often used before starting to implement any new design or process to identify ways or situations in which failure/risk can occur("FMEA grows up: trends in failure mode and effects analysis," 2006)**.** The failure can be due to a step during the process or an external factor affecting the process("An introduction to FMEA. Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and Effect Analysis," 2002). FMEA aims to take measures to prevent and

reduce these conditions. It is a documentation of the entity's knowledge of the risks and current procedures in place to prevent them("An introduction to FMEA. Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and Effect Analysis," 2002).

FMEA is a predictive tool for what may go wrong so it can be addressed ahead of time. FMEA is a method used to direct work on areas that either happens most frequently and cause the most harm or may have the lowest rate of detection("An introduction to FMEA. Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and Effect Analysis," 2002). FMEA is enlightening because there are times when people start working on the process, and of course, many healthcare processes are very complicated and very complex, and they sometimes begin in the wrong place("An introduction to FMEA. Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and Effect Analysis," 2002). FMEA is a method that directs the risk manager to risks that require more focus, this does not mean it will not work on other places, but it does mean that that is an excellent place to start.

It is a tool brought from outside from the industry to the health care, aim to help risk managers determine process failures. It is designed to be a mechanism by which the process or equipment can be looked to determine where are the failure points or where is the place that may not work the way it supposes too("FMEA grows up: trends in failure mode and effects analysis," 2006). Then, using a system in that looking at the frequency of how often the event happened, the severity of what may happen of that fail, and the ability to detect, whether or not failure can be picked up before it can harm the workers and before it becomes catastrophic("An introduction to FMEA.

Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and Effect Analysis," 2002).

The output of an FMEA is the “Risk Priority Number (RPN)” which is calculated by multiplying the severity, the occurrence and the existing capability to detect the failure prior to approaching the employees ("An introduction to FMEA. Using failure mode and effects analysis to meet JCAHO's proactive risk assessment requirement. Failure Modes and Effect Analysis," 2002).

Risk Priority Number (RPN) = Severity (effect) x likelihood of occurrence (frequency x detection (control)

4.3.2. *“Structured what-if technique (SWIFT)”*

“Structured What-If Technique (SWIFT)” is a prospective risk investigation technique that utilizes structured brainstorming with guide words and hints for risk identification. SWIFT is perceived as an agile method comparing with Failure mode and effects analysis (FMEA) (Card, Ward, & Clarkson, 2012). It is employed in different contexts, including healthcare.When SWIFT is used alone, it has limited validity. As a result, in a health care setting, SWIFT is used with “failure mode and effects analysis” to show significant risk(Card et al., 2012).

4.3.3. *Data Mining*

The widespread availability of information technology had led to an enlarged amount of data in a proactive way not seen in history before, which made the issue of big data on the Internet a matter of controversy, in terms of the feasibility of its existence in this random image(Tarasova, Biziukova, Filimonov, Poroikov, & Nicklaus, 2019). The big data means unimaginable amounts of data of multiple types and sources with a size of hundreds of terabytes or even petabytes (Petabytes is the number one followed by 15 zeros). This led to an increase in the need to develop

powerful tools for analysing data and extracting information and knowledge from them or also known as knowledge discovery in databases (KDD). Traditional and statistical methods cannot deal with this huge amount, so smart tools are used to process this data(Wang, Huang, Luo, Pei, & Xu, 2018).

Hence what appeared to be called data mining, a technique that aims to extract knowledge from vast amounts of data, based on mathematical algorithms that are the basis for data mining and are derived from many sciences such as statistics, mathematics, logic, learning science, artificial intelligence and expert systems, science Pattern recognition, and machine science(Tarasova et al., 2019).

Data mining appeared in the late eighties and proved its existence as one of the successful solutions for analysing vast amounts of data, by converting it from merely accumulated and incomprehensible data to valuable information that can be exploited and utilized thereafter.

The data exploration phase has attracted much attention in the research community over the past decade, in an attempt to develop scalable algorithms and adapt to increasing amounts of data in the search for meaningful cognitive patterns(Droit et al., 2007). Packages of algorithms and software have grown dramatically over the past decade, to the point that expansion has made it difficult for workers in this field to track available technologies to solve a particular task.

One of the professional sectors that are beginning to benefit from this concept is healthcare(Chi & Street, 2007). With the growth in electronic health records (electronic health records), more and more facilities and the collection of vast amounts of digital data for the patient, thus health care providers and researchers can use data mining from vast stores of data to reveal previously unknown knowledge patterns and

then use this information to build predictive models to improve diagnosis and health care outcomes(Linos, Kotsioni, & Papageorgiou, 2005).

4.4.Risk control

Control of risks is a vital aspect of the laboratory protection phase. Once the risks are identified and evaluated, the risk must be dealt with either by eliminating these risks or reducing them. Specific strategies must be provided to control the risks involved, and the methods of risk control are usually categorized from the above Lowest level of protection and reliability, this process is known as a hierarchy of control that is divided into three levels: elimination, replacement, and Isolation(Chartres, Bero, & Norris, 2019). Eliminate the risks permanently if they outweigh the potential benefits, and this level is the highest in the hierarchy. Replace the risk with something less dangerous. Isolation of danger by using barriers or distance. In addition, there are several ways to control risks, including transferring risks to another entity, avoiding them, minimizing their adverse effects, accepting some or all of their consequences, and preparing plans to deal with the risks that must occur(Aven, 2016).

4.5. Record keeping and reviewing.

It is necessary to review, evaluate, and revise the monitoring procedures that have been implemented to ensure that they are working as planned, and to maintain a work environment free from risks,(Kessels-Habraken, De Jonge, Van der Schaaf, & Rutte, 2010) it is essential to keep abreast of the latest updates to get an accurate picture of the overall progress of laboratory and to be able to identify and monitor new risks.

Maintaining records of the risk management process is also necessary to demonstrate compliance with the work environment safety and health law and

regulations, and to be able to review risks while providing any training to employees efficiently, or when any changes in legislation or business activities occur(John Robson, 2005).

2. METHOD

2.1. Sample

A prospective and retrospective cross sectional study was conducted in the period of January to March of 2020 at Biomedical Laboratory Science Department (BMS)- College Health Sciences (CHS) at the Qatar University(QU). First, the undergraduate Fall and Spring study plan for Biomedical Sciences courses (BIOM) was obtained from the Qatar University (QU) official website. The list of the courses that were scheduled in the spring of 2020 was fourteen (14) courses-. Then the courses were divided into two groups. The first courses that do not include a practical section, while the second group includes courses that have a practical section (see *Figure 1*). The study was approved by the head of the BMS department. The study sample was chosen from the second group courses, which have a lab session, namely the medical microbiology (BIOM 322) and hematology & hemostasis (BIOM 451) courses. These courses were selected as it the most active labs where biological samples such as body fluids, microbial strains, chemical reagents, and various procedures are used in such labs, which makes an ideal selection for the present study as a good model of risk assessment.

Figure 1. Chart showing the Biomedical Sciences (BMS) Spring 2020 courses.

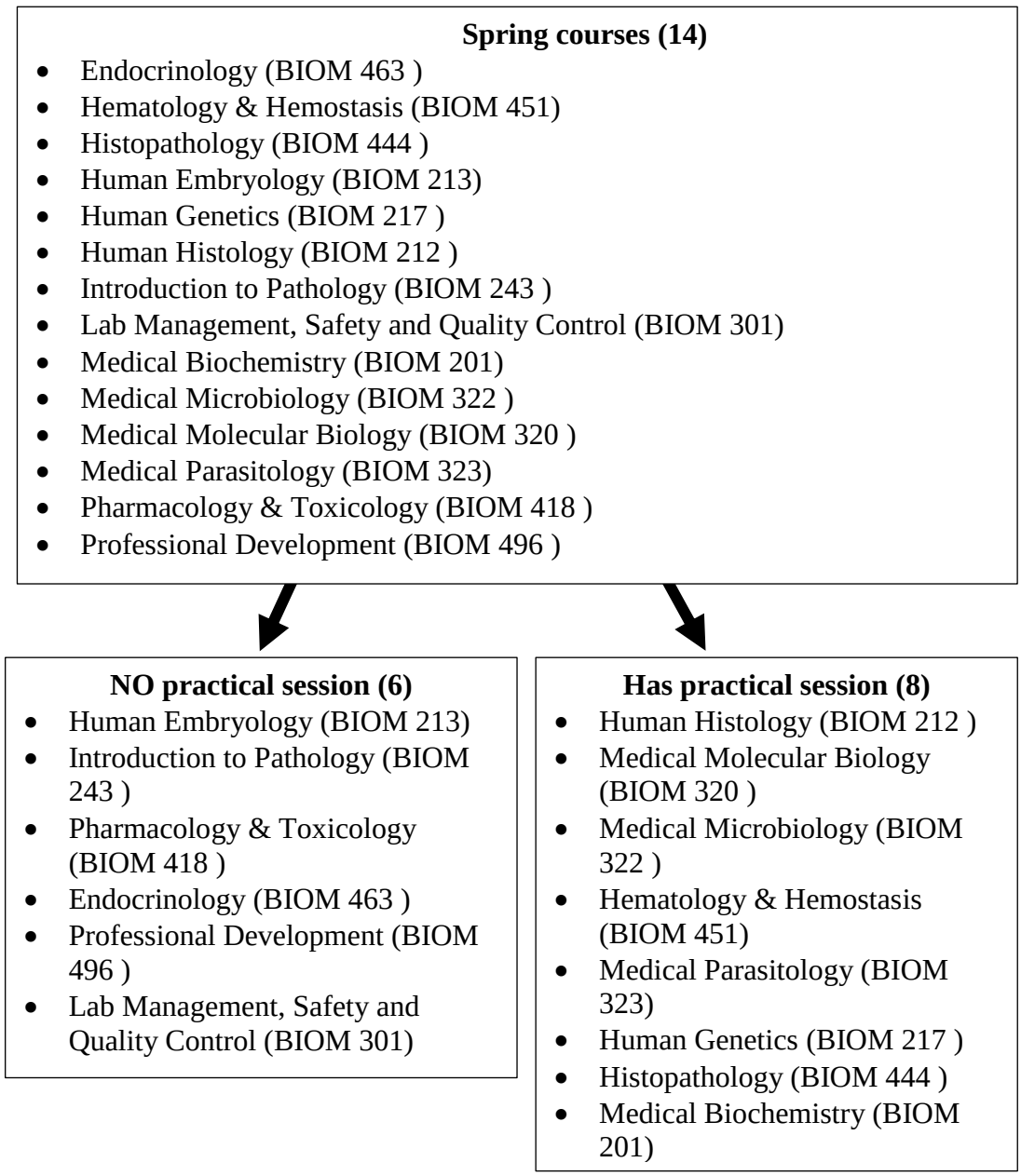


Figure 1. A show all 14 courses scheduled in Spring 2020 in the BMS department. B and C. courses without laboratory section and with laboratory sections, scheduled for spring 2020 in the BMS department, respectively.

2.2. Methodology

Initially, an oral interview was held with the persons in charge responsible and faculty members for the previously chosen educational laboratories. The aim of this interview was to introduce the objectives and the goals of this capstone project and to define the steps for conducting the project. Another interview was held with persons in charge to discuss a set of questions, which were prepared in advance The questions were concern about the following topics; the sources of the samples, the types of risks present in the laboratory, work instruction sheet, vaccinations, student training, staff training, equipment maintenance plan, equipment maintenance record, the average number of people working in the lab daily (including students), emergency protocols, in campus health and safety staff contact, previous accidents reports, health and safety inspection reports, safety equipment in the laboratory, a list of experiments performed by students, and list of microorganism used by students.

The required documents were collected from the persons in charge. Two tables have been prepared with each table assigned to a specific laboratory. Both tables included the name of the documents, from whom they were obtained, date of obtaining them. In addition, a separate column in both tables was assigned for missing documents, as shown in table 5.

Table 5. The collected documents and missed documents in microbiology and hematology labs, Spring 2020.

Microbiology Lab			
Name of document	Obtained from	Date of obtaining	Missing documents
Manual (SOP) + meeting with Dr. Sawsan	Persons in charge	13/1/2020	Equipment list
Lab Safety manual		30 /1/2020	Equipment maintenance
Incident and violation forms		30 /1/2020	Bacteria strain
MSDS infectious substances		5/2/2020	Waste management SOP
Name of document	Obtained from	Date of obtaining	Missing documents
MSDS Chemical		5/2/2020	Previous inspection reports from QU
MSDS carbon dioxide		5/2/2020	Chemical inventory list
List of bacteria used in each lab session		10/2/2020	
List of experiments performed in each lab session		10/2/2020	
Hematology lab			
Name of document	Obtained from	Date of obtaining	Missing documents
Haematology Manual	Persons in charge	20/1/2020	Previous inspection reports
Lab Safety manual		20/1/2020	Equipment inventory
MSDS chemical		17/2/2020	Equipment maintenance plan
			Equipment maintenance record
			Chemical inventory list
			Waste management SOP

A total of four lists were made, and two lists were allocated to the microbiology Laboratory and the other two to the Hematology Laboratory. The first two lists from each laboratory included the names of the materials mentioned in the Material Safety Data Sheet (MSDS). On the other hand, the other two lists from each laboratory were assigned the names of the materials that were actually used inside the laboratory during the practical sessions, as shown in table 6. Then, the two pre-prepared lists were compared, and the purpose of this was to find out if the MSDS was up to date or not.

Table 6. The lists of A. material and B. microorganisms either mentioned on the the Material Safety Data Sheet (MSDS) or were used during the practical session.

Microbiology lab	
Materials and microorganisms mentioned in "the material safety data sheet (MSDS)"	Materials and microorganisms that were used in each laboratory session
A. Material • *L̈O*FFLER'S methylene blue solution for microscopy • "Agar VRB crystal violet-neutral red-bile agar for microbiology (39,5 g for 1-liter of culture medium)" • "Blood agar (base) no.2 for the cultivation of fastidious pathogens and other microorganisms" • "di-iodine pentoxide GR for analysis granular 0.5-2.5 mm" • Ethanol 96% extra pure Ph Eur, Bp • "MacConkey agar for microbiology (50.1 g for 1-erliter of culture medium) Fluorocult ®" • Malachite green oxalate (C.I. 4200) for microscope and for microbiology	A. Material • Slide Catalase • Coagulase • blood agar plate • Mannitol salt agar • Novobiocin test • Gram stain • Bacitracin susceptibility test • Optochin sensitivity test • bile esculin test • Lancefield group test • latex agglutination test • Chocolate agar plate • Oxidase test B. Microorganisms • *Staphylococcus aureus* • *Staphylococcus epidermidis*

Microbiology lab	
Materials and microorganisms mentioned in "the material safety data sheet (MSDS)"	Materials and microorganisms that were used in each laboratory session
• "Nutrient broth for microbiology (8 g for 1-erliter of culture medium)" • Nutrient agar for microbiology (20 g for 1-erliter of culture medium) • "Peptone water (buffered) for microbiology (25,5 g for 1-liter of culture medium)" • "Phenol red indicator pH 6,4-8,2 ACS" • Safranine O (C.I 50240) for microbiology Certistain • Sodium hypochlorite solution (6-14% active chlorine) • "Sulfuric acid 95-98% extra pure Ph Eur,BP,NF,*ÖAB*, Ph Fran" • Ziehl-Neelsen carbol-fuchsin solution for microscope • Hydrogen peroxide solution 31% Ultrapur ® A. Microorganisms • *"Campylobacter jejuni, C. coli, C. fetus subsp. Jejuni"* • *"Candida albicans"* • *Escherichia coli, enteroinvasive* *Haemophilus influenzae (group b) or haemophilus meningitis* • *Klebsiella spp.* • *Mycobacterium tuberculosis, mycobacterium bovis* • *Neisseria gonorrhoeae* • *Pseudomonas spp. (P. aeruginosa, P. cepacia) and (excluding B. mallei, B.pseudomallei)* • *Salmonella paratyphi* • *Staphylococcus aureus* • *Streptococcus pneumoniae* *Streptococcus pyogenes*	• *Streptococcus pneumonia* • *Enterococcus* • *Streptococcus pyogenes* • *Streptococcus agalactiae* • *Streptococcus faecalis* • *Haemophilus influenzae* • *Neisseria gonorrhoeae*

Hematology lab	
Materials mentioned in the material safety data sheet (MSDS)	Materials that were used in each laboratory session
• Sickle-Chex® • Drabkin's Reagent • APTT XL • Ab-Trol 2 Borderline Control (10 x1mL) • Reticulocyte Stain • Giemsa stain • Brilliant Cresyl blue solution • DPX Mountant for histology • TWEEN® 20 • LISS-ADD • "Seraclone (anti-A, anti -B, anti D, anti AB,…….)" • Anti-Human-Globulin- • ASI HSV IgG Herpes Simplex Virus Test Kit • ASI EB VCA IgG Epstein-Barr Virus Test • ASI TPHA Test • ASI ASO Slide Test • ASI RF Direct Slide Test with Disposable Cards • Antibody • Wash Buffer • TMB Substrate Solution • Fetal Hemoglobin Kit • Sulfuric Acid 0.1N • Blood grouping reagents (anti A, anti B, anti D, anti A,B) + Reverse DiluentBio Vue ® System (ABD/ reverse cassette)"	• Drabkin's solution. • Commercial Wright's stain • Commercial buffer • Deionized water

Two tables were prepared; each table was assigned to a specific laboratory. In this table, the names of chemicals and microorganisms were grouped according to the handling and storage section in the MSDS (see appendix). This table aims to identify the hazards in the laboratory and shed light on the safety and security requirements for all materials and microorganisms. According to these requirements, a checklist

was prepared. Then, the checklist was used during the inspection of both laboratories (see appendix).

In addition, hazard identification sheet has been prepared that contains the name of the hazard. In this sheet, the hazards were divided according to their type into, chemical, biological, physical, electrical, and other hazards (see appendix). The main objective of this sheet is to identify the control measures, which are actions taken to reduce exposure to the hazards.

The date inspection was discussed as persons in charge. A specific day and time were agreed upon so that it does not conflict with the date of practical sessions. It was important for the laboratory to be empty in order not to disturb the students and faculty during their work. Also, to provide an opportunity to freely view and inspect all parts of the laboratory. Then the inspection process of the previously selected laboratories was carried out. The microbiology laboratory first, and then haematology laboratory were examined. Before the inspection of both laboratories, the staff in charge was informed orally that "the next week, the inspection process will be carried out for the microbiology laboratory which he is responsible for." During the inspection process, biosafety level 2 (BSL2) checklists, data collection sheets (hazard identification sheet, and hazard evaluation sheet) were used. Separate The checklist and sheets were allocated to each laboratory. Some photos were taken during the inspection as evidence.

The hazard identification sheet includes a description of the hazard, the risk associated, and the type of hazard, whether chemical, biological, physical, or ergonomic (see appendix). On the other hand, the hazard evaluation sheet includes the name of hazard, control measures, likelihood, severity, and risk rating (see appendix). The hazard description was the same on both sheets.

The control measures in the hazard evaluation sheet were divided into two types. The first type is the control measures that exist in the laboratory, and they were referred to in the sheet "adopted control measures." The second type of control measures are not present in the laboratory and have been proposed. This type was referred to as "recommended control measures." For the control measures the "Hierarchy of control measures" was used as shown in *Figure 2*

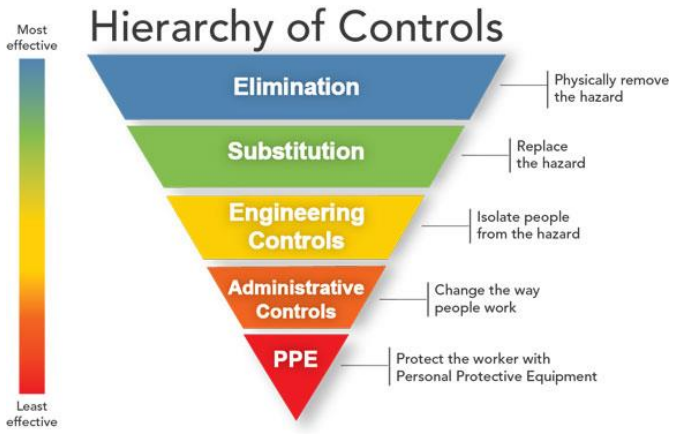


Figure 2. Hierarchy of controls.

Adopted from CDC - Hierarchy of Controls - NIOSH Workplace Safety and Health Topic. (2015, January 13). https://www.cdc.gov/niosh/topics/hierarchy/default.html

Then, each hazard was assessed in terms of severity and likelihood of occurrence. The severity and likelihood of occurrence were graded from 1 to 5 according to the following tables:

Table 7. The five levels of likelihood of occurrence.

Likelihood	Level	Occurrence criteria
Frequent	5	Likely to occur many times per year
Moderate	4	Likely to occur once a year
Occasional	3	Might occur once in 3 years
Remote	2	Might occur once in 5 year
Unlikely	1	Might occur once in 10 years

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

Table 8. The five levels of severity.

Severity	Level	Occurrence criteria
Critical	5	Fatal/ permanent injury; Poison/ Infection with unknown cure; Spill outside campus; > $10 million damage; > 1 year downtime
Very serious	4	30 days MC/hospitalization; Infection with known cure; Spill outside building; > $1 million damage; > 3-month downtime
Serious	3	10 days MC/hospitalization; Injury with 1-month recovery; Spill outside Lab/room; $100,000 damage; > 1-month downtime
Marginal	2	3 days MC; Very mild exposure; Spill outside workplace; > $10,000 damage; > 5 days downtime
Negligible	1	First aid treatment only; mild / no exposure; Spill within workplace; < $5,000 damage; No significant downtime

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

Each risk was evaluated twice in terms of risk and likelihood of occurrence. The first time, the risk was evaluated in the light of the control measure currently in the laboratory, and the other time, the risk was evaluated in the light of the proposed control methods. The aim of this risk was to show the change in severity and the likelihood of risk.

After that, the grade of severity was multiplying by the grade of likelihood to get "Risk Priority Number (RPN)." According to the multiplication score, the risks were labelled as high, warning, medium, or low, as shown in the table below. Appropriate control measures are taken to reduce the risk level to an acceptable or residual level.

Table 9. The four levels of Risk Priority Number (RPN).

Score	**Risk level**	**Action**
16 ~ 25	High	Operation not permissible Stop operation and review control
12 ~ 15	Warning	High priority remedial action Implement additional controls immediately
8 ~ 10	Medium	Remedial action at appropriate time Proceed with care. Additional control advised
1 ~ 6	Low	Residual Risk /Risk acceptable No imminent dangers. Frequent review in the change of procedure, material or environment

Adopted from: Tun, T. (2017). Biomedical Laboratory: Its Safety and Risk Management.

After that, the risk matrix (5×5) was created to have all five levels of severity and likelihood. Risk Priority Number (RPN) is calculated across the table. The red

zone expresses the high-risk rating (RR), which is between 16 and 25. The orange zone expresses the warning-risk rating (RR), which is between 12 and 15. The yellow zone expresses the medium-risk rating (RR), which is between 8 and 10. The green zone expresses the low-risk rating (RR), which is between 1 and 6, as shown in table 10.

Table 10. Risk matrix (5×5).

	Severity				
Likelihood	Critical(5)	Very serious(4)	Serious(3)	Marginal(2)	Negligible(1)
Frequent (5)	High		Warning	Medium	
Moderate (4)					
Occasional (3)	Warning		Medium	Low	
Remote (2)	Medium				
Unlikely (1)					

Ethical approval was not deemed necessary because no human or animal or biohazard was used for the study. The study was approved by the HOD, as mentioned earlier.

2.3. Data analysis

After data collection, the data from the data collection sheets (hazard identification sheet and hazard evaluation sheet) was coded and entered into the computer and analysed by Microsoft office for Mac (version 16.35) program and applying descriptive statistics (frequencies and percentage).

3.RESULTS

1. Microbiology laboratory.

1.1. Distribution of hazards types at the microbiology lab

We analysed the hazards types and it's the frequency in the microbiology lab. As displayed in *figure 3*, the physical, ergonomic, and chemical hazards have the highest percentages of the laboratory hazards, with an equal percentage of 25% of each hazard. The percentage of biohazards is 18.75% and electrical hazards are 6.25 and, radiation hazards are 0%.

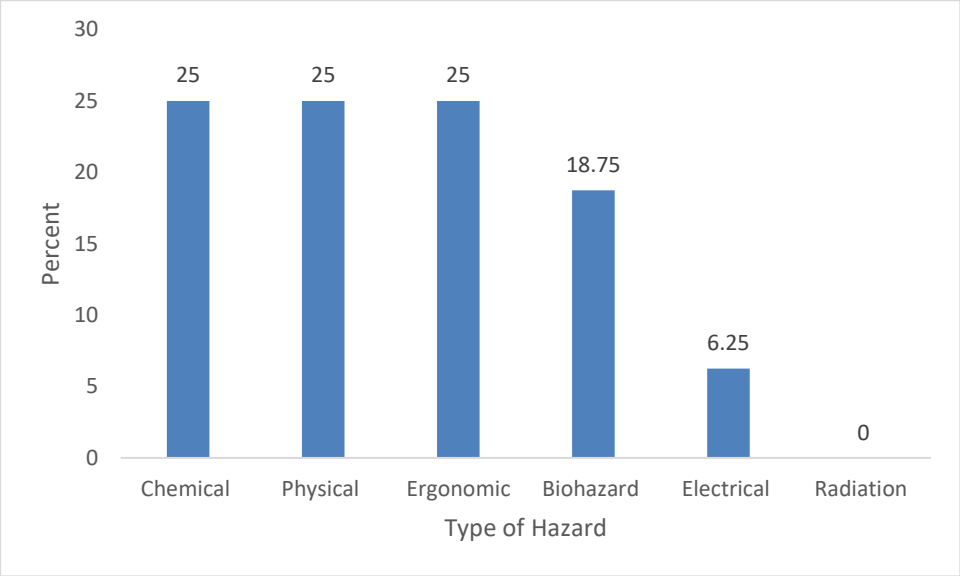
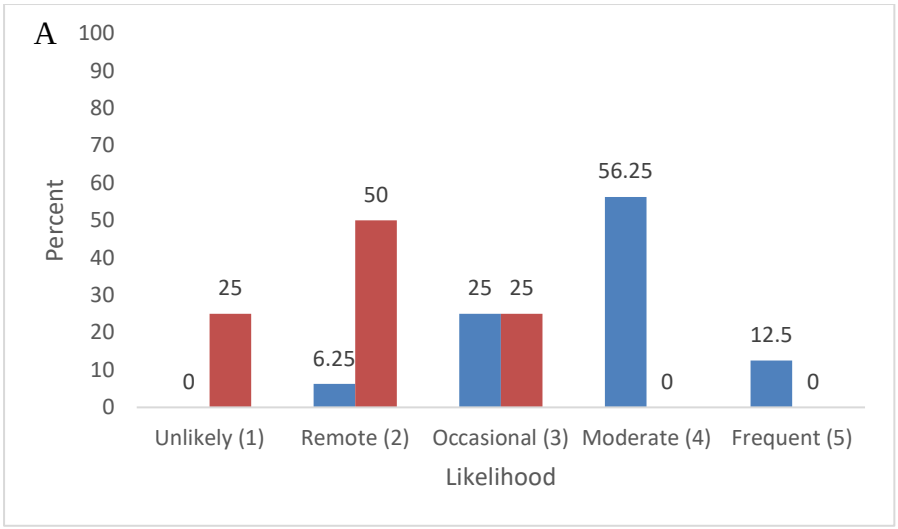


Figure 3. Bars shows the percentage of different types of hazards in the Microbiology laborato

Table 11. Risk assessment for the adopted and the recommended control measures at microbiology lab.

	Adopted control measure		**Recommended control measure**	
Likelihood	Count	Percent (%)	Count	Percent (%)
Unlikely (1)	0	0	4	25
Remote (2)	1	6.25	8	50
Occasional (3)	4	25	4	25
Moderate (4)	9	56.25	0	0
Frequent (5)	2	12.5	0	0
	Adopted control measure		**Recommended control measure**	
Severity	Count	Percent (%)	Count	Percent (%)
Negligible (1)	0	0	1	6.25
Marginal (2)	0	0	12	75
Serious (3)	2	12.5	3	18.75
Very serious (4)	11	68.75	0	0
Critical (5)	3	18.75	0	0
	Adopted control measure		**Recommended control measure**	
Risk Priority Number (RPN)	Count	Percent (%)	Count	Percent (%)
High (16-25)	8	50	0	0
Warning (12-15)	6	37.5	0	0
Medium (8-10)	2	12.5	3	18.75
Low (1-6)	0	0	13	81.25

Data are presented as number and count for each likelihood, severity, Risk Priority Number (RPN) of hazards.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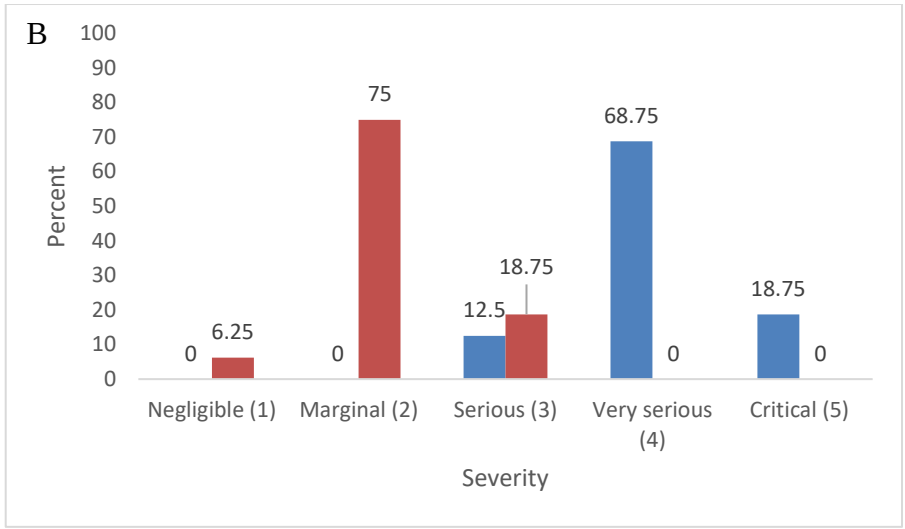
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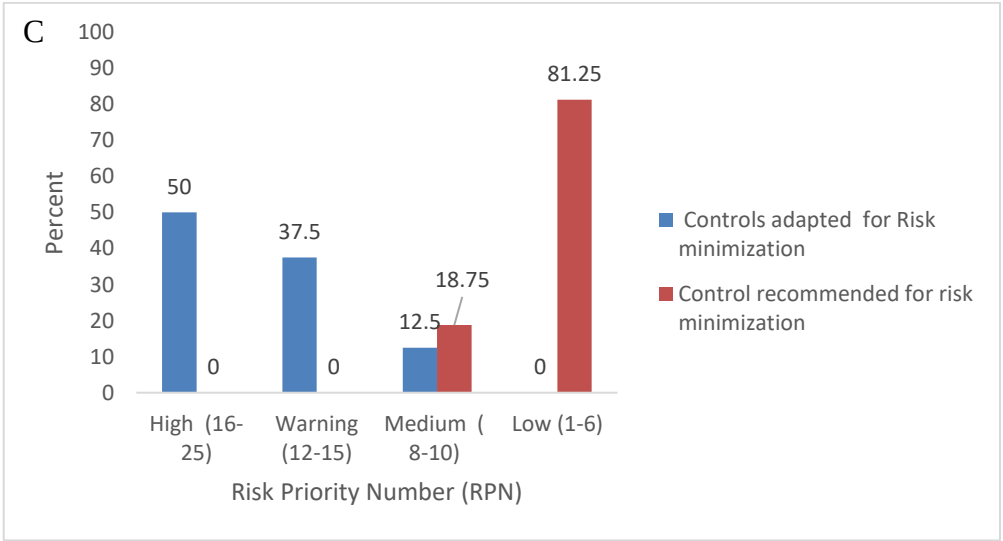
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High (16-25)
Warning (12-15)
Medium (8-10)
Low (1-6)
Risk Priority Number (RPN)
Controls adapted for Risk minimization
Control recommended for risk minimization

Figure 4. Risk assesment for the adopted and the recommended control measures at microbiology lab.

A. The percentage of different grades of likelihood between the adopted control measures and the recommended risk control measures in the microbiology lab.**b.** the percentage of different grade of severity between the adopted control measures and the recommended risk control measures in the microbiology lab. **C.** The percentage of different grades of risk priority number (RPN) between the adopted control measures and the recommended control measures in the microbiology lab.

1.2. The risk assessment and the control measures adopted at the microbiology lab.

1.2. A. The assessment of likelihood assessment in adopted control measure in microbiology laboratory

Table 11 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 11. The likelihood of frequent (5) is two hazards (n=2, 12.5%). The number of hazards s the likelihood of moderate (4) is nine (n=9, 56.25%). The number of hazards ss the likelihood of occasional (3) is four (n=4, 25%). The number of hazards has the likelihood of remote (2) is one (n=1, 6.25%). None of the identified hazards have the likelihood of unlikely (1). The data was presented as a graph in *figure 4.a.*

1.2.B. The assessment of severity in the adopted control measure in microbiology laboratory

We assessed the hazard severity and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1). Table 11. Shows the number of hazards has a severity of critical (5) is three (n=3, 18.75%). The number of hazards has severity of very serious (4) is eleven (n=11, 68.75%). The number of hazards has severity of serious is two (n=2, 12.5%). None of the identified hazards have the severity of marginal (2) and negligible (1). Data are presented in *figure 4.b.*

1.2.C. The assessment of risk priority number (RPN) in the adopted control measures in microbiology laboratory

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 11

show the number of hazards has high- RPN (16-25) is eight (n=8, 50%). The number of hazards has warning- RPN (12-15) is six (n=6, 37.5%). The number of hazards has medium- RPN (8-10) is two (n=2, 12.5%). None of the identified hazards have low-RPN (1-6), as shown in *figure 4.c.*

1.2.D. Risk Matrix (5x5) for the adopted control measure in microbiology laboratory

Further, we assess the risk priority number in the microbiology lab, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard.

Table 12 shows the risk matrix (5x5) for adopted control measures and risk distribution at the microbiology lab.

Table 12 shows the likelihood of the risk: frequent (5), moderate (4), occasional (3), remote (2), unlikely (1). The severity of the risk: critical (5), very serious (4), serious (3), marginal (2), and negligible (1). The red zone expresses the high- RPN, which is between 16 and 25. The orange zone expresses the warning-RPN, which is between 12 and 15. The yellow zone expresses the medium- RPN, which is between 8 and 10. The green zone expresses the low- RPN, which is between 1 and 6. The numbers in the table 12 indicate a number of hazards. One hazard (n=1, 6.25%) has a likelihood of moderate (4) and severity of critical (5). One hazard (n=1, 6.25%) has a likelihood of remote (2) and severity of very serious (4). Two hazards (n=2, 12.5%) has a likelihood of occasional (3), and severity of critical (5). Two hazards (n=2, 12.5%) has a likelihood of occasional (3) and severity of very serious (4). Two hazards (n=2, 12.5%) has a likelihood of moderate (4) and severity of serious (3). Two hazards (n=2, 12.5%) has a likelihood of frequent (5) and severity of very serious (4). Six hazards (n=6, 37.5%) has a likelihood of moderate (4) and severity of very serious (4).

Table 12. The Risk Matrix (5x5) for adopted control measures and risk distribution at the microbiology lab

			Severity		
Likelihood	Critical (5)	Very serious (4)	Serious (3)	Marginal (2)	Negligible (1)
Frequent (5)		2			
Moderate (4)	1	6	2		
Occasional (3)	2	2			
Remote (2)		1			
Unlikely (1)					

Data are presented as numbers

1.2.E. *Risk assessment chart for adopted control measure in microbiology laboratory*

Further, we developed the risk assessment chart to visualize the severity of these risks, as shown in *figure 5***.** The total number of hazards that were identified in the microbiology laboratory is sixteen (n=16) hazards (r1 to r16). In *figure 5*, the x-axis shows the severity of hazards, while the y-axis shows the likelihood of the occurrence of hazards. The blue points indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. The red zone expresses the high- risk priority number, which is between 16 and 25. The orange zone expresses the warning- risk priority number, which is between 12 and 15. The yellow zone expresses the medium- risk priority number, which is between 8 and 10. The green zone expresses the low- risk priority number, which is between 1 and 6. The number of hazards located in the red zone is nine (n=9, 56.25%). The number of hazards located in the orange zone is six (n=6, 37.5%). The number of hazards located in the yellow zone is one (n=1, 6.25%).

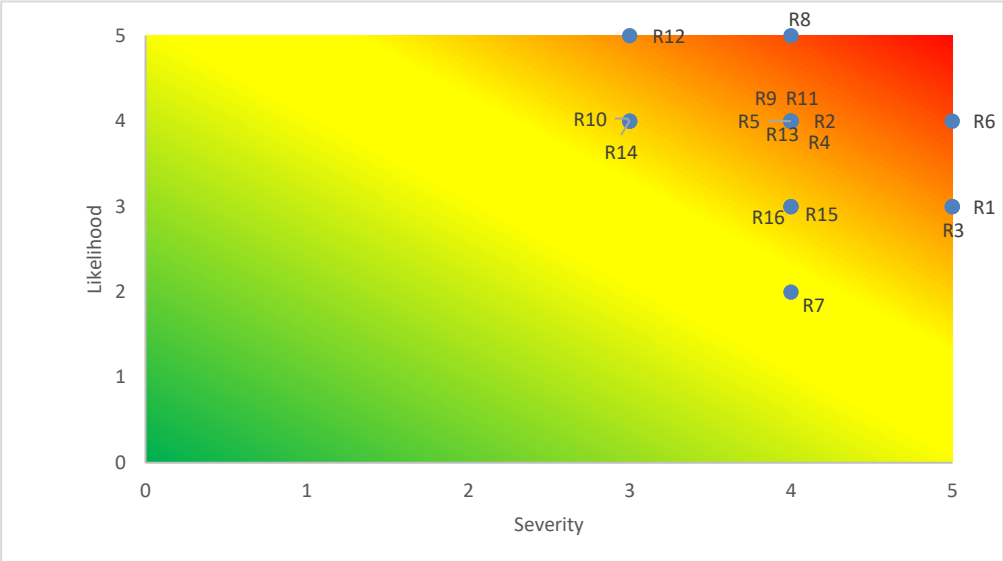

Figure 5. The risk assessment chart for the adopted control measures in the microbiology lab.

The blue points in figure 5 indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard.

1.3. The risk assessment and the control measures recommended at the microbiology lab.

1.3.A. The assessment of the likelihood assessment in recommended control measure at the microbiology lab.

Table 11 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 11. The likelihood of unlikely (1) is four (n=4, 25%). The number of hazards has the likelihood of remote (2) is eight (n=8, 50%). The number of hazards has the likelihood of occasional (3) is four (n=4, 25%). None

of the identified hazards have the likelihood of frequent (5) or moderate (4). The data was presented as a graph in *figure 4.a.*

1.3.B. The assessment of severity in recommended control measure at the microbiology lab.

we assessed the hazard severity, and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1). Table 11 shows that the number of hazards has a severity of marginal (2) is twelve (n=12, 75%). the number of hazards has severity of serious (3) is three (n=3, 18.75%). none of the hazards have a severity of very serious (4) or critical (5). data are presented in *figure 4.b.*

1.3.C. The assessment of Risk Priority Number (RPN) in the recommended control measures at the microbiology lab.

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 11 shows that the number of hazards has low- RPN (1-6) is thirteen (n=13, 81.25%). The number of hazards has medium- RPN (8-10) is three (n=3, 18.75%). None of the identified hazards have warning- RPN or high- RPN (1-6), as shown in *figure 4.c.*

1.3.D. Risk Matrix (5x5) for the recommended control measures at the microbiology lab.

Further, we assess the risk priority number in the microbiology lab, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 13 shows the risk matrix (5x5) for recommended control measures and risk distribution at the microbiology lab.

Table 13 shows the likelihood of the risk: frequent (5), moderate (4), occasional (3), remote (2), unlikely (1). The severity of the risk: critical (5), very serious (4), serious (3), marginal (2), and negligible (1). The red zone expresses the

high- RPN, which is between 16 and 25. The orange zone expresses the warning- RPN, which is between 12 and 15. The yellow zone expresses the medium- RPN, which is between 8 and 10. The green zone expresses the low- RPN, which is between 1 and 6. The numbers in table 13 indicate the number of hazards. One hazard (n=1, 6.25%) has the likelihood of occasional (3) and severity of serious (3). One hazard (n=1, 6.25%) has the likelihood of unlikely (1) and severity of critical (5). One hazard (n=1, 6.25%) has the likelihood of remote (2) and severity of serious (3). One hazard (n=1, 6.25%) has the likelihood of unlikely (1) and severity of serious (3). One hazard (n=1, 6.25%) has the likelihood of remote (2) and severity of negligible (1). Three hazards (n=3, 18.75%) has the likelihood of occasional (3) and severity of marginal (2). Six hazards (n=6, 37.5%) has the likelihood of remote (2) and the severity of marginal (2). Two hazards (n=2, 12.5%) has the likelihood of unlikely (1) and severity of marginal (2).

Table 12. The risk matrix (5x5) for recommended control measures and risk distribution at the microbiology lab.

			Severity		
Likelihood	Critical (5)	Very serious (4)	Serious (3)	Marginal (2)	Negligible (1)
Frequent (5)					
Moderate (4)					
Occasional (3)			1	3	
Remote (2)			1	6	1
Unlikely (1)	1		1	2	

Data are presented as numbers

1.3.E. Risk assessment chart for the recommended control measures at the microbiology lab.

Further we developed the risk assessment chart to visualize the severity of these risks, as shown in *figure 6*. The total number of hazards that were identified in the microbiology laboratory is sixteen (n=16) hazards (r1 to r16). In *figure 6*, the x-axis shows the severity of hazards, while the y-axis shows the likelihood of the occurrence of hazards. The blue points indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. The red zone expresses the high- risk priority number , which is between 16 and 25. The orange zone expresses the warning- risk priority number, which is between 12 and 15. The yellow zone expresses the medium- risk priority number, which is between 8 and 10. The green zone expresses the low- risk priority number, which is between 1 and 6. The number of hazards located in the green zone is fifteen (n=15, 93.75%). The number of hazards located in the yellow zone is one (n=1, 6.25%).

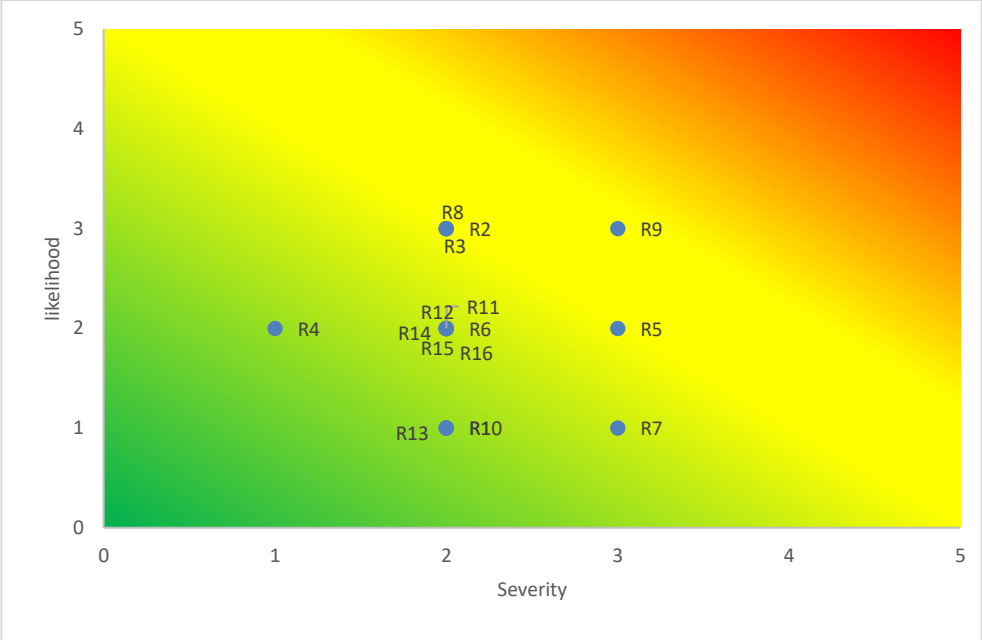

Figure 6. The risk assessment chart for the recommended control measures in the microbiology lab.

The blue points in figure 6 indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard.

1.4. Comparison between adopted and recommended control measures at the microbiology lab.

1.4.A. The assessment of *the likelihood at the microbiology lab.*

Table 11 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 11**.** The likelihood of frequent (5) is 12.5% (n=2) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage of hazards has a likelihood of moderate (4) is 56.25% (n=9) for adopted control measures and 0% (n=0) for the recommended control measures. The

percentage of hazards has a likelihood of occasional (3) is 25% (n=4) for adopted control measures and 25% (n=4) for the recommended control measures. The percentage of hazards have a likelihood of remote (2) is 6.25% (n=1) for adopted control measures and 50% (n=8) for the recommended control measures. The percentage of hazards have a likelihood of unlikely (1) is 0% (n=0) for adopted control measures and 24% (n=4) for the recommended control measures. The data was presented as a graph in *figure 4.a.*

1.4.B. *The assessment of severity at the microbiology lab.*

We assessed the hazard severity, and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1). Table 11 shows the percentage of hazards that have a severity of critical (5) is 18.75% (n=3) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage of hazards have a severity of very serious (4) is 68.75% (n=11) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage of hazards has a severity of serious (3) is 12.5% (n=2) for adopted control measures, and 18.75% (n=3) for the recommended control measures. The percentage of hazards have a severity of marginal (2) is 0% (n=0) for adopted control measures and 75% (n=12) for the recommended control measures. The percentage of hazards have a severity of negligible (1) is 0% (n=0) for adopted control measures and 6.25% (n=1) for the recommended control measures. Data are presented in *figure 4.b.*

1.4.C. The assessment of Risk Priority Number (RPN) at the microbiology lab.

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 11 shows that the percentage of hazards that have high- RPN (16-25) is 50% (n=8) for adopted control measures and 0% (n=0) for the recommended control measures. The

percentage of hazards have warning- RPN (16-25) is 37.5% (n=6) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage of hazards have medium- RPN (16-25) is 12.5% (n=2) for adopted control measures and 18.75% (n=3) for the recommended control measures. The percentage of hazards has low- RPN (16-25) is 0% (n=0) for adopted control measures and 81.25% (n=13) for the recommended control measures, as shown in *figure 4.c.*

1.5. Assessment of Biosafety Level 2 (BSL2) requirements in microbiology lab.

The number of statements in the biosafety level 2 (BSL2) checklist is 61. The microbiology lab follows the biosafety level 2 (BSL2) requirements by 52.5% (n= 32), while the microbiology lab not following the biosafety level 2 (BSL2) requirements by 47.5% (n=29) as shown in *figure 7.*

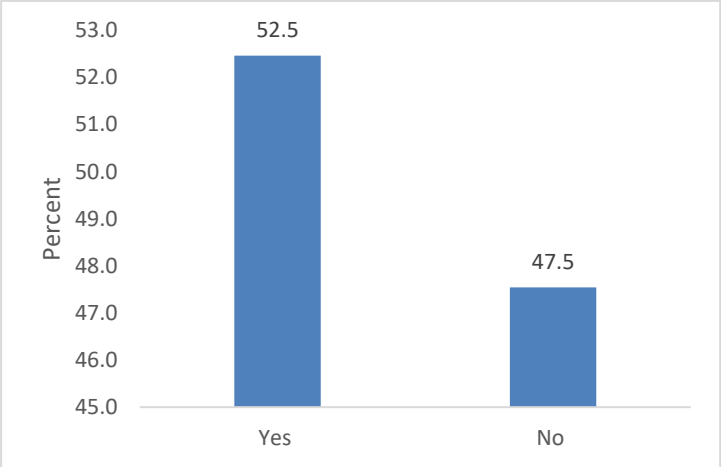

Figure 7. The percentage of following the biosafety level 2 (BSL2) requirements in the microbiology laboratory.

2. Haematology laboratory.

2.1. Distribution of hazards types at the Haematology lab.

We analysed the hazards types, and its frequency in the haematology lab. As displayed in figure 8, chemical and ergonomic hazards have the highest percentages of haematology laboratory hazards, with an equal percentage of 31% of each hazard. The biohazards and physical hazards have equal percentages of 15%. The percentage of electrical hazards is 8% and, radiation hazards are 0%.

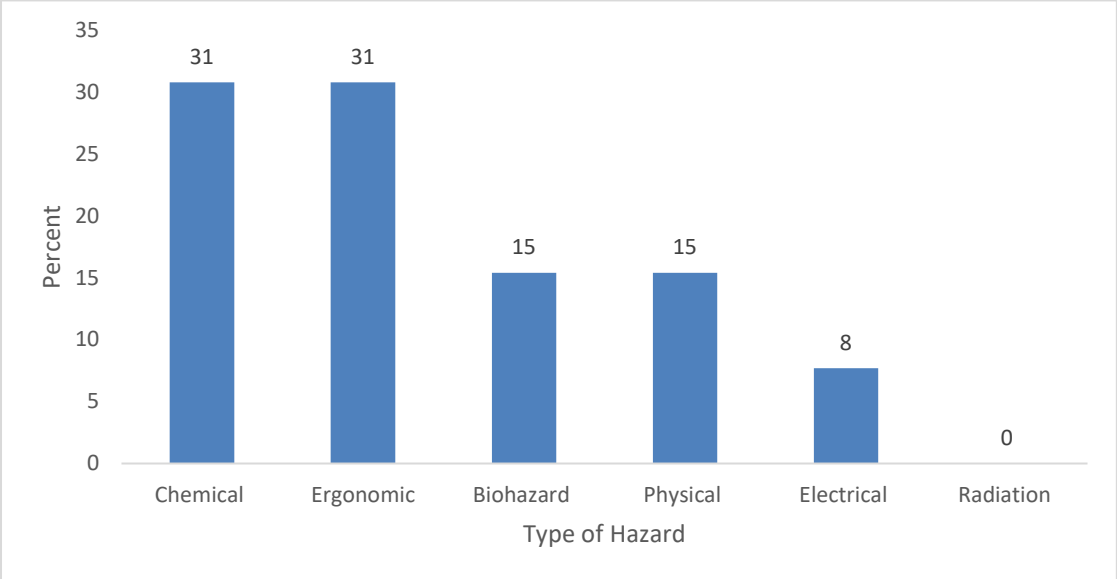

Figure 8. The percentage of different types of hazards in the Haematology laboratory.

Table 13. Risk assessment for adopted and recommended control measures at haematology lab.

	Adopted control measure		**Recommended control measure**	
Likelihood	Count	Percent (%)	Count	Percent (%)
Unlikely (1)	0	0	3	23
Remote (2)	0	0	7	54
Occasional (3)	5	38	3	23
Moderate (4)	6	46	0	0
Frequent (5)	2	15	0	0
	Adopted control measure		**Recommended control measure**	
Severity	Count	Percent (%)	Count	Percent (%)
Negligible (1)	0	0	1	8
Marginal (2)	0	0	10	77
Serious (3)	3	23	2	15
Very serious (4)	8	62	0	0
Critical (5)	2	15	0	0
	Adopted control measure		**Recommended control measure**	
Risk Priority Number (RPN)	Count	Percent (%)	Count	Percent (%)
High (16-25)	6	46	0	0
Warning (12-15)	6	46	0	0
Medium (8-10)	1	8	2	15
Low (1-6)	0	0	11	85

Data are presented as number and count for each likelihood, severity, Risk Priority Number (RPN) of hazards.

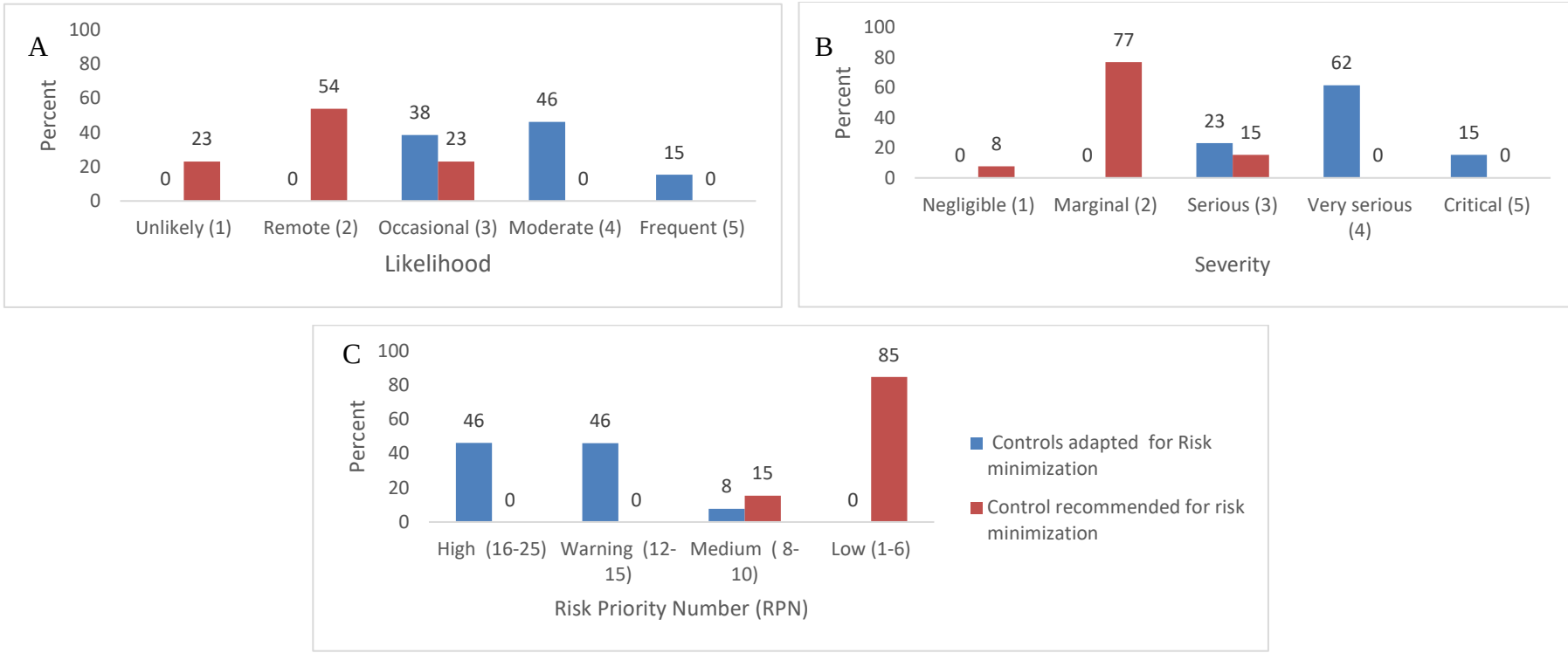

Figure 9. Risk assestment for adopted and recommended control measures at hematology lab.

A. The percentage of different grades of likelihood between the adopted control measures and the recommended risk control measures in the haematology lab. **B.** The percentage of different grade of severity between the adopted control measures and the recommended risk control

measures in the haematology lab. **C.** The percentage of different grades of risk priority number (RPN) between the adopted control measures and the recommended control measures in the haematology lab.

2.2. The risk assessment and the control measures adopted at the Haematology lab.

2.2.A. The assessment of the likelihood assessment for the adopted control measures at the Haematology lab.

Table 14 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 14. The likelihood of frequent (5) is two (n=2, 15%). The number of hazards has the likelihood of moderate (4) is six (n=6, 46%). The number of hazards has the likelihood of occasional (3) is five (n=5, 38%). None of the identified hazards have the likelihood of unlikely (1) or remote (2). The data was presented as a graph in *figure 9.a.*

2.2.B. The assessment of grade severity for the adopted control measures at the Haematology lab.

We assessed the hazard severity, and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1). Table 14 shows the number of hazards has severity of critical (5) is two (n=2, 15%). The number of hazards has severity of very serious (4) is eight (n=8, 62%). The number of hazards has severity of serious is three (n=3, 23%). None of the identified hazards have the severity of marginal (2) and negligible (1). Data are presented in *figure 9.b.*

2.2.C. The assessment of Risk Priority Number (RPN) for the adopted control measures at the Haematology lab.

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 14 shows that the number of hazards has high- RPN (16-25) is six (n=6, 46%). The number of hazards has warning- RPN (12-15) is six (n=6, 46%). The number of

hazards has medium- RPN (8-10) is one (n=2, 8%). None of the identified hazards have low- RPN (1-6), as shown in *figure 9.c.*

2.2.D. Risk Matrix (5x5) for the adopted control measures at the Haematology lab.

Further, we assess the risk priority number in the microbiology lab, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard.

Table 15 shows the risk matrix (5x5) for adopted control measures and risk distribution at the microbiology lab.

Table 15 shows the likelihood of the risk: frequent (5), moderate (4), occasional (3), remote (2), unlikely (1). The severity of the risk: critical (5), very serious (4), serious (3), marginal (2), and negligible (1). The red zone expresses the high- RPN, which is between 16 and 25. The orange zone expresses the warning- RPN, which is between 12 and 15. The yellow zone expresses the medium- RPN, which is between 8 and 10. The green zone expresses the low- RPN, which is between 1 and 6. The numbers in the table indicate a number of hazards. Two hazards (n=2, 15.4%) has a likelihood of occasional (3) and severity of critical (5). Two hazards (n=2, 15.4%) has a likelihood of frequent (5) and severity of very serious (4). Two hazards (n=2, 15.4%) has a likelihood of moderate (4) and severity of serious (3). Three hazards (n=3, 23.1%) has a likelihood of occasional (3) and severity of very serious (4). Three hazards (n=3, 23.1%) has a likelihood of moderate (4) and severity of very serious (4). One hazard (n=1, 7.6%) has a likelihood of occasional (3) and severity of serious (3).

Table 14. The Risk Matrix (5x5) for adopted control measures and risk distribution at the Haematology lab.

			Severity		
Likelihood	Critical (5)	Very serious (4)	Serious (3)	Marginal (2)	Negligible (1)
Frequent (5)		2			
Moderate (4)		3	2		
Occasional (3)	2	3	1		
Remote (2)					
Unlikely (1)					

Data are presented as numbers

2.2.E. Risk assessment chart for the adopted control measures at the Haematology lab.

Further, we developed the risk assessment chart to visualize the severity of these risks, as shown in *figure 10.* The total number of hazards that were identified in the haematology laboratory are thirteen (n=13) hazards (r1 to r16). In *figure 10***,** the x-axis shows the severity of hazards, while the y-axis shows the likelihood of the occurrence of hazards. The blue points indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. The red zone expresses the high- RPN, which is between 16 and 25. The orange zone expresses the warning- RPN, which is between 12 and 15. The yellow zone expresses the medium- RPN, which is between 8 and 10. The green zone expresses the low- RPN, which is between 1 and 6. The number of hazards located in the red zone is five (n=5, 38.5%). The number of hazards located in the orange zone is seven (n= 7, 53.8%). The number of hazards located in the yellow zone is one (n=1, 7.7%). The number of hazards located in the green zone is zero (n=0, 0%).

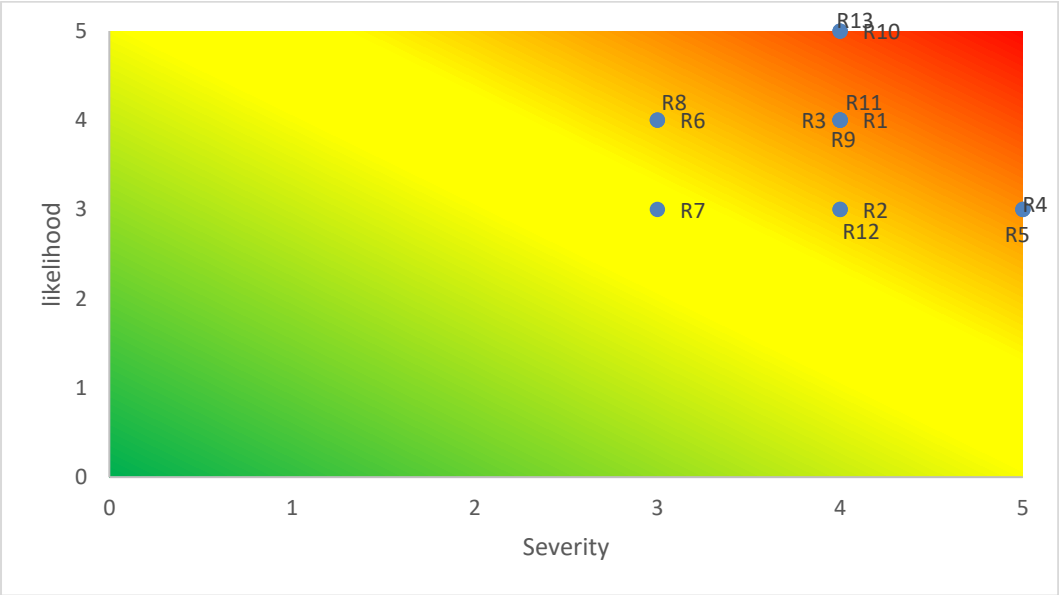

Figure 10. The risk assessment chart for the adopted control measures in the Haematology
lab.

The blue points in *figure 10* indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard.

2.3. The risk assessment and the control measures recommended at the Haematology lab.

2.3.A. The assessment of the likelihood for the recommended control measures at the Haematology lab.

Table 14 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 14. The likelihood of unlikely (1) is three (n=3, 23%). The number of hazards has the likelihood of remote (2) is seven (n=7, 54%). The number of hazards has the likelihood of occasional (3) is three (n=3, 23%). None

of the identified hazards have the likelihood of frequent (5) or moderate (4). The data was presented as a graph in *figure 9.a.*

2.3.B. The assessment of grade severity for the recommended control measures at the Haematology lab.

We assessed the hazard severity and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1).

Table 14 shows the number of hazards has severity of negligible (1) is one (n=1, 8%). The number of hazards has severity of marginal (2) is ten (n=10, 77%). The number of hazards has a severity of serious (3) is two (n=2, 15%). None of the hazards have a severity of very serious (4) or critical (5). Data are presented in *figure 9.b.*

2.3.C. The assessment of *Risk Priority Number (RPN) for the recommended control measures at the Haematology lab.*

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 14 shows that the number of hazards has low- RPN (1-6) is eleven (n=11, 85%). the number of hazards has medium- RPN (8-10) is two (n=2, 15%). none of the identified hazards have warning- RPN or high- RPN (1-6), as shown in *figure 9.c.*

2.3.D. Risk Matrix (5x5) for the recommended control measures at the Haematology lab.

Further, we assess the risk priority number in the haematology lab, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 16 shows the risk matrix (5x5) for recommended control measures and risk distribution at the haematology lab.

Table 16 shows the likelihood of the risk: frequent (5), moderate (4), occasional (3), remote (2), unlikely (1). The severity of the risk: critical (5), very serious (4), serious (3), marginal (2), and negligible (1). The red zone expresses the high- RPN which

is between 16 and 25. The orange zone expresses the warning- RPN, which is between 12 and 15. The yellow zone expresses the medium- RPN, which is between 8 and 10. The green zone expresses the low- RPN, which is between 1 and 6. The numbers in the table indicate a number of hazards. Two hazards (n=2, 15.4%) has a likelihood of occasional (3) and severity of marginal (2). One hazard (n=1, 7.6%) has a likelihood of occasional (3) and severity of serious (3). One hazard (n=1, 7.6%) has a likelihood of remote (2) and severity of serious (3). One hazard (n=1, 7.6%) has a likelihood of remote (2) and severity of negligible (1). Three hazards (n=3, 23.1%) has a likelihood of unlikely (1) and severity of marginal (2). Five hazards (n=5, 38.7%) have a likelihood of remote (2) and severity of marginal (2).

Table 15. The Risk Matrix (5x5) for recommended control measures and risk distribution at the Haematology lab.

			Severity		
Likelihood	Critical (5)	Very serious (4)	Serious (3)	Marginal (2)	Negligible (1)
Frequent (5)					
Moderate (4)					
Occasional (3)			1	2	
Remote (2)			1	5	1
Unlikely (1)				3	

Data are presented as numbers

2.2.E. Risk assessment chart for the recommended control measures at the Haematology lab.

Further, we developed the risk assessment chart to visualize the severity of these risks, as shown in *figure 11*. The total number of hazards that were identified in the haematology laboratory are thirteen (n=13) hazards (r1 to r16). In *figure 11*., the x-

axis shows the severity of hazards, while the y-axis shows the likelihood of the occurrence of hazards. The blue points indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. The red zone expresses the high- RPN, which is between 16 and 25. The orange zone expresses the warning- RPN, which is between 12 and 15. The yellow zone expresses the medium- RPN, which is between 8 and 10. The green zone expresses the low- RPN, which is between 1 and 6. The number of hazards located in the red zone is zero (n=0, 0%). The number of hazards located in the orange zone is 0 (n= 0, 0%). The number of hazards located in the yellow zone is one (n=1, 7.6%). The number of hazards located in the green zone is twelve (n=12, 92.4%).

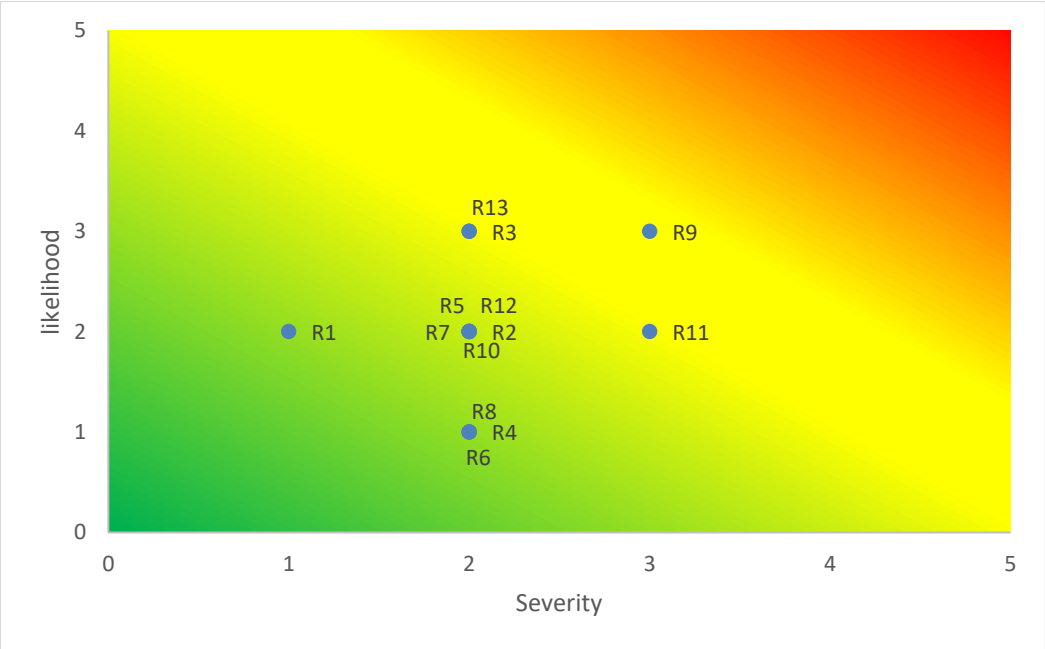

Figure 11. The risk assessment chart for the recommended control measures in the Haematology lab.

The blue points in figure 11 indicate the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard.

2.4. Comparison between adopted and recommended control measures at the Haematology lab.

2.4.A. The assessment of *the likelihood assessment at the Haematology lab.*

Table 14 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 14. The likelihood of frequent (5) is 15% (n=2) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage likelihood of moderate (4) is 46% (n=6) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage likelihood of occasional (3) is 38% (n=5) for adopted control measures and 23% (n=3) for the recommended control measures. The percentage likelihood of remote (2) is 0% (n=0) for adopted control measures and 54% (n=7) for the recommended control measures. The percentage likelihood of unlikely (1) is 0% (n=0) for adopted control measures and 23% (n=3) for the recommended control measures. The data was presented as a graph in *figure 9.a.*

2.4.B. The assessment of grade severity at the Haematology lab.

We assessed the hazard severity and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2) and negligible (1).

Table 14 shows the percentage severity of critical (5) is 15% (n=2) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage severity of very serious (4) is 62% (n=8) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage severity of serious (3) is 23%

(n=3) for adopted control measures and 15% (n=2) for the recommended control measures. The percentage severity of marginal (2) is 0% (n=0) for adopted control measures and 77% (n=10) for the recommended control measures. The percentage severity of negligible (1) is 0% (n=0) for adopted control measures and 8% (n=1) for the recommended control measures. Data are presented in *figure 9.b.*

2.4.C. The assessment of Risk Priority Number (RPN) at the Haematology lab.

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 14 show the percentage of high- RPN (16-25) is 46% (n=6) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage of warning- RPN (16-25) is 46% (n=6) for adopted control measures and 0% (n=0) for the recommended control measures. The percentage of medium- RPN (16-25) is 8% (n=1) for adopted control measures and 15% (n=2) for the recommended control measures. The percentage of low- RPN (16-25) is 0% (n=0) for adopted control measures and 85% (n=11) for the recommended control measures as shown in *figure 9.c.*

2.5. Assessment of Biosafety Level 2 (BSL2) requirements in Haematology.

The number of statements in the biosafety level 2 (bsl2) checklist is 61. The haematology lab follows the biosafety level 2 (bsl2) requirements by 68.9% (n= 42), while the haematology lab not following the biosafety level 2 (bsl2) requirements by 31.1% (n= 19) as shown in *figure 12.*

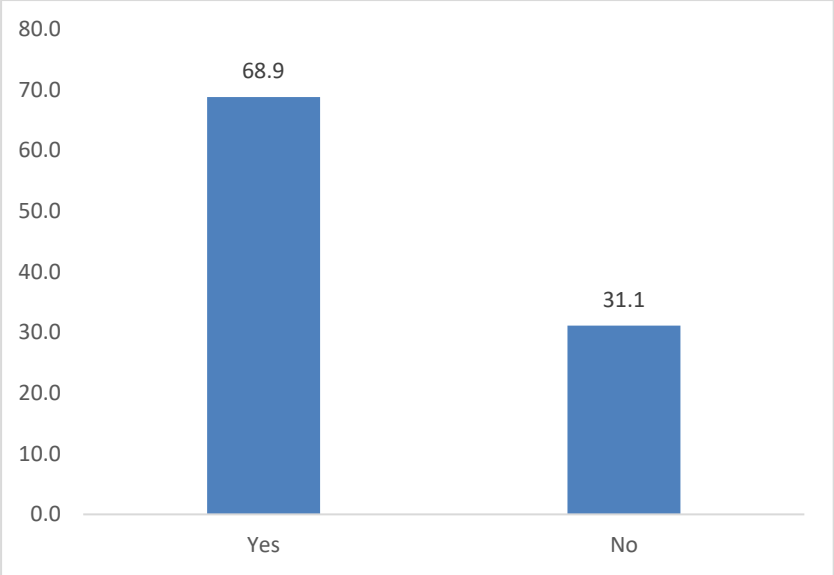

Figure 12. The percentage of following the Biosafety Level 2 (BSL2) requirements in the Haematology laboratory.

Table 16. The risk assessment for adopted and recommended control measues at microbiology and haematology labs

Type of Hazard	**Haematology lab**		**Microbiology lab**	
	Count	Percent (%)	Count	Percent (%)
Chemical	4	31	4	25
Ergonomic	4	31	4	25
Biohazard	2	15	3	18.75
Physical	2	15	4	25
Electrical	1	8	1	6.25
Radiation	0	0	0	0
Total	13	100	16	100

	Haematology lab				**Microbiology lab**			
	Adopted control measure		Recommended control measure		Adopted control measure		Recommended control measure	
Likelihood	Count	Percent (%)	Count	Percent (%)	Count	Percent (%)	Count	Percent (%)
Unlikely (1)	0	0	4	25	0	0	3	23
Remote (2)	1	6.25	8	50	0	0	7	54
Occasional (3)	4	25	4	25	5	38	3	23
Moderate (4)	9	56.25	0	0	6	46	0	0
Frequent (5)	2	12.5	0	0	2	15	0	0

	Haematology lab		**Microbiology lab**	
	Adopted control measure	Recommended control measure	Adopted control measure	Recommended control measure

Severity	Count	Percent (%)	Count	Percent (%)	Count	Percent (%)	Count	Percent (%)
Negligible (1)	0	0	1	6.25	0	0	1	8
Marginal (2)	0	0	12	75	0	0	10	77
Serious (3)	2	12.5	3	18.75	3	23	2	15
Very serious (4)	11	68.75	0	0	8	62	0	0
Critical (5)	3	18.75	0	0	2	15	0	0

	Haematology lab				**Microbiology lab**			
	Adopted control measure		Recommended control measure		Adopted control measure		Recommended control measure	
Risk Priority Number (RPN)	Count	Percent (%)	Count	Percent (%)	Count	Percent (%)	Count	Percent (%)
High (16-25)	8	50	0	0	6	46	0	0
Warning (12-15)	6	37.5	0	0	6	46	0	0
Medium (8-10)	2	12.5	3	18.75	1	8	2	15
Low (1-6)	0	0	13	81.25	0	0	11	85

Data are presented as percent and count

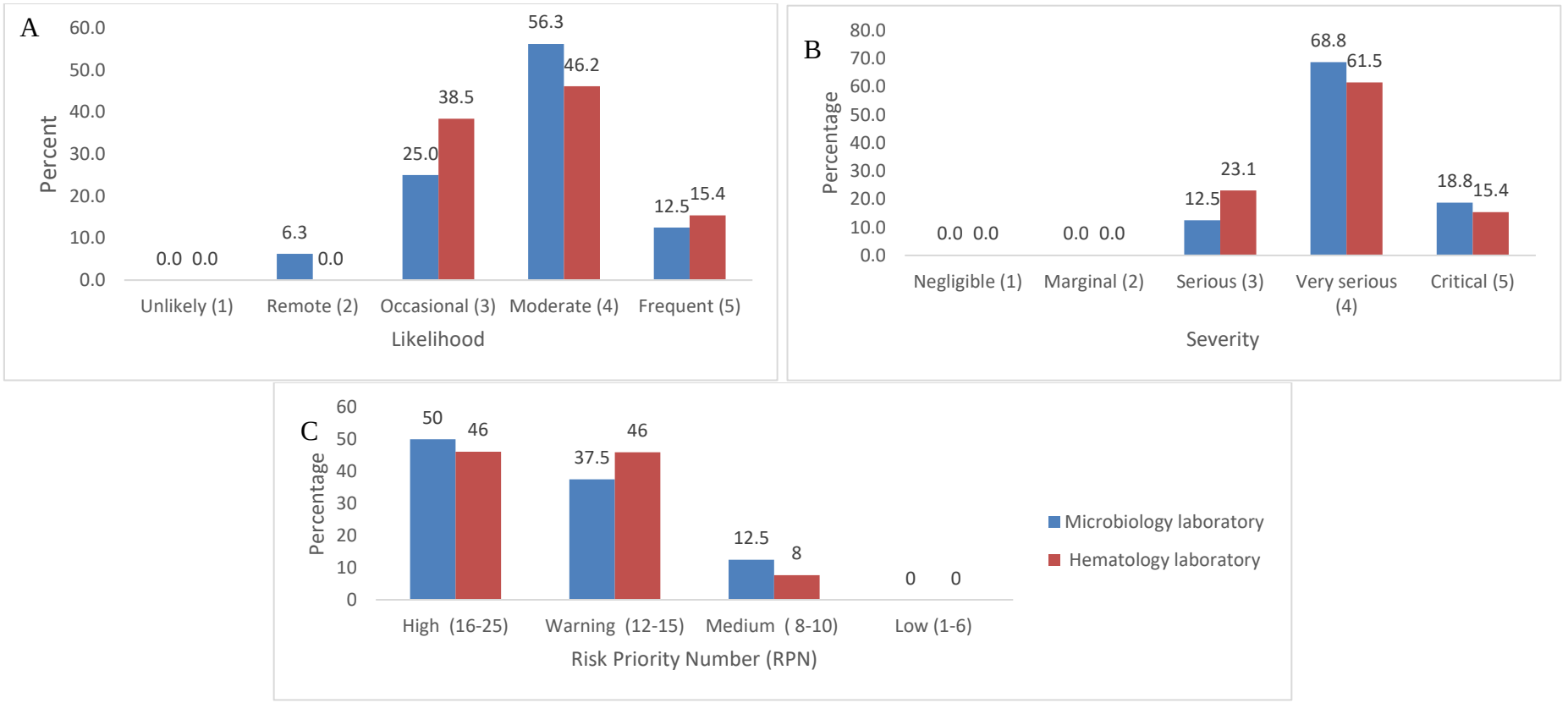

Figure 13. The risk assessment for adopted control measues at microbiology and haematology labs.

A. the percentage of different grades of the likelihood.**B.** the percentage of different grades of severity. **C.** the percentage of different grade of Risk Priority Number (RPN).

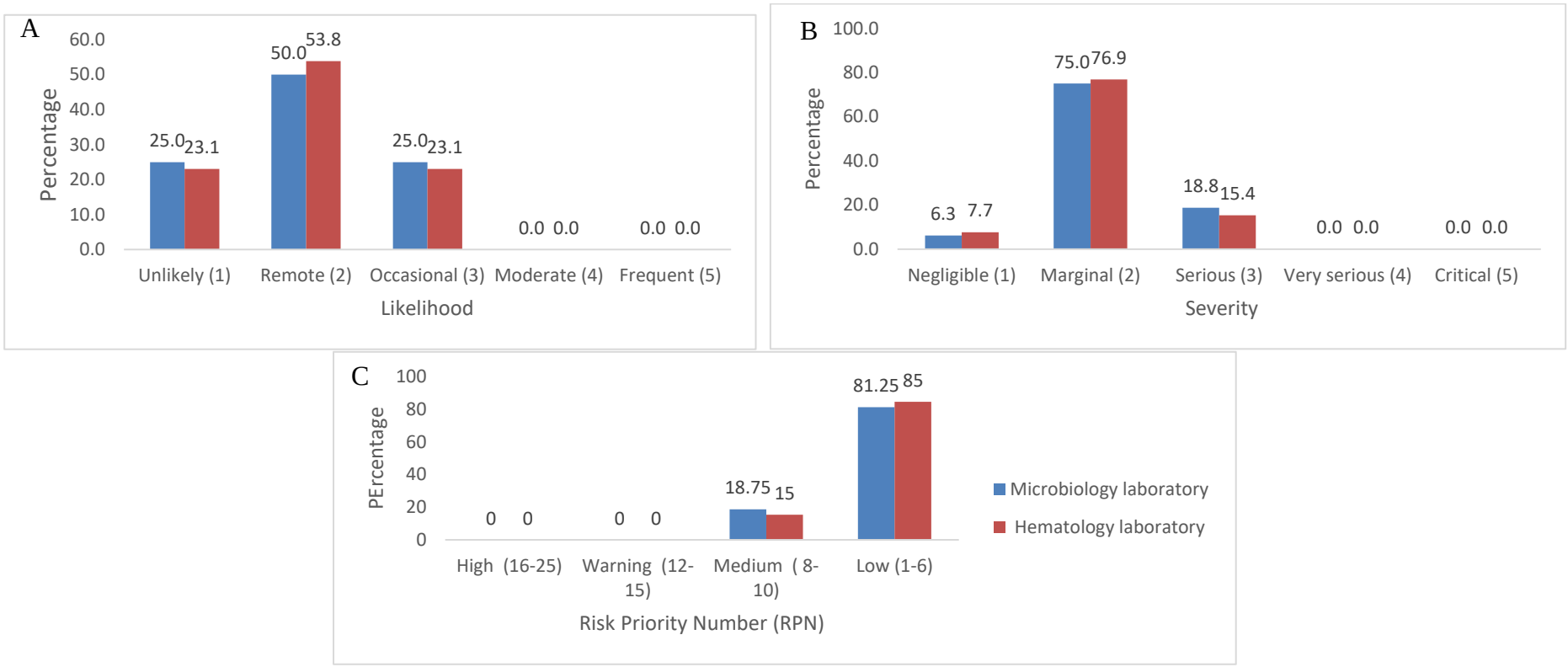

Figure 14. The risk assessment for recommended control measues at microbiology and haematology labs.

A. The percentage of different grades of the likelihood **b.** The percentage of different grades of severity **c.** The percentage of different grade of risk priority number (RPN).

3. Comparison between the microbiology laboratory and the haematology laboratory.

3.1. Distribution of hazards types at the microbiology lab and the haematology lab

We analysed the hazards types and its frequency in microbiology and haematology labs. Table 17 demonstrates that the percentage of biohazard is 18.75% (n= 3) in the microbiology lab and 15% (n=2) in the haematology lab. The percentage of chemical hazards is 25% (n=4) in the microbiology lab and 31%(n=4) in the haematology lab. The percentage of radiation hazard is 0% (n=0) in both the microbiology and the haematology labs. The percentage of physical hazards is 25% (n=4) in the microbiology lab and 15%(n=2) in the haematology lab. The percentage of electrical hazards is 6.25%(n=1) in the microbiology lab and 8% (n=1) in the haematology lab. The percentage of ergonomic hazard is 25% (n=4) in the microbiology lab and 31% (n=4) in the haematology lab. The total number of hazards identified in the microbiology lab is sixteen (n=16), while the total number of hazards identified in the haematology lab is thirteen (n=13). The data was presented as a graph in figure 15

.

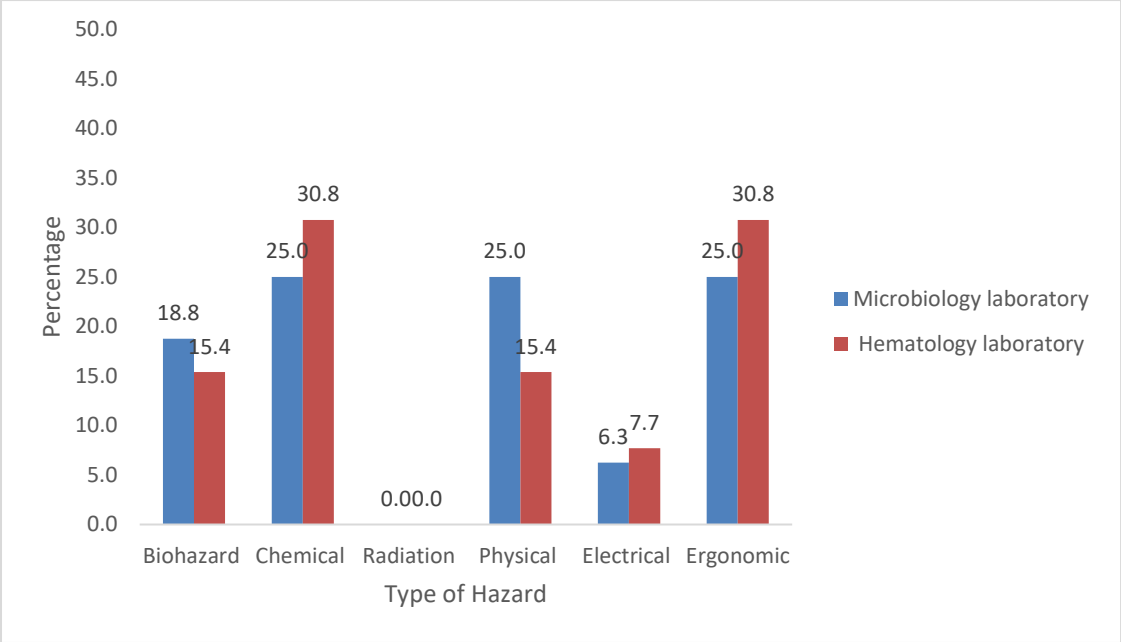

Figure 15. Bars show the percentage of different type of hazard in both microbiology laboratory and haematology lab.

3.2. The risk assessment and the control measures adopted at microbiology lab and the haematology lab

3.2.A. The assessment of likelihood for the adopted control measure

Table 17 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5), as shown in table 17. The likelihood of frequent (5) is two (n=2, 12.5%) in the microbiology lab and two (n=2, 15%) in the haematology lab. The number of hazards the have the likelihood of moderate (4) is nine (n=9, 56.25%) in the microbiology lab and six (n=6, 46%) in the haematology lab. The number of hazards the have the likelihood of occasional (3) is four (n=4, 25%) in the microbiology lab and five (n=5, 38%) in the haematology lab. The number of hazards the have the likelihood of remote (2) is one (n=1, 6.25%) in the microbiology lab and

zero (n=0, 0%) in the haematology lab. None of the hazards have the likelihood of unlikely (1) in microbiology lab and haematology lab. The data was presented as a graph in *figure 13.a.*

3.2.B. The assessment of severity for the adopted control measure

We assessed the hazard severity and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1). Table 17 shows the number of hazards has the severity of critical (5) is three (n=3, 18.75%) in the microbiology lab and two (n=2, 15%) in the haematology lab. The number of hazards has the severity of very serious (4) is eleven (n=11, 68.75%) in the microbiology lab and eight (n=8, 62%) in the haematology lab. The number of hazards has the severity of serious (3) is two (n=2, 12.5%) in the microbiology lab and three (n=3, 23%) in the haematology lab. The number of hazards has the severity of marginal (2) is zero (n=0, 0%) in both haematology and microbiology laboratories. The number of hazards has the severity of negligible (1) is zero (n=0, 0%) in both haematology and microbiology laboratories. Data are presented in *figure 13.b.*

3.2.C. The assessment of risk priority number (RPN) for the adopted control measures

We calculated the risk priority number (RPN) for each risk, which is calculated by multiplying the severity by the likelihood of occurrence of each hazard. Table 17 shows the number of hazards has the high- RPN (16-25) is eight (n=8, 50%) in the microbiology lab and six (n=6, 46%) in the haematology lab. The number of hazards has the warning- RPN (12-15) is six (n=6, 37.5%) in the microbiology lab and six (n=6, 46%) in the haematology lab. The number of hazards has the medium- RPN (8-10) is two (n=2, 12.5%) in the microbiology lab and one (n=1, 8%) in the haematology lab. The number of hazards has the low- RPN (1-6) is zero (n=0,0%) in both the microbiology and the haematology labs, as shown in *figure 13.c.*

3.3. The risk assessment and the control measures recommended at Microbiology lab and the haematology lab

3.3.A. The assessment of likelihood for recommended control measure

Table 17 demonstrates the number and the percentage of hazards, which have the likelihood. The likelihood has five scales based on its frequency from unlikely (1) up to frequent (5) as shown in table 17. None of the hazards have the likelihood of frequent (5) or moderate (4) in both microbiology lab and haematology lab. The number of hazards the have the likelihood of occasional (3) is four (n=4, 25%) in the microbiology lab and three (n=3, 23%) in the haematology lab. The number of hazards the have the likelihood of remote (2) is eight (n=8, 50%) in the microbiology lab and seven (n=7, 54%) in the haematology lab. The number of hazards the have the likelihood of unlikely (1) is four (n=4, 25%) in the microbiology lab and three (n=3, 23%) in the haematology lab. The data was presented as a graph in *figure 14.a.*

3.3.B *The assessment of severity for recommended control measure*

We assessed the hazard severity and its grades based on five scales, which are critical (5) very serious (4), serious (3), marginal (2), and negligible (1). Table 17 shows the number of hazards has the severity of critical (5) is zero (n=0, 0%) in both haematology and microbiology laboratories. The number of hazards has the severity of very serious (4) is zero (n=0, 0%) in both haematology and microbiology laboratories. The number of hazards has the severity of serious (3) is three (n=3, 18.75%) in the microbiology lab, and two (n=2, 15%) in the haematology lab. The number of hazards has the severity of marginal (2) is twelve (n=12, 75%) in the microbiology lab and ten (n=10, 77%) in the haematology lab. The number of hazards has the severity of negligible (1) is one (n=1, 6.25%) in the microbiology lab and one (n=1, 8%) in the haematology lab. Data are presented in *figure 14.b.*

3.3.C. *The assessment of risk priority number (RPN) for the recommended control measures*

Table 17 shows that the number of hazards has the high- RPN (16-25) is zero (n=0,0%) in both the microbiology and the haematology labs. The number of hazards has the warning- RPN (12-15) is zero (n=0,0%) in both the microbiology and the haematology labs. The number of hazards has the medium- RPN (8-10) is three (n=3, 18.75%) in the microbiology lab and two (n=2, 15%) in the haematology lab. The number of hazards has the is low- RPN is thirteen (n=13, 81.25%) in the microbiology lab and eleven (n=11, 85%) in the haematology lab, as shown in *figure 14.c.*

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4. DISCUSSION

The biomedical laboratory is fully occupied with risks. The biomedical laboratory is a workplace where physical, ergonomic, chemical, biohazards, electrical hazards, and, radiation hazards are handled (Park, 200). Safety in the laboratory is the first concern for any institute, and it is the responsibility of everyone. The safety could not be accomplished by one assembly or one individual or one section. The importance of risk assessment in biomedical lab rise since some students lack full knowledge of the hazards around them, how to deal with risks, lack of commitment, and adherence to the rules of security and safety, and many of them generate a curiosity motivation in dealing with all materials and equipment in the laboratory. Besides, scientific experiments usually demand chemicals, fumes, heating sources, and other possibly hazardous variables. According to a study done by Ridgway and his colleagues (2003), the use of organic solvents is prevalent in laboratories for experimental and routine work, while the degree of hazard may vary, all solvents should be considered potentially hazardous. In addition, biomedical fields utilize human and biological specimens from healthy subjects as well as disease patients, which requires more attention, especially after the outbreak of COVID-19 as a pandemic crisis worldwide. Also, the training of biomedical students is critical since the student will be potential laboratory personnel in the hospital, medical care centers, and biomedical research field and should be aware of such risks and biosafety measures. Such safety is essential for all kinds of risks, especially biological hazards, and the transmission of diseases is vital in the biomedical field. According to a study done by West and his colleagues (2007), the preponderance of education laboratories do not folllow safety standards in the Kansas City region. All students, teaching assistants (TAs), lab technicians, faculties, and other related workers, need to be aware

of safety procedures and practices. To have the proper safety procedures, all potential risks required to be identified, assessed and controlled, which is referred to as the risk management process (RM). According to Zaveri et al. (2012), the elimination of work-related hazards in laboratories necessitates a full awareness of the hazards and practical control measures to be implemented.

Risk identification is the most crucial step as the risk need to be identified first to be controlled. Risk evaluation is the process of estimating the likelihood of occurrence and severity of risk identified and calculating Risk Priority Number (RPN). The severity has five different levels, which are Critical (5), Very serious (4), Serious (3), Marginal (2), and Negligible (1). Similarly, the likelihood of occurrence has five different levels, which are Frequent (5), Moderate (4), Occasional(3), Remote (2), and Unlikely (1). The Risk Priority Number (RPN) has four levels, which are High-RPN (16-25), Warning-RPN(12-15), Medium-RPN (8-10), and Low-RPN (1-6). Once the risk is evaluated, the most appropriate control measure is selected based on the Hierarchy of control measures and the Risk Priority Number (RPN). The hierarchy of control measures includes elimination/ substitution, physical control, administrative control, and personal protective equipment (PPE).

This cross-sectional study was conducted to evaluate the safety of the Microbiology and the Hematology labs, identifying potential hazards and determining the actions or controls required to eliminate or reduce any risks to the Biomedical Sciences (BMS) students, teaching assistants (TAs), Lab Technicians, Faculties and other related workers, following a Risk management(RM) process.

Two Biomedical Sciences (BMS) education laboratories were selected, which are Microbiology and hematology labs. The results of the current study demonstrated three significant findings as to the primary outcome. First, chemical and ergonomic

hazards have the highest percentages for both hematology and Microbiology laboratory hazards, with an equal percentage of 31% and 25% of each hazard. The total number of hazards that were identified are thirteen (n=13) hazards in the hematology laboratory and sixteen (n=16) hazards in the Microbiology laboratory.

Second, there is a gap between adopted and recommended control measures per each lab in terms of likelihood, severity, and the risk priority number (RPN), as shown in the hazard evaluation sheet (see appendix). We conclude that the recommended control measures are appropriate as they reduced the risk level to an acceptable or residual level. For example, the likelihood of frequent (5) decreased from 12.5% (n=2) for adopted control measures and 0% (n=0) for the recommended control measures in the microbiology lab. Also, the percentage of hazards has the severity of critical (5) decreases from 18.75% (n=3) for adopted control measures to 0% (n=0) for the recommended control measures in the microbiology lab. The percentage of hazards has high- RPN (16-25) decreased from 50% (n=8) for adopted control measures to 0% (n=0) for the recommended control measures in the microbiology lab.

Third, the likelihood, severity, and the risk priority number (RPN) at microbiology lab are higher than the hematology lab for adopted control measures. For example, the number of hazards has a likelihood of moderate (4) for the adopted control measures is nine (n=9) in microbiology comparing to five (n=5) in the hematology lab. The number of hazards has the severity of very serious (4) for the adopted control measures is eleven (n=11) in microbiology comparing to eight (n=8) in the hematology lab. The number of the hazard located in the red zone (high-RPN) for the adopted control measures is nine (n=9, 56.25%) in microbiology lab comparing to five (n=5, 38.5%) in hematology lab as shown in table 17.

For the distribution of hazard types, the findings of the current study demonstrated chemical and ergonomic hazards have the highest percentages for both laboratories, with an equal percentage of 25% of each hazard in microbiology lab and with an equal percentage of 31% of each hazard in hematology lab. We can conclude that about a quarter of the hazards present in both laboratories are due to chemical and ergonomic hazards. The results show that chemical has the highest percentages of 31% of each hazard, ergonomic hazards 31%, biohazards 15%, physical hazards 15%, electrical hazards 8% and, and radiation hazards 0% in hematology lab. Also, the results show that the physical, ergonomic, and chemical hazards have the highest percentages of the laboratory hazards, with an equal percentage of 25% of each hazard . A study conducted by Haile (2012) mentioned that laboratory workers are at risk for ergonomic injury during performing repetitive laboratory procedures such as pipetting, using cell counters and working at microscopes. They mentioned that ergonomic injury is strongly associated with work-related musculoskeletal disorders (WMSDs) . Also, they found that ergonomic hazard can be reduced by developing comfortable working environment and applying ergonomic principles. Also, A previously published study by Terry et al. (2001) demonstrated that musculoskeletal disorders has increased significantly in the laboratory due to the repetitive nature of work. A recent study conducted by Mitchell (2014) showed that the static contraction posture over elongate duration can result in injury of neck and shoulder. Additionally they showed that not enough laboratory lighting could rise stress on eyes as working. The percentage of biohazards is 18.75%, and electrical hazards are 6.25% and, radiation hazards are 0% in the microbiology lab. A previously published study by Thafer (2013) reported that biological and chemical hazards have the highest percentages of hazards, with 75% to biological hazards, and 70% to chemical hazards.

The results of this study differ with Nattat (2010) that 49% physical hazards, 31.8% biological hazards,30.9% ergonomic hazards, 29.1% psychological hazards, and 26.4% chemical hazards.

Moreover, the comparison between adopted and recommended control measures shows a decrease in the severity, the likelihood of occurrence, and risk priority number (RPN). In this study, a significant difference between adopted and recommended control measures has been revealed in both labs. For example, hazard number six (r6) in microbiology lab, which is exposure to bsl-2 biological agents during reading culture plates, removing caps or swabs, sub culturing, streaking plates. The likelihood has decreased from moderate (4) to remote (2). The severity has decreased from critical (5) to marginal (2). The risk priority number (RPN) has decreased from high- RPN (20) to low- RPN (4). For example, hazard number five (R5) in the hematology lab, which is using real blood samples obtained from Hamad Hospital. The likelihood has decreased from occasional (3)to remote (2). The severity has decreased from serious (3) to marginal (2). The risk priority number (RPN) has reduced from medium- RPN (9) to low- RPN (4). In support of this current finding, a recent study conducted by Thafer (2013) showed that the control of hazards reduces the occurrence of occupational diseases and accidents. Also, a recent study by Ajaz et al. (2008) demonstrated similar findings to the current data that mounting safety-engineered strategies lead to a major decrease in injuries in laboratories. According to stein et al.(2003), the compulsory preventive measures such as immunization against hepatitis B, implementing standard precautions, continuous education, as well as the development of written guidelines on the prevention of blood-borne infections must be implemented. These results match with the results of Zafar et al. (2009) significant decrease in needle stick injuries due to continuous emphasis on increasing awareness

through consistent educational conferences. Ozsahin et al. (2006) training of laboratory workers would benefit greatly from educational initiatives designed to promote laboratory safety. Khalil (2008), there is statistically significant connection between the availability of means of protection, prevention, and the extent to which workers use, the commitment of employees to use, and performance among employees.

5. SUMMARY AND CONCLUSION

Biomedical laboratories are considered one of the essential educational means in the college of health sciences (CHS). That is because these laboratories have several benefits for the student, such as permit students to see how science conceptions are implemented and cooperate more straightforwardly with th world. In this study, two education laboratories from biomedical science program were selected, which are hematology (BIOM 451) and microbiology (BIOM 322). The results of this study displayed that a quarter of hazards present in both laboratories are due to chemical and ergonomic hazards. Chemical and ergonomic hazards have the highest percentages for both laboratories, with an equal percentage of 25% of each hazard in the microbiology lab and with an equal percentage of 31% of each hazard in the hematology lab. The severity, likelihood of occurrence, and risk priority number (RPN) are higher in the microbiology lab than the hematology lab. This study gave some recommendations about the currently adopted control measure.

6. RECOMMENDATIONS

1. QU need office for ergonomic safety to ensure that spread awareness among students and staff.
2. Ensure use of proper chairs, benches, cabinets, pipetting , microscope to ensure no musculoskeletal stress , and ensure no disorders related to joints, movements.
3. Entrance to the laboratory should be restricted to only authorized personal such as laboratory technicians, students and teaching faculty.
4. Make sure lab's safety equipment—including fume hood and biosafety cabinet class 2 (BSC 2) are available in the lab when handling any toxic or hazardous agent.
5. Attention of unusual risks to immunocompromised persons, feeding mothers, and pregnant.
6. Designate multiple hand washing sinks.
7. Keep record of equipment maintenance
8. Make the equipment’s maintenance available
9. Provide work instruction sheet that outlines the recommended safe method of undertaking the laboratory test.
10. Follow proper chemical storage practice.
11. Use proper furniture such as cabinet and chairs are required.
12. Use the appropriate colour for the biohazard waste bin, and it should be yellow
13. Organize chemicals and biological agents in Material safety data sheet (MSDS) alphabetically by common name, to make it easier to find a particular one in a stressful situation

7. LIMITATIONS

The current study had some limitations, like the relatively small sample size (two education labs) and the restriction of location (the only college of health sciences).

8. FUTURE WORKS

In the future, additional studies are needed to be done in order to prove the findings of this study. For example, more researches should be done to study the severity of each type of identified hazard. Also, the perception and knowledge of occupational hazards among students and persons in charge need to be studied. The sample size should be expanded to include other education laboratories in CHS or another institute.

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APPENDIX A. HAZARD IDENTIFICATION SHEET FOR THE MICROBIOLOGY LAB

Table 1. Hazard Identification Sheet for Microbiology laboratory

Assessment completed by: Dr. Hashim Al-Hussain Wasaif AlShammari	Date: 10/2/2020
Location: Qatar University, College of art and science(C01), Biomedical laboratories area (D126, D125, and D124)	Ref #:
Description of Task/ Guidelines referenced	
Experiment √	laboratory √ Equipment and Machines √

Hazard Identification – Material		Hazard(s) tick if applicable							
Risk factor	Hazard Description	Risk (Harm)	Biohazard	Chemical	Radiation	Physical	Electrical	Ergonomic
R1	Entry, use of equipment by unauthorised persons	Injury from machinery, chemicals, etc						√
R2	Spillage and Splashes of hazardous chemicals	Contamination of skin and eyes Inhalation of vapour or fumes		√				
R3	Spillage of tube culture media	Contamination of skin and eyes Inhalation of vapour or fumes	√					
R4	Fire hazard of flammable chemicals e.g., Gram stain chemicals	Burns and explosion		√				

Risk factor	Hazard Description	Risk (Harm)	Biohazard	Chemical	Radiation	Physical	Electrical	Ergonomic
R5	Accidental exposure to toxic chemical	Toxicity, oncogenicity, allergenicity, and death.		√				
R6	Exposure to BSL-2 biological agents (during reading culture plates, removing caps or swabs, sub culturing, streaking plates)	Presence of pathogens. Infection	√					
R7	Gas cylinder	Dropping cylinder when transporting, release of contents or pressure.				√		
R8	Inexperienced and untrained personnel	Carrying out tasks without care due to insufficient knowledge or training						√
R9	Lack/inadequate maintenance of equipment	Shock burns from electrical equipment. Cut, bruise or fracture etc mechanical equipment				√		
R10	Lack of work instruction sheet	In correct using of equipment’s and machine						√

R11	Hot machine e.g., incinerator and slide warmer	Burns/scalds from contact with flames, material, surfaces etc.			√		
R12	Unsuitable storage e.g., store bulk flammable chemicals in wood cabinet	Fire, spillage and explosion		√			
R13	Inadequate hygiene arrangement	Contamination of the skin					√
R14	Unattended equipment left running e.g., incinerator	Various injuries/ill health				√	
R15	Improper disposal of contaminated objected e.g. disposal contaminated items into demonistic waste	Contamination, Infections and Injuries	√				
R16	Broken slides, tubes and glass wares	Cut, injuries and infections			√		

APPENDIX B. HAZARD IDENTIFICATION SHEET FOR THE HAEMATOLOGY LAB

Table 2. Hazard identification sheet for Haematology laboratory

Assessment completed by: Wasaif AlShammari	Date: 26 /2/2020
Location: Qatar University, College of art and science(C01), Biomedical laboratories area (D122)	Ref #:

Description of Task/ Guidelines referenced

Experiment √ laboratory √ Equipment and Machines √

Hazard Identification – Material Hazard(s) tick if applicable

Risk factor	Hazard Description	Risk (Harm)	Biohazard	Chemical	Radiation	Physical	Electrical	Ergonomic
R1	Entry, use of equipment by unauthorised persons	Injury from machinery, chemicals, etc						√
R2	Spillage and splashed of hazardous chemicals	Contamination of skin and eyes Inhalation of vapour or fumes		√				
R3	Fire hazard of flammable chemicals e.g., Wright stain	Burns and explosion		√				
R4	Accidental exposure to toxic chemical	Toxicity, oncogenicity, allergenicity, and death.		√				
R5	Using real blood samples obtained from Hamad Hospital	Exposure to bloodborne pathogens e.g. HIV, HBV, and HCV	√					
R6	Inexperienced and untrained personnel	Carrying out tasks without care due to insufficient knowledge or training						√
R7	Lack/inadequate maintenance of equipment	Shock burns from electrical equipment. Cut, bruise or fracture etc mechanical equipment				√		
R8	Use of electrical equipment, possible harm Shock, burn, fire.	Shock, burn, fire					√	

Risk factor	Hazard Description	Risk (Harm)	Biohazard	Chemical	Radiation	Physical	Electrical	Ergonomic
R9	Lack of work instruction sheet	In correct using of equipment's and machine						√
R10	Unsuitable storage e.g., store bulk flammable chemicals in wood cabinet	Fire, spillage and explosion		√				
R11	Inadequate hygiene arrangement	Contamination of the skin						√
R12	Improper disposal of contaminated objected e.g. disposal contaminated items into demonistic waste	Contamination, Infections and Injuries	√					
R13	Broken slides, tubes and glass wares	Cut, injuries and infections				√		

APPENDIX C. HAZARD EVALUATION SHEET FOR THE MICROBIOLOGY LAB

Table 3. Hazard evaluation Sheet for Microbiology laboratory

Assessment completed by: Date:
Dr. Hashim Al-Hussain 10/2/2020
Wasaif AlShammari
Location: Ref #:
Qatar University, College of art and science(C01),
Biomedical laboratories area (D126, D125, and D124)

Description of Task/ Guidelines referenced

Experiment √ laboratory √ Equipment and Machines √

Hazard Evaluation

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Entry, use of equipment and chemicals by unauthorised persons	None	3	5	15	Warning	Only authorised persons allowed entry and to use equipment	1	2	2	Low
Spillage and splashed of	Chemical spill kit provided in wet.	4	4	16	High	Instruction on how to use a chemical spill kit.	3	2	6	medium

hazardous chemicals	Sign to indicate the location of chemical spill kit. Wear "personal protective equipment (PPE)" e.g. goggles					Sign to indicate the location of "Personal Protective Equipment (PPE) "				
Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Spillage of tube culture media	Biological spill kit provided in wet.	3	5	15	Warning	Instruction on how to use Biological spill kit. Sign to indicate the location of Biological spill kit	3	2	6	Medium
Fire hazard of flammable chemicals e.g., Gram stain	Make suitable, inspected, and in good condition fire extinguish	4	4	16	High	Engineering control: chemical storage and operations involving hazardous chemicals. Usage of fume hood when handling volatile flammable chemicals.	2	1	2	Low

chemicals	er available. Personal protective equipment (PPE): use gloves when handling flammable solvents.					Administrative control: acknowledgment and conformance to control measure listed in the Standard Operating procedure for the use of chemical				
Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Accidental exposure to toxic chemical	Engineering control: eyewash provided. Personal protective equipment (PPE): use gloves when handling toxic chemicals.	4	4	16	High	Administrative control: knowledge of MSDS thus taking appropriate action	2	3	6	Low

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Exposure to BSL-2 biological agents (during reading culture plates, removing caps or swabs, sub culturing, streaking plates)	Maintain and regularly test containment arrangements. Develop safe work procedures and train staff. Health surveillance, including appropriate immunization. Provide students with PPE.	4	5	20	High	Work under Biosafety Cabinet (BSC class 2). The attention of unusual risks to immunocompromised persons, feeding mothers and pregnant. Implement microbial control procedures — separate sink designated to hand washing only.	2	2	4	Low
Gas cylinder	Material safety	2	4	8	Medium	Train employees on	1	3	3	Low

	sheet available.					using the Gas cylinder. Utilize proper safety trolleys and restraints. Good general ventilation. Get rid of empty cylinders				
Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Inexperienced and untrained personnel	Provide a safety orientation.	5	4	20	High	Allow students to read and understand a safety manual for the Medical Microbiology lab. Train employees and demonstrate to students in using equipment and methods.	3	2	6	Low
Lack/inadequate maintenance of equipment	None	4	4	16	Medium	Ensure equipment is maintained in a safe condition.	3	3	9	Medium

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Lack of work instruction sheet	None	4	3	12	Warning	Ensure students know how to use, operate, and understand the hazards incorporated with particular equipment. Standard operating statuses and foreseeable potential irregular conditions must be respected.	1	2	2	Low
Hot machine e.g., incinerator	Work away from	4	4	16	High	Use forceps or tweezers to remove and	2	2	4	Low

and slide warmer	flammable substances.					place slides on a slide warmer. Slide warmer and incinerator should be left turned on and unattended to warm up. Put a sign showing that it is hot near to the equipment.				
Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Unsuitable storage e.g., store bulk flammable chemicals in wood cabinet	None	5	4	20	High	Ensure storage arrangement suitably and do not overload. Use a flammable chemical cabinet.	2	2	4	Low
Inadequate hygiene arrangement	Clean lab benches before and after performing a laboratory experiment	4	3	12	Warning	Proper handwashing facilities available. Clean lab coats available. Protective clothing is	1	2	2	Low

						disposed appropriately, or laundered by the institution (lab coats are not taken home) “				
Unattended equipment left running e.g., incinerator	None	4	4	16	High	Avoid turning on unattended equipment, such as an incinerator, to warm up. Make sure all requirements are switched off when leaving the laboratory.	2	2	4	Low

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Improper disposal of contaminated objected e.g. disposal contaminated items into demonistic waste	Ensure students know how to dispose of different types of waste properly.	3	4	12	Warning	Use the proper color biohazard waste bin. Picture shows types of wastes disposed in right waste bin.	2	2	4	Low

Broken slides, tubes and glass wares	Glassware that is biologicall y contaminat ed and broken should be placed in a sharp bin and then autoclaved.	3	4	12	Warnin g	Display procedure on the walls for easy access. Ddon’t pickup broken glasses with hands and use appropriate equipment’s Forceps used to hold broken slides rather than hands or gloves	2	2	4	Low

APPENDIX D. HAZARD EVALUATION SHEET FOR THE HAEMATOLOGY LAB

Table 4. Hazard evaluation Sheet for Haematology laboratory

Assessment completed by: Wasaif AlShammari	Date: 26 /2/2020
Location: Qatar University, College of art and science(C01), Biomedical laboratories area (D122)	Ref #:
Description of Task/ Guidelines referenced	
Experiment √	laboratory √ Equipment and Machines √

Hazard Evaluation

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Fire hazard of flammable chemicals e.g., Wright stain	Make suitable, inspected, and in good condition fire extinguisher available.	4	4	16	High	Engineering control: chemical storage and operations involving hazardous chemicals. Usage of fume hood when handling volatile flammable chemicals. Administrative control:	2	1	2	Low

	Personal protective equipment (PPE): use gloves when handling flammable solvents.					acknowledgment and conformance to control measure listed in the Standard Operating procedure for the use of chemical				
Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Broken slides, tubes and glass wares	Glassware that is biologically contaminated and broken should be placed in a sharp bin and then autoclaved.	3	4	12	Warning	Display procedure on the walls for easy access. Don’t pickup broken glasses with hands and use appropriate equipment’s Forceps used to hold broken slides rather than hands or gloves	2	2	4	Low

Spillage and splashed of hazardous chemicals	Chemical spill kit provided in wet. Sign to indicate the location of chemical spill kit. Wear “personal protective equipment (PPE)” e.g. goggles	4	4	16	High	Instruction on how to use a chemical spill kit. Sign to indicate the location of “Personal Protective Equipment (PPE) “	3	2	6	mediu m

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Mediu m, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Mediu m, High)
		Likeliho od of occurren ce (grade 1-5) (A)	Hazard (Severit y) (grade 1-5) (B)	Risk (likeliho od x hazard) (A x B)			Likeliho od of occurre nce (grade 1-5) (A)	Hazard (Severit y) (grade 1-5) (B)	Risk (likeliho od x hazard) (A x B)	
Entry, use of equipment and chemicals by unauthorise d persons	None	3	5	15	Warnin g	Only authorised persons allowed entry and to use equipment	1	2	2	Low
Use of electrical equipment,	Sockets are not overloaded, conduct repairs	3	5	15	Warnin g	Assure machine and equipment are maintained	2	2	4	Low

possible harm Shock, burn, fire.	by qualified staff.					in good status, placed in proper locations, trained students and employees to look for deficits.				

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Lack of work instruction sheet	None	4	3	12	Warning	Ensure students know how to use, operate, and understand the hazards incorporated with particular equipment. Standard operating statuses and foreseeable potential irregular conditions must be respected.	1	2	2	Low

Using real blood samples obtained from Hamad Hospital	Develop safe work procedures and train staff. Health surveillance, including appropriate immunization. Provide students with PPE.	3	3	9	Medium	Maintain and regularly test containment arrangements. Work under Biosafety Cabinet (BSC class 2). The attention of unusual risks to immunocompromised persons, feeding mothers and pregnant. Implement microbial control procedures.	2	2	4	Low

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Inadequate hygiene arrangement	Clean lab benches before and after performing a laboratory experiment	4	3	12	Warning	Proper handwashing facilities available. Clean lab coats available.	1	2	2	Low

						Protective clothing is disposed appropriately, or laundered by the institution (lab coats are not taken home) “				
Lack/inadequate maintenance of equipment	None	4	4	16	High	Ensure equipment is maintained in a safe condition.	3	3	9	Medium

Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Unsuitable storage e.g., store bulk flammable chemicals in wood cabinet	None	5	4	20	High	Ensure storage arrangement suitably and do not overload. Use a flammable chemical cabinet.	2	2	4	Low
Accidental exposure to toxic chemical	Engineering control: eyewash provided. Personal	4	4	16	High	Administrative control: knowledge of MSDS thus taking	2	3	6	Low

	protective equipment (PPE): use gloves when handling toxic chemicals.					appropriate action				
Hazard Description	Controls adapted for Risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)	Control recommended for risk minimization	Risk evaluation			Risk Rating (Low, Medium, High)
		Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)			Likelihood of occurrence (grade 1-5) (A)	Hazard (Severity) (grade 1-5) (B)	Risk (likelihood x hazard) (A x B)	
Improper disposal of contaminated objected e.g. disposal contaminated items into demonistic waste	Ensure students know how to dispose of different types of waste properly.	3	4	12	Warning	Use the proper color biohazard waste bin. Picture shows types of wastes disposed in right waste bin.	2	2	4	Low
Inexperienced and untrained personnel	Provide a safety orientation.	5	4	20	High	Allow students to read and understand a safety manual for the Medical Microbiology lab. Train employees and demonstrate to students in using	3	2	6	Low

	equipment and methods.

APPENDIX E . BIOSAFETY LEVEL 2 (BSL2) CHECKLIST FOR THE MICROBIOLOGY LAB

Table 5. Biosafety level 2 checklist for Microbiology laboratory

Statement	Yes	No
"Access to the laboratory is limited or restricted at the discretion of the Principal Investigator or laboratory supervisor when experiments are in progress."		√
Appropriate signs to not Eat, drink, smoking are posted in the door	√	
"Required procedures for entering the laboratory are posted at the entrance to the laboratory when infectious agents are present"	√	
"Required procedures for exiting the laboratory are posted at the entrance to the laboratory when infectious agents are present"		√
Appropriate disinfectant is available to disinfect Spills and splashed	√	
Laboratory Wastes are placed in durable, leaf-proof containers	√	
The hazardous waste collection area is clearly identified and marked by signs	√	
"A biohazard sign is posted at the entrance to the laboratory"	√	
Biosafety level sign is posted at the entrance to the laboratory		√
"Laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposure"	√	
Material safety data sheet is updated		√
"All the persons entering the lab are advised about the potential hazards"	√	
All the personal working in the lab received immunization or prophylactic interventions for HBV	√	
Laboratory safety manual is available and accessible	√	
Small volumes of hazards chemicals are stored in the lab		√
"All laboratory personally especially pregnant women are providing information regarding immune competence and conditions that may predispose them to infection"		√
Contact information of the TA in-charge of the lab is posted in the laboratory door		√
Chemicals are stored properly in chemical cabinet or flammable chemicals cabinet		√
Properly maintained Laboratory equipment's and machines are used		√
Chemicals are routinely inspected		√
First aid cabinet is available	√	
First aid cabinet is contain required equipment's	√	
First aid is regularly inspected		√

“Biosafety cabinet level, preferably class II, is available whenever procedures with a potential for creating aerosols or splashes”		√

Statement	**Yes**	**No**
“A personal protective equipment (PPE) e.g. Gloves , face mask, goggles have direction signs posted inside the laboratory”		√
“Protective clothing is disposed appropriately, or laundered by the institution (lab coats are not taken home) “		√
Eye protection e.g. Goggles is available for anticipated splashed or spraying infectious or hazardous material	√	
Face protection e.g. Face shield is available for anticipated splashed or spraying infectious or hazardous material		√
“Laboratory doors are self-closing and have lock”	√	
“The laboratory has sink for hand washing . The sink may be manually , hands-free or automatically operated.”		√
The laboratory is designed in a way, so it is easy to clean	√	
The lab has good house keeping	√	
The lab furniture are clean and in good condition	√	
The ceiling is properly fixed and secured		√
The floor is clean and free of slipping hazard	√	
The drainage system is functioning properly		√
The maintenance records for lab equipment’s/ tools is available		√
Laboratory cabinet and drawers is capable of supporting anticipated use		√
“Bench top are impervious to water and resistant to heat , organic solvent, acid , alkalis, and other chemicals”	√	
“Appropriate chairs are used in the laboratory work “		√
“An eyewash station is readily available”	√	
An safety shower station is readily available	√	
Biological spill kit procedure is available in the lab		√
Chemical spill kit procedure is available in the lab		√
The exit pathway is free from obstruction		√
The fire emergency procedure is displayed clearly	√	
The emergency exit door is working properly	√	
The fire extinguisher is accessible	√	
The fire extinguisher is inspected monthly	√	
The fire alarm equipment is working	√	
The fire alarm equipment is inspected	√	

The fire suppression system is provided and inspected		√
All the electronic wiring/ sockets/ extension cords/ adaptors is safe & not overloaded.	√	
The operating instructions for machines and equipment's e.g. Autoclave are available and displayed in the lab		√
Statement	**Yes**	**No**
The lab lights are adequate	√	
The lab lights are working properly	√	
The chemical inventory is available		√
Material safety data sheet (MSDS) is available and accessible	√	
Material safety data sheet (MSDS) is updated		√
Laboratory has adequate supervision (1supervisor : 15 students)		
Chemical spill kit is quarterly inspected		√
The gas cylinders secured and located away from electric connection, flammable or combustible , and corrosive material	√	
The gas cylinders are labelled with name of the gas type	√	
The full gas cylinders are segregated from the empty cylinders	√	
The gas cylinders is free from any signs of leak or damage	√	

APPENDIX F. BIOSAFETY LEVEL 2 CHECKLIST (BSL2) FOR THE HAEMATOLOGY LAB

Table 6 .Biosafety level 2 checklist for Hematology laboratory

Statement	Yes	No
"Access to the laboratory is limited or restricted at the discretion of the Principal Investigator or laboratory supervisor when experiments are in progress."		√
Appropriate signs to not Eat, drink, smoking are posted in the door	√	
"Required procedures for entering the laboratory are posted at the entrance to the laboratory when infectious agents are present"		√
"Required procedures for exiting the laboratory are posted at the entrance to the laboratory when infectious agents are present"	√	
Appropriate disinfectant is available to disinfect Spills and splashed	√	
Laboratory Wastes are placed in durable, leaf-proof containers	√	
The hazardous waste collection area is clearly identified and marked by signs	√	
"A biohazard sign is posted at the entrance to the laboratory"	√	
Biosafety level sign is posted at the entrance to the laboratory		√
"Laboratory personnel receive appropriate training regarding their duties, the necessary precautions to prevent exposure"	√	
Material safety data sheet is updated	√	
"All the persons entering the lab are advised about the potential hazards"	√	
All the personal working in the lab received immunization or prophylactic interventions for HBV	√	
Laboratory safety manual is available and accessible	√	
Small volumes of hazards chemicals are stored in the lab		√
"All laboratory personally especially pregnant women are providing information regarding immune competence and conditions that may predispose them to infection"		√
Contact information of the TA in-charge of the lab is posted in the laboratory door		√
Chemicals are stored properly in chemical cabinet or flammable chemicals cabinet		√
Properly maintained Laboratory equipment's and machines are used	√	
Chemicals are routinely inspected		√
First aid cabinet is available	√	
First aid cabinet is contain required equipment's	√	

First aid is regularly inspected		√
Fume hood is available whenever procedures with a potential for creating aerosols or splashes	√	

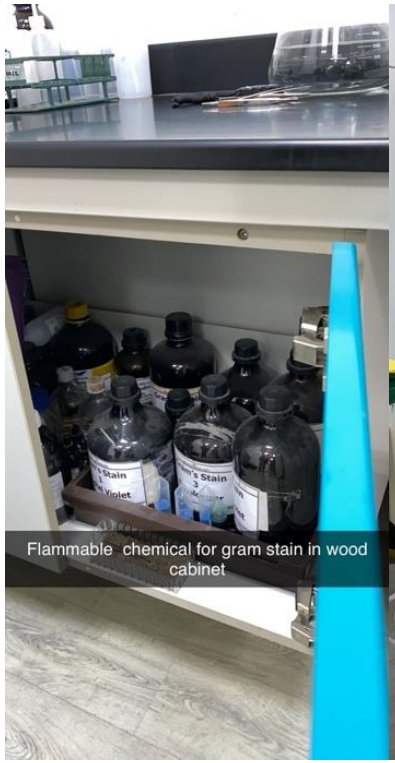
Statement	**Yes**	**No**
"A personal protective equipment (PPE) e.g. Gloves , face mask, goggles have direction signs posted inside the laboratory"	√	
"Protective clothing is disposed appropriately, or laundered by the institution (lab coats are not taken home) "		√
Eye protection e.g. Goggles is available for anticipated splashed or spraying infectious or hazardous material		√
Face protection e.g. Face shield is available for anticipated splashed or spraying infectious or hazardous material	√	
"Laboratory doors are self-closing and have lock"		√
"The laboratory has sink for hand washing . The sink may be manually , hands-free or automatically operated."		√
The laboratory is designed in a way, so it is easy to clean	√	
The lab has good house keeping	√	
The lab furniture are clean and in good condition	√	
The ceiling is properly fixed and secured	√	
The floor is clean and free of slipping hazard	√	
The drainage system is functioning properly	√	
The maintenance records for lab equipment's/ tools is available		√
Laboratory cabinet and drawers is capable of supporting anticipated use		√
"Bench top are impervious to water and resistant to heat , organic solvent, acid , alkalis, and other chemicals"	√	
"Appropriate chairs are used in the laboratory work "		√
"An eyewash station is readily available"	√	
An safety shower station is readily available	√	
Biological spill kit procedure is available in the lab	√	
Chemical spill kit procedure is available in the lab	√	
The exit pathway is free from obstruction	√	
The fire emergency procedure is displayed clearly	√	
The emergency exit door is working properly	√	
The fire extinguisher is accessible	√	
The fire extinguisher is inspected monthly	√	
The fire alarm equipment is working	√	
The fire alarm equipment is inspected	√	

The fire suppression system is provided and inspected	√	
All the electronic wiring/ sockets/ extension cords/ adaptors is safe & not overloaded.	√	
The operating instructions for machines and equipment's e.g. Autoclave are available and displayed in the lab		√
Statement	**Yes**	**No**
The lab lights are adequate	√	
The lab lights are working properly	√	
The chemical inventory is available		√
Material safety data sheet (MSDS) is available and accessible	√	
Material safety data sheet (MSDS) is updated	√	
Laboratory has adequate supervision (1supervisor : 15 students)	√	
Chemical spill kit is quarterly inspected		√

References:

1. *Biosafety Level 2 Checklist(n.d.),* http://webfiles.ehs.ufl.edu/bsl2checklist.pdf
2. *CDC Import Permit Inspection Checklist for BSL-2 Laboratories (BMBL 5th Edition)(n.d.),* https://www.cdc.gov/cpr/ipp/inspection/docs/Import_Permit_Checklist_BSL-2.pdf

APPENDIX G . PICTURES FROM THE MICROBIOLOGY THE LAB


Flammable chemical for gram stain in wood cabinet

Sign how to use spill kit


Physical hazard , roof is broken


Physical hazard

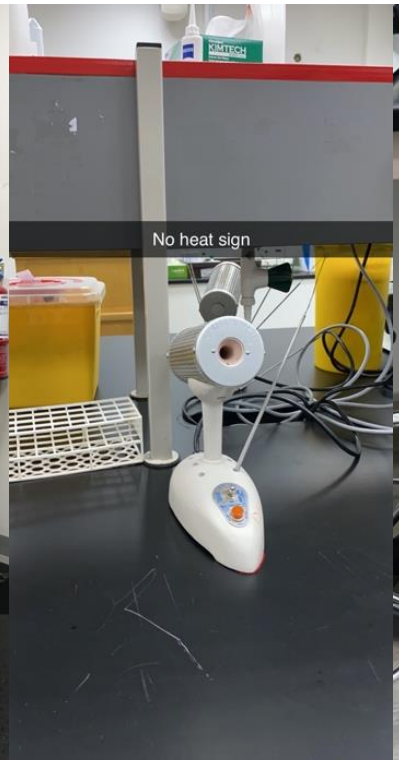

Flammable chemical in wood cabinet

No sign

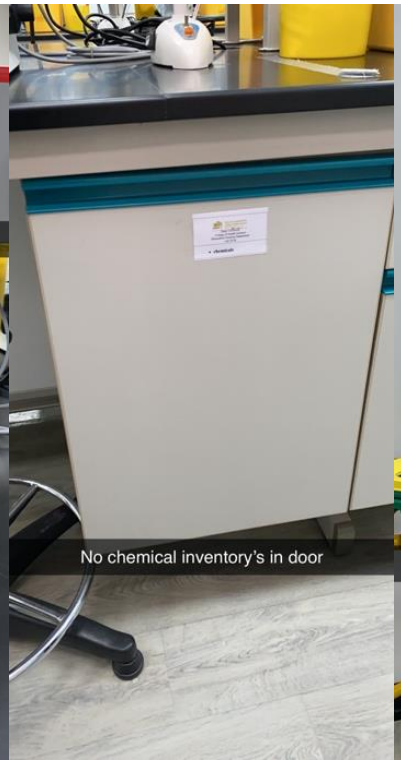

No sign hot


No wood chair

No inventory list

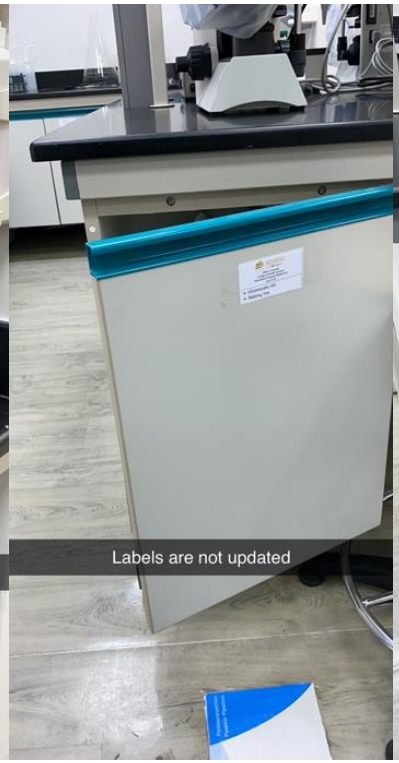


No heat sign


No chemical inventory's in door

Biohazards spill kit not inspected


Flammable chemical!!


Labels are not updated


NOTICE ملاحظة
NO FOOD OR DRINK PERMITTED IN CLASSROOMS OR LABS
CAUTION تحذير
BIOHAZARD
AUTHORIZED PERSONNEL ONLY
No lab incharged details

Inspected eyewash

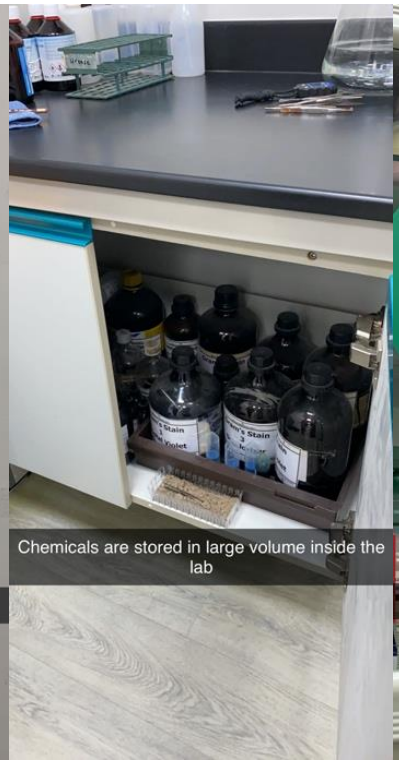

No work instructions


Obstruction of emergency exist


No chemical storage cabinets

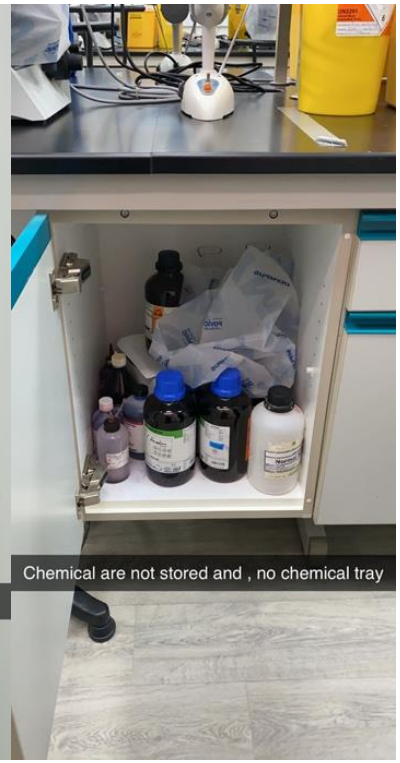

No maintenance sheet
Drainage is covered
Not labeled
BIOHAZARD
Biohazard waste bin is not up to the standards as it should be yellow

No hand washing sink



Chemicals are stored in large volume inside the lab

Fist aid is no inspected



Chemical are not stored and , no chemical tray


No fume hood or BSC class 2 , but have chemical need this


Biohazard waste bin should be covered


!!

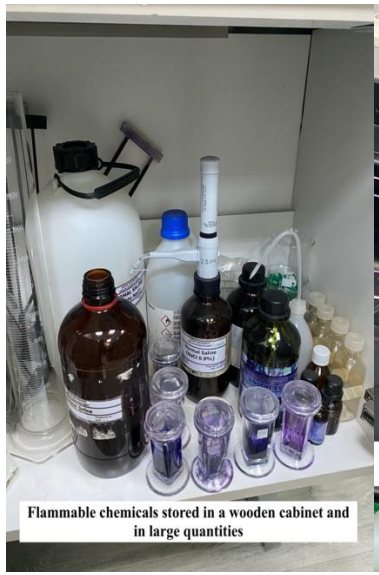
APPENDIX H. PICTURES FORM THE HAEMATOLOGY LAB

The flammable chemicals are stored in large quantities in a cabinet made of wood

NOT the proper colour for biohazard bin, it should be yellow

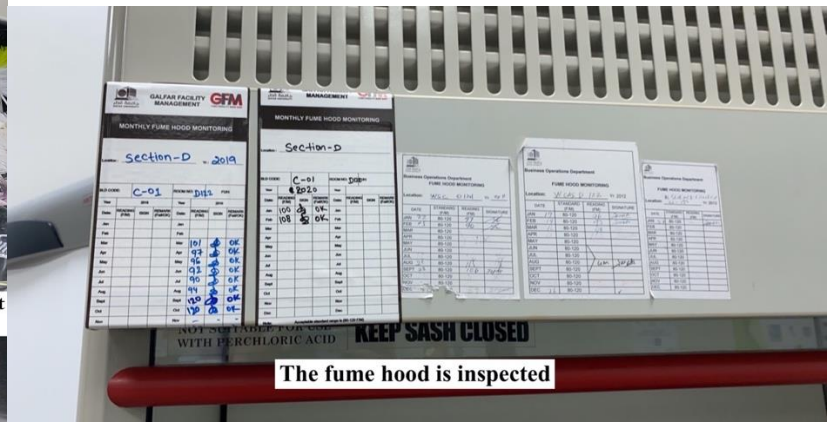
No proper locattion for chemcial spill kit

Sign and loaction of Biohazard waste bin doot match



Flammable chemicals stored in a wooden cabinet and in large quantities

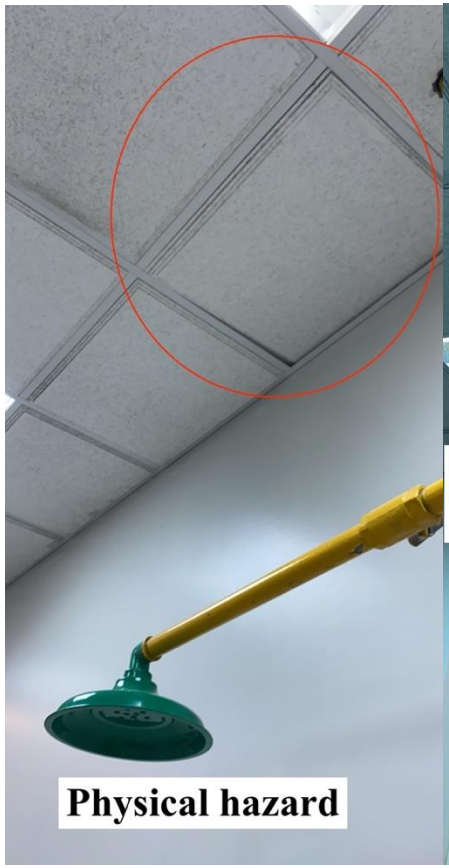
Gram stain sink is crowded with not clean glass tools



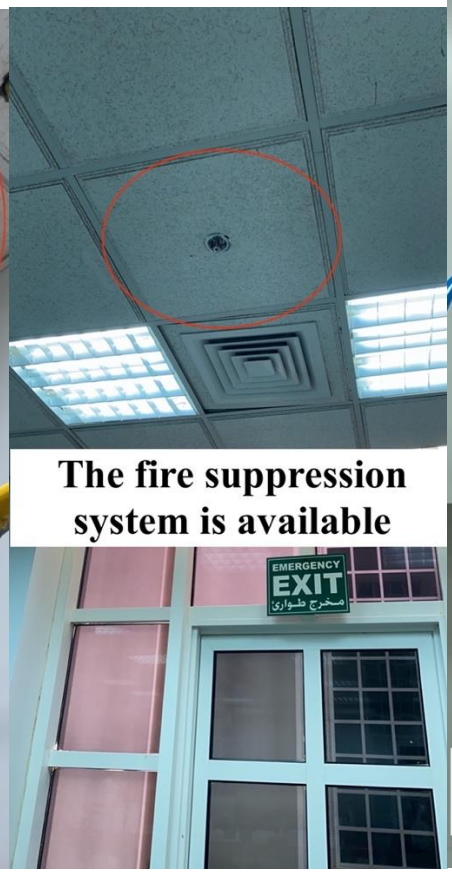
The fume hood is inspected

The sign indicates location of PPE is available and gloves are available, but safety goggles are missing!

Gram stain sink is very crowded and untidy



Physical hazard



The fire suppression system is available

First aid is not regularly inspected

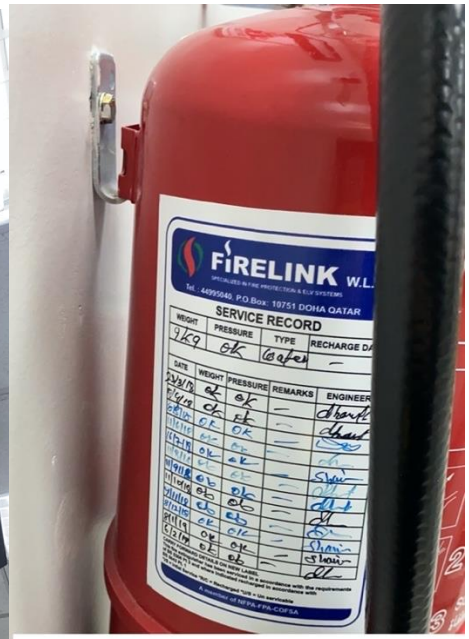
Flammable chemicals in a wooden cabinet

Wooden chair

Safety shower is inspected

Appropriate fire extinguishers are available

Fire alarm is available



The water fire extinguisher is inspected

The powder fire extinguisher is inspected

APPENDIX I. APPROVAL FROM HEAD OF BIOMEDICAL SCIENCES DEPARTMENT

Subject: Date: From: To:

CC: AEachments:

RE: Approval to a-end undergraduate laboratories

Monday, January 13, 2020 at 1:13:34 PM Arabian Standard Time

Marawan Abdelhamid Mahm Abou Madi

Wasaif Raja AlShammari, Tameem Ali Qaid Hadwan, Ibrahim Mustafa, Sawsan S. A. Said, Layla Kamareddine

Nasser Moustafa Ragheb Rizk image001.jpg

Approved,
wish you all the best Wasaif for your project

Dr. Marawan Abu-Madi PhD, MLS (ASCP)^{cm}

Associate Professor, Department Head Department of Biomedical Science College of Health Sciences
Qatar University

P.O. Box 2713, Doha - Qatar Tel: 00974- 4403-4791
Fax: 00974- 4403-4801 Email: abumadi@qu.edu.qa

Web: http://www.qu.edu.qa/artssciences/

From: Wasaif Raja AlShammari <wa1103787@student.qu.edu.qa> **Sent:** Monday, January 13, 2020 12:34 PM
To: Marawan Abdelhamid Mahm Abou Madi <abumadi@qu.edu.qa> **Cc:** Nasser Moustafa Ragheb Rizk <nassrizk@qu.edu.qa>

Subject: Approval to a-end undergraduate laboratories Dear Dr Marwan,

I hope this email finds you well,

I am a master Biomedical Sciences student Management track, I am currently doing my Capstone project regarding the risk management in undergraduate laboratories with Dr Nasser Risk.

A\er a lengthy dialogue and discussion with the capstone supervisor, Dr. Nasser, the choice was made for **Hematology and homeostasis; and medical microbiology** for my Capstone project because they are one of the most important and at the same]me one of the most dangerous laboratories in the CHS.

I am wriJng to request your approval to aEend these pracJcal sessions for Spring 2020. AEending these pracJcal classes will help me a lot in collecJng informaJon .

I await your response.

Thank you,
Wasaif AlShammari

APPENDIX J. HANDLING AND STORAGE REQUIREMENTS FOR EACH CHEMICAL AND BIOLOGICAL AGENT IN THE MICROBIOLOGY LAB

Control measure	Chemical	Infectious substances
Tightly closed	o di-iodine pentoxide GR for analysis granular 0.5-2.5 mm o Malachite green oxalate (C.I. 4200) for microscope and for microbiology o Nutrient agar for microbiology (20g for 1 litre of culture medium) o Phenol red indicator pH 6,4-8,2 ACS o Safranine O (C.I 50240) for microbiology Certistain o Sulfuric acid 95-98% extra pure Ph Eur,BP,NF,$\ddot{O}AB$, Ph Fran o Agar VRB crystal violet-neutral red-bile agar for microbiology (39,5 g for 1 litre of culture medium) o Sodium hypochlorite solution (6-14% active chlorine) o Ethanol 96% extra pure Ph Eur, Bp o MacCONKEY agar for microbiology (50.1 g for 1 litre of culture medium) Fluorocult ® o Ziehl-Neelsen carbol-fuchsin solution for microscope o $L\ddot{O}$FFLER'S methylene blue solution for microscopy o Nutrient broth for microbiology (8 g for 1 litre of culture medium) o Peptone water (buffered) for microbiology (25,5 g for 1 litre of culture medium)	

Control measure	Chemical	Infectious substances
	o Blood agar (base) no.2 for the cultivation of fastidious pathogens and other microorganisms o Hydrogen peroxide solution 31% Ultrapur ®	
Well-ventilated place	o Sulfuric acid 95-98% extra pure Ph Eur,BP,NF,$\ddot{O}AB$, Ph Fran o Ethanol 96% extra pure Ph Eur, Bp o Ziehl-Neelsen carbol-fuchsin solution for microscope o $L\ddot{O}$FFLER'S methylene blue solution for microscopy o Hydrogen peroxide solution 31% Ultrapur ®	
Storage temperature (No restriction)	o Sulfuric acid 95-98% extra pure Ph Eur,BP,NF,$\ddot{O}AB$, Ph Fran o Phenol red indicator pH 6,4-8,2 ACS o di-iodine pentoxide GR for analysis granular 0.5-2.5 mm o Ethanol 96% extra pure Ph Eur, Bp	
Storage temperature (+5 °C to +30 °C)	o Safranine O (C.I 50240) for microbiology Certistain o Malachite green oxalate (C.I. 4200) for microscope and for microbiology	
Storage temperature (+15 °C to +25 °C)	o Nutrient agar for microbiology (20g for 1 litre of culture medium) o Agar VRB crystal violet-neutral red-bile agar for microbiology (39,5 g for 1 litre of culture medium) o MacConkey agar for microbiology (50.1 g for 1 litre of culture medium) Fluorocult ®	

Control measure	Chemical	Infectious substances
	o Ziehl-Neelsen carbol-fuchsin solution for microscope o $L\ddot{O}$FFLER'S methylene blue solution for microscopy o Nutrient broth for microbiology (8 g for 1 litre of culture medium) o Peptone water (buffered) for microbiology (25,5 g for 1 litre of culture medium) o Blood agar (base) no.2 for the cultivation of fastidious pathogens and other microorganisms	
Dry place	o Phenol red indicator pH 6,4-8,2 ACS o Safranine O (C.I 50240) for microbiology Certistain o Nutrient agar for microbiology (20g for 1 litre of culture medium) o Malachite green oxalate (C.I. 4200) for microscope and for microbiology o di-iodine pentoxide GR for analysis granular 0.5-2.5 mm o Agar VRB crystal violet-neutral red-bile agar for microbiology (39,5 g for 1 litre of culture medium) o MacConkey agar for microbiology (50.1 g for 1 litre of culture medium) Fluorocult ® o Nutrient broth for microbiology (8 g for 1 litre of culture medium) o Peptone water (buffered) for microbiology (25,5 g for 1 litre of culture medium)	

Control measure	Chemical	Infectious substances
	o Blood agar (base) no.2 for the cultivation of fastidious pathogens and other microorganisms	
Away from combustible substances Keep away from sources of ignition and heat	o di-iodine pentoxide GR for analysis granular 0.5-2.5 mm o Hydrogen peroxide solution 31% Ultrapur ® o Ethanol 96% extra pure Ph Eur, Bp o Ziehl-Neelsen carbol-fuchsin solution for microscope o *LÖ*FFLER'S methylene blue solution for microscopy o Hydrogen peroxide solution 31% Ultrapur ®	
Handling under pressure Sensitive to light (protect from light)	o Sodium hypochlorite solution (6-14% active chlorine) o Sodium hypochlorite solution (6-14% active chlorine) o Hydrogen peroxide solution 31% Ultrapur ®	
Limited shelf life	Sodium hypochlorite solution (6-14% active chlorine)	
Store below + 15 °C	Sodium hypochlorite solution (6-14% active chlorine)	
Store in no metal container	Sodium hypochlorite solution (6-14% active chlorine)	
Decompose to form gas product Fire and explosion	o Sodium hypochlorite solution (6-14% active chlorine) o Ethanol 96% extra pure Ph Eur, Bp	

Control measure	Chemical	Infectious substances
	o Ziehl-Neelsen carbol-fuchsin solution for microscope o LÖFFLER'S methylene blue solution for microscopy	
Biosafety level 2 practice		o o Campylobacter jejuni, C. coli, C. fetus subsp. Jejuni o Candida albicans o Escherichia coli, enteroinvasive o Haemophilus influenzae (group b) or haemophilus meningitis o Mycobacterium tuberculosis, mycobacterium bovis o Neisseria gonorrhoeae o Pseudomonas spp. (P. aeruginosa, P. cepacia) and (excluding B. mallei, B. pseudomallei) o Salmonella paratyphi o Klebsiella spp. o Staphylococcus aureus o Streptococcus pneumoniae o Streptococcus pyogenes
Biosafety level 3 practice (aerosol production)		o Haemophilus influenzae (group b) or haemophilus meningitis o Mycobacterium tuberculosis, mycobacterium bovis o Neisseria gonorrhoeae
Wearing PPE		o Campylobacter jejuni, C. coli, C. fetus subsp. Jejuni o Candida albicans o Escherichia coli, enteroinvasive o Salmonella paratyphi o Pseudomonas spp. (P. aeruginosa, P. cepacia) and (excluding B. mallei, B.pseudomallei) o Neisseria gonorrhoeae

- Mycobacterium tuberculosis , mycobacterium bovis
- Klebsiella spp.
- Haemophilus influenzae (group b) or haemophilus meningitis
- Staphylococcus aureus
- Streptococcus pyogenes
- Streptococcus pneumoniae

APPENDIX K. HANDLING AND STORAGE REQUIREMENTS FOR EACH CHEMICAL IN THE HAEMATOLOGY LAB

Control measure	Chemical
Avoid freezing	ASI TPHA Test
	ASI ASO Slide Test
	Drabkin's Reagent
	ASI RF Direct Slide Test with Disposable Cards
Store at room temperature.	Drabkin's Reagent
	Antibody
Contact with acid liberates Cyanide fumes.	Drabkin's Reagent
Store locked up.	APTT XL
	Sulfuric Acid
well-ventilated place	Reticulocyte Stain
	Giemsa stain
	Brilliant Cresyl blue solution
	DPX Mountant for histology
	TWEEN® 20
	Wash Buffer
	Fetal Hemoglobin Kit
	Sulfuric Acid
	ASI RF Direct Slide Test with Disposable Cards
	ASI TPHA Test
	ASI ASO Slide Test

Control measure	Chemical
Keep away from incompatibles such as oxidizing agents, combustible materials, organic materials, metals, acids, alkalis, moisture	Sulfuric Acid
May corrode metallic surfaces	Sulfuric Acid
Store in a metallic or coated fiberboard drum using a strong polyethylene inner package.	Sulfuric Acid
fresh air supply in HVAC	ASI TPHA Test
	ASI ASO Slide Test
	ASI RF Direct Slide Test with Disposable Cards
Store in cool place	Reticulocyte Stain
	Sulfuric Acid
	Giemsa stain
	Brilliant Cresyl blue solution
	DPX Mountant for histology
	TWEEN® 20
	Wash Buffer
	Fetal Hemoglobin Kit
Keep container tightly closed	Reticulocyte Stain
	APTT XL
	Sulfuric Acid
	Giemsa stain
	Brilliant Cresyl blue solution
	DPX Mountant for histology
	TWEEN® 20
	480 LISS-ADD
	TMB Substrate Solution

Control measure	Chemical
	Fetal Hemoglobin Kit
Do not store above 23°C (73.4°F).	Sulfuric Acid
Store dry place	Reticulocyte Stain
	Giemsa stain
	Brilliant Cresyl blue solution
	DPX Mountant for histology
	TWEEN® 20
	Wash Buffer
	Fetal Hemoglobin Kit
	Sulfuric Acid
Containers which are opened must be carefully resealed and kept upright to prevent leakage.	Brilliant Cresyl blue solution
	Fetal Hemoglobin Kit
	DPX Mountant for histology
Highly flammable liquid and vapour	Brilliant Cresyl blue solution
	DPX Mountant for histology
Keep away from heat, hot surfaces, sparks, open flames and other ignition sources. No smoking.	Brilliant Cresyl blue solution
	DPX Mountant for histology
Wear rubber gloves	480 LISS-ADD
Storage temperature should be controlled to between 2 and 8°C	480 LISS-ADD
	ASI HSV IgG Herpes Simplex Virus Test Kit
	ASI EB VCA IgG Epstein-Barr Virus Test
	ASI TPHA Test
	ASI ASO Slide Test
	Fetal Hemoglobin Kit
	ASI RF Direct Slide Test with Disposable Cards

Control measure	Chemical
Biosafety level 2	ASI HSV IgG Herpes Simplex Virus Test Kit
	ASI EB VCA IgG Epstein-Barr Virus Test
Store in the original container	480 LISS-ADD
Protect from light.	TMB Substrate Solution