DEVELOPMENT OF SAFETY SELF-AUDIT MECHANISM FOR CHEMICAL LABORATORIES IN HIGHER LEARNING INSTITUTE: A CASE STUDY IN UNIVERSITI MALAYA

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FACULTY OF ENGINEERING
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RESEARCH PROJECT SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF SAFETY, HEALTH AND ENVIRONMENT ENGINEERING

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Field of Study : Safety and Health, Self-Audit, Chemical Hazard Management

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DEVELOPMENT OF SAFETY SELF-AUDIT MECHANISM FOR CHEMICAL LABORATORIES IN HIGHER LEARNING INSTITUTE: A CASE STUDY IN UNIVERSITI MALAYA

ABSTRACT

Safety compliance and implementation of best practices are commonly enhanced through scheduled auditing and subsequent improvement processes. The audits are commonly conducted by third parties (internal or external). However, when the number of laboratories involved are in hundreds, third party audits may not take place as per schedule and may affect the safety level of the laboratories. One of the means to overcome this issue is by developing a self-audit mechanism that can be used by the person(s) in charge of the laboratories itself to conduct the audit. Therefore, in this work, a comprehensive self-audit checklist was developed by taking into consideration safety related activities and facilities in typical chemical laboratories. Subsequently, the checklist was used to gather information on selected laboratories. The self-audit checklist consisted of nineteen (19) key categories. Guideline to use the checklist is also provided in the self-audit mechanism. The practicality of the checklist developed was validated by auditing one, two and three chemical laboratories in Faculty of Engineering, Faculty of Medicine, and Faculty of Science, respectively. The result showed that the safety self-audit mechanism is practical as a tool to conduct a comprehensive safety audit in chemical laboratories, with minimum time and monetary requirement. Hence, the study has proven that the safety self-audit mechanism developed can be used to initiate safety self-audit practices in chemical laboratories in higher learning institution in Malaysia.

Keywords: **chemical laboratory, safety self-audit, higher learning institution, self-regulated**

PEMBANGUNAN MEKANISMA AUDIT KENDIRI KESELAMATAN UNTUK MAKMAL KIMIA DI INSTITUT PENGAJIAN TINGGI: KAJIAN KES DI UNIVERSITI MALAYA

ABSTRAK

Pematuhan keselamatan dan pelaksanaan amalan terbaik lazimnya dipertingkatkan melalui pengauditan berjadual dan proses penambahbaikan berterusan. Audit lazimnya dijalankan oleh pihak ketiga (dalaman atau luaran). Walaubagaimanapun, apabila bilangan makmal yang terlibat adalah beratus, audit pihak ketiga mungkin tidak berlaku mengikut jadual dan boleh menjejaskan tahap keselamatan makmal. Salah satu cara untuk mengatasi isu ini adalah dengan membangunkan mekanisma audit kendiri yang boleh digunakan oleh individu yang bertanggungjawab ke atas makmal itu sendiri untuk menjalankan audit. Oleh itu, dalam projek penyelidikan ini, senarai semak audit kendiri yang komprehensif telah dibangunkan dengan mengambil kira aktiviti dan fasiliti berkaitan keselamatan di makmal kimia lazim. Seterusnya, senarai semak ini digunakan untuk mengumpul maklumat mengenai makmal-makmal terpilih. Senarai semak audit kendiri terdiri daripada sembilan belas (19) kategori utama. Garis panduan untuk menggunakan senarai semak dibangunkan dalam mekanisma audit kendiri. Kebolehgunaan senarai semak yang dibangunkan telah disahkan dengan menjalankan audit di satu, dua dan tiga makmal kimia, masing-masing di Fakulti Kejuruteraan, Fakulti Perubatan, dan Fakulti Sains. Keputusan menunjukkan bahawa mekanisma audit kendiri keselamatan adalah praktikal sebagai alat untuk menjalankan audit keselamatan yang komprehensif di makmal kimia, dengan keperluan masa dan kewangan yang minimum. Justeru, kajian telah membuktikan bahawa mekanisma audit kendiri keselamatan yang dibangunkan boleh digunakan untuk memulakan amalan audit kendiri keselamatan di makmal kimia di institusi pengajian tinggi di Malaysia.

Kata kunci: **makmal kimia, audit keselamatan kendiri, institusi pengajian tinggi, kawal selia kendiri**

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LIST OF SYMBOLS AND ABBREVIATIONS

CAR	:	Clean Air Regulation
CePSO	:	Certified Environmental Professional in Scrubber Operation
CePSWaM	:	Certified Environmental Professional in Scheduled Waste Management
CHRA	:	Chemical Health Risk Assessment
CIMAH 1996	:	Control of Industrial Major Hazard 1996
CLASS 2013	:	Classification, Labelling and Safety Data Sheet of Hazardous Chemicals 2013
DOE	:	Department of Environment
DOSH	:	Department of Occupational Safety & Health
ERP	:	Emergency Response Plan
ERT	:	Emergency Response Team
FMA 1967	:	Factory and Machinery Act 1967
GFCI	:	Ground Fault Circuit Interrupters
GHS	:	Globally Harmonized System of Classification and Labelling of Chemicals
HIRARC	:	Hazard Identification Risk Assessment and Risk Control
HLI	:	Higher Learning Institution
ICOP	:	Industry Code of Practice
IHT1	:	Industrial Hygiene Technician 1
IHT2	:	Industrial Hygiene Technician 2
LBAE	:	Licensing Board Atomic Energy
LEV	:	Local Exhaust Ventilation
NADOPOD	:	Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease
OSH	:	Occupational Safety & Health
OSHA 1994	:	Occupational Safety and Health Act 1994
PPE	:	Personal Protective Equipment
SDS	:	Safety Data Sheets

SOCSO	:	Social Security Organization
UBBL 1984	:	Uniform Building By-Laws 1984
UM	:	Universiti Malaya
USECHH 2000	:	Use and Standard of Exposure Chemical Hazardous to Health 2000
WHMIS	:	Workplace Hazardous Materials Information System

CHAPTER 1: INTRODUCTION

1.1. Background

Workplace safety is crucial because workers desire to work in a safe and protected atmosphere. Workers will feel safe and comfortable to work in an organization whose employers consistently emphasizes the aspects of occupational safety and health (OSH). At the same time, the low industrial accident rate also gives a good image to the country, thus attracting foreign industries to invest in the country. Employers who neglect aspects of OSH, as well as failed to conduct risk analysis and establish effective risk control will increase the risk of accidents in the workplace.

According to statistics by Bernama, accidents at work in Malaysia reported in 2017 were 42,513 cases, equivalent to 116 cases per day. Meanwhile, fatal accidents are 711 cases, which is equivalent to 2 cases every day (M. o. H. Resources, 2018).The government through the Social Security Organization (SOCSO) has released a total of RM 3.27 billion for the purpose of paying compensation to the victims involved. This proves that every accident that occurs involves high costs and in turn harms the affected parties, either directly or indirectly.

In Higher Learning Institution HLI, laboratory is one of the workplaces that needs to be emphasized regarding safety and health. Laboratory is a place of scientific research activities, which involving experimental works, measurement and training. Scientific laboratories are usually differentiated according to the field of knowledge that is specialized, mainly, physics laboratories, chemistry laboratories, biology laboratories, computer laboratories, and language laboratories. Most of the laboratories at HLI are chemistry laboratories (include reference). For example, Universiti Malaya has 822 laboratories, of which 385 are chemistry laboratories.

Various types of hazards can be found in chemical laboratories especially chemical hazards for example flammable, combustible liquids, compressed gases, explosive and organic peroxides etc., other hazards include electrical hazards, biological hazards, physical hazards must also be emphasized to ensure the safety and health of workers throughout the laboratory is monitored and maintained.

Various acts and regulations are used as a reference for occupational safety and health audits. The mainstay of this occupational safety and health act is the Occupational Safety and Health Act 1994. OSHA 1994 is an act to make further provisions to ensure the safety, health and welfare of persons at work, to protect others against risks to safety or health related to activities of people who are working, to establish the National Council for Safety and Health Employment, and for matters connected therewith. (Ministry Of Human Resources, 1994)

Audits should always be done on a regular basis. An audit is an inspection process. A safety and health audit are an inspection related to safety and health based on relevant acts, regulations, guidelines, standards, policies and references. Audits are usually conducted by a third person or an outsider from the organization consisting of people competent to conduct the audit. Meanwhile, most organizations will conduct self-audits as a preparatory measure of external audits and at the same time ensure that workplace risks are identified in advance. This self-audit process is also a measure of self-regulation which is an important concept in OSHA 1994. Self-audit in HLI will usually be carried out by certain employees who are appointed and given special training.

Laboratory safety self -audits are typically performed by employees of the same organization to other laboratory users. The audit is conducted randomly or specifically to a scheduled laboratory workplace. There are audits or inspections that require expert personnel from outside the organization or competent persons to conduct inspections in HLI laboratories such as CHRA assessors, IHT1 for chemical exposure monitoring, IHT2 for Local exhaust ventilation inspection, and other relevant competencies. A laboratory safety self -audit mechanism needs to be established in order to provide knowledge on occupational safety and health audits and their implementation at the user level of the laboratory itself. To know the audit tasks and knowledge on the matters being audited such as act or regulation related at the laboratory user level to the HLI management level.

Based on the case study, Chemical laboratory safety self -audit mechanism will be one of the efforts in achieving the goals of Universiti Malaya Occupational Safety and Health Policy as stated which is to identify all significant hazards, assess risks and implement effective control measures to mitigate risks that may arise in the course of university activities ; Provide staff, students and contractors such information, instruction, training, and supervision as is necessary, to ensure an appropriate level of competency in safety and health related matters ; Provide staff, students and other stakeholders involved in the University's activities a safe and supportive work and learning environment by establishing a framework that promotes safety and health ; Engage effectively with all stakeholders and actively promote OSH initiatives so as to prevent or reduce the potential risk of injuries, disease and ill health that relate to the University's activities ; Monitor and report the effectiveness of the University's safety and health performance periodically and commit to continuous improvement in achieving the objectives of this policy ; And to undertake regular review of this Policy to ensure the University observes, implements and fulfils all OSH requirements.

1.2. Problem statement

A chemical laboratory is a workplace with high potential of exposure to safety & health hazards such as toxic gas release, sharp edge from broken glassware and slippery floor. Normally, in a laboratory, safety is prioritised to ensure the occupants carry out their experiments or tasks safely and do not pose any harm to other people. This can be achieved by implementation of a proper safety management in laboratory. Although general safety guidelines, procedures and policies for chemical laboratory in HLI have been established, there is the need to develop a clear and comprehensive self-auditing mechanism that can be used by safety or laboratory personnel to conduct safety audit in chemical laboratories in UM. Furthermore, it has been identified that some of the safety and laboratory personnel may not have sufficient knowledge and skills in conducting safety self-audit. Hence, there is a need to provide relevant training to equip them with the right knowledge and skills to ensure the effectiveness of safety audit. Based on the two gaps mentioned above, it is proposed to develop a safety self-audit mechanism for chemical laboratories. The feasibility of implementing such a mechanism will also be studied.

1.3. Research Question

1. What is the potential risk associated to chemical laboratories?
2. What are key elements of safety self-audit in chemical laboratories?

1.4. Aim and objective

The aim of this work is to develop a safety self-audit mechanism for chemical laboratories in HLI. Therefore, the objectives of this work are as follows:

(a) To identify the elements of safety chemical laboratory audit.

(b) To map the elements of safety in chemical laboratory with related act, regulations, policy, and standards.

(c) To validate the safety self-audit mechanism developed using a selected case study.

1.5. Scope

This study focuses on the safety self-audit aspects in chemical laboratories in HLIs. The validation of the mechanism developed was conducted using selected chemical laboratories in Universiti Malaya as the case study.

1.6. Significant of the study

In this work, safety self-audit mechanism for chemical laboratory in HLI is developed.

The elements of workplace safety are arranged and described by category for laboratory users. Self-audit mechanism can ensure the safety of the workplace; especially chemical laboratories are monitored by the users of the laboratory themselves at the same time can produce a perfect preparation to face audits or inspections from outside. This self-audit mechanism will have a significant impact on the progress of self-regulation of workplace safety, especially chemical laboratories in HLI throughout Malaysia.

1.7. Report outline

Chapter 1: Introduction

This chapter describes the background of the study focusing on the safety & health aspects pertaining to chemical laboratory while highlighting the need to implement safety self-audit mechanism and provide training programs for safety and laboratory personnel in UM. The benefits of implementing the safety self-audit mechanism in chemical laboratory are discussed. This chapter will cover the problem statement, research objectives and scope of research.

Chapter 2: Literature review

Local and foreign acts & regulations related to the chemical laboratory management are discussed in this chapter. Safety self-audit audit mechanism and the implementation of safety self-audit in various laboratories are also discussed.

Chapter 3: Methodology

In this chapter, the detailed methodology of this study is explained. The methods include chemical laboratory site visit, development and distribution of survey questions, interviews and data collection to form the elements of the audit checklist. The items on safety self-audit checklist are also included in this chapter.

Chapter 4: Results and Discussion

This chapter discusses the results obtained from this study which consists of a detailed safety self-audit checklist for chemical laboratories and the mechanism of implementing the safety self-audit. The validation of safety self-audit mechanism developed using a selected case study is also evaluated.

Chapter 5: Conclusion and recommendation for future work

This chapter concludes the findings that reflect the objectives of this study and the recommendations for future work are summarized.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction to Malaysian act & regulations related to safety and health

2.1.1. OSHA 1994 (Minister of Human Resources, 1994)

The Occupational Safety and Health Act (OSHA) was passed on February 25, 1994, with the goal of ensuring the safety, health, and welfare of all employees in all workplaces. It was established on the basis of self-regulation, with people who produce and work with hazards bearing the major responsibility for guaranteeing workplace safety and health. With the establishment of the National Council for Occupational Safety and Health, the Act also provides for a consultative procedure at the policy level. This consultative procedure extends to the implementation of safety and health initiatives, with representatives from both employers and employees serving on the safety and health committee.

The Act is made up of 67 sections separated into 15 parts and three schedules. The first three sections define the Act's goals and lay the groundwork for the appointment of officers and the National Council. The Act's core provisions are found in Parts IV through VI. These sections outline the general responsibilities of people who produce risks, such as employers, self-employed individuals, designers, manufacturers, and suppliers, as well as those who deal with risks, such as employees. Other sections detail how the Act will be implemented and enforced.

2.1.1.1. USECHH Regulations 2000 (Minister of Human Resources, 2000)

Occupational Safety and Health (Use and Standard of Exposure Chemical Hazardous to Health) Regulations 2000 (USECHH Regulations) established a legal framework for controlling chemical hazardous to health exposure at work.

The purpose of these laws is to establish a standard for worker exposure to chemicals that are detrimental to their health at work. If a chemical is not listed in schedules I or II but has been designated as hazardous under CLASS Regulations, it will be covered under USECHH Regulations if used at work.

2.1.1.2. CLASS Regulations 2013 (ChemSafetyPro.COM, 2016)

On October 11, 2013, Malaysia's Occupational Safety and Health (Classification, Labelling, and Safety Data Sheet of Hazardous Chemicals) Regulations (known as the CLASS Regulations) were gazetted, bringing GHS into the country and requiring obligatory notification of hazardous chemicals.

Each calendar year, a manufacturer or importer must prepare an inventory of hazardous chemicals imported or supplied in quantities of 1 tonne or more. An inventory of this nature must be reported to the Department of Occupational Safety and Health by March 31 of the following year.

Chemical makers, importers, formulators, and distributors are also required by CLASS regulations to classify, label, and package chemicals, as well as compile safety data sheets, in accordance with the Industry Code of Practice (ICOP), which is aligned with UN GHS Rev. 3.

2.1.2. FMA 1967 (ACT, 2010)

The purpose of the Factories and Machinery Act (FMA) 1967, also known as Act 139, is to regulate factories in terms of worker safety, health, and welfare, as well as the registration and inspection of machinery. DOSH must certify and inspect certain high-risk machinery, such as boilers, unfired pressure vessels, passenger lifts, and other lifting equipment, such as mobile cranes, tower cranes, passenger hoists, overhead moving cranes, and gondolas. Before being installed and operated in Malaysia, all factories and general machinery must be registered with DOSH.

DOSH enforces 16 regulations under FMA 1967 which is Electric Passenger and Goods Lift Regulations, 1970, Fencing of Machinery and Safety Regulations, 1970, Notification, Certificate of Fitness and Inspection Regulations, 1970, Persons-In-Charge Regulations, 1970, Safety, Health and Welfare Regulations, 1970, Steam Boilers and Unfired Pressure Vessel Regulations, 1970, Certificates of Competency-Examinations Regulations, 1970, Administration Regulations, 1970, Compounding of Offences Rules, 1978, Compoundable Offences Regulations, 1978, Lead Regulations, 1984, Asbestos Process Regulations, 1986, Building Operations and Works of Engineering Construction (Safety) Regulations, 1986, Mineral Dust Regulations, 1989, Noise Exposure Regulations, 1989, Notification, Certificate of Fitness and Inspection (Amendment) Regulations, 2004.

2.1.3. Environmental Quality Act 1974 (Database, 2021c)

An act relating to pollution prevention, abatement, and control, as well as environmental enhancement, and for related reasons.

This Act addresses pollution prevention, abatement, and control, as well as environmental enhancement. It is broken down into the following sections: Preliminary (I); Administration (II); Licensing (III); Pollution Prevention and Control (IV); Appeal and Appeal Board (V); Miscellaneous (VI); (VI). The Director General of Environmental Quality and the Minister with responsibility for environmental protection share powers and functions related to environmental protection.

Article 4 establishes the Environmental Quality Council, whose mission is to provide general advice to the Minister on subjects relating to this Act and any other matter presented to it by the Minister. Part III outlines the steps required to seek a permit from the Director-General of Environmental Quality. Additional provisions are provided in regard to pollution restriction and control. They specifically address the following issues: plan requirements and approval; discharge restrictions; pollution of the atmosphere, noise pollution, soil pollution, and inland water pollution; and ban of oil and waste discharge into Malaysian waters.

After consulting with the Council, the Minister may issue an order prescribing any activity that may have a major environmental impact as a prescribed activity. Any person intending to engage in any prescribed activity must submit to the Director-General a report that includes an assessment of the impact that such activity will have or is likely to have on the environment, as well as proposed measures to prevent, reduce, or control said negative impact on the environment. The appointment of the

Appeal Board, the information to be submitted by the parties affected, the Director-and General's other officers' inspection authorities, and offences and punishments are among the final requirements. The Act went into effect on April 15, 1975.

2.1.3.1. Schedule Waste Regulation 2005 (Database, 2021b)

The disposal, treatment, management, storage, and transportation of scheduled wastes are all covered by these regulations. Scheduled wastes are defined as any waste that falls within one of the waste categories stated in the First Schedule to these Regulations. Every waste generator must ensure that all scheduled wastes are appropriately stored, treated on-site, and transferred to and received at designated locations for treatment, disposal, or recovery of material or product from scheduled wastes. Every waste generator must guarantee that planned wastes that must be moved or transferred are packaged, labelled, and transported in compliance with the Director General's requirements. There are seven (7) schedules attached to these Regulations that cover the following topics: notification of scheduled wastes; labelling requirements for scheduled wastes containing explosive chemicals; inventory of scheduled wastes; consignment note for scheduled wastes; and information. The 15th of August, 2005, is the effective date of these Regulations.

2.1.3.2. Clean Air Regulation 2014 (Manufacturers, 2021)

The Environmental Quality (Clean Air Regulations) 2014 were published in the Federal Register on June 4, 2014 and took effect on June 5, 2014. CAR 2014 intends to control air pollution emissions from industrial sources such as power plants, waste fuel plants, and asphalt mixing plants.

The Environmental Quality (Clean Air) Regulations 1978 and the Environmental Quality (Dioxin and Furan) Regulations 2004 have been replaced by CAR 2014.

2.1.4. Uniform Building By-Laws 1984

In Malaysia, the Uniform Building By-Laws (UBBL) 1984, issued under the Street Drainage and Building Act 1974, require a principal submitting person (PSP), such as a Professional Architect or Professional Engineer, to submit designs for approval prior to construction.

The UBBL 1984 specifies the structural requirements of a building in terms of material design and specifications, loadings, foundation, and superstructure; it also governs the design, specifications, and construction of walls, floors, and building structures. A building's construction and fire criteria were also specified in the UBBL 1984 (Fui, 2021).

UBBL 1984 is a building code that establishes minimum standards for the control and construction of streets, drainage, and buildings in the jurisdictions of municipal governments (Corporation, 2016).

2.1.5. Fire Service Act 1988 (Rescue, 1988)

An Act to make necessary provision for the effective and efficient functioning of the Fire and Rescue Department, for the protection of persons and property from fire risks or emergencies and for purposes connected therewith.

2.1.6. Electricity Supply Act 1990 (Database, 2021a)

The Electricity Supply Act of 1990 is a law that governs the electricity supply industry, including the regulation of the industry, the supply of electricity at reasonable prices, the licensing of any electrical installation, plant, and equipment, and the control of any electrical installation, plant, and equipment in relation to matters relating to the safety of people and the efficient use of electricity, as well as other matters.

This Act governs a variety of areas of the energy supply sector, including the delivery of power at fair prices, the licensing, registration, and regulation of any electrical installation, plant, or equipment for matters relating to human safety, and the effective use of electricity.

The Energy Commission, established under the Energy Commission Act 2001, has the following functions, duties, and powers: to issue licenses; to exercise regulatory functions in respect of the licensee's service of providing electricity; to promote competition in the generation and supply of electricity; and to promote the efficient use of electricity.

2.2. Introduction to laboratory safety self-audit

Identifying hazards in the workplace is the first step to assess risks in the workplace. Hazard is a cause or a condition that has the potential to cause harm in the form of injury or bad health to humans, property damage, environmental damage or a combination of any of these harms. Hazard control is the process of implementing measures to reduce the risks associated with hazards. While the control hierarchy is the appropriate order of priority set for the type of measures to be taken to control risk. Hazard identification is necessary for employees to identify the unwanted event that led to the existence of the hazard and the mechanisms that allow the unwanted event to occur (Habes & Putz-Anderson, 1985).

HIRARC is a process of identifying resource conditions, situations, processes and others that can cause harm and make a risk assessment. Taking control measures HIRARC is required to enable organizations to manage hazards more effectively and at the same time in accordance with the Requirements of the OSHA Law 1994, CIMAH Regulations 1996 & USECHH Regulations 2000 (Ministry of Human Resources, 2008).

Laboratories are essential parts of universities and research institutes where hazardous substances and processes are necessary for study. All stakeholders involved in research operations within the institution, including administrators and researchers, are responsible for safety as a mandatory concept (A. C. S. s. C. o. C. Safety, 2015) check citation. Stakeholders are exposed to a variety of hazards as a result of the laboratories and their surroundings (Oshima, 2016). With an easy-to-use, succinct checklist, a successful self-inspection programme encourages laboratory employees to participate in the QA process. This list is used to confirm that the Occupational Safety and Health Act (OSHA), other appropriate regulatory agencies, and institutional policies requiring safety equipment, standards, and practices are available and in use in the workplace (Yemoto, 2012).

2.3. Safety and health in Malaysia

2.3.1. DOSH background and function

The Ministry of Human Resources has a department called the Department of Occupational Safety and Health (DOSH). This department is in charge of maintaining the safety, health, and welfare of persons at work, as well as protecting other people from the hazards that arise from many activities sectors, such as: Manufacturing, Quarrying and mining, Construction, Restaurants and Hotels, Agriculture, forestry, and fishing, Communication, storage, and transportation, Statutory Authorities and Public Services, Gas, electricity, water, and sanitary services are examples of utilities., Finance, insurance, real estate, and business services are all examples of financial services., Trades in Wholesale and Retail.

The department, as a government agency, is in charge of administering and enforcing legislation related to occupational safety and health in the country, with the goal of becoming a national leader in developing a safe and healthy work culture that contributes to improving the quality of working life.

DOSH function is to research and evaluate workplace safety and health policies and laws. To enforce the following laws:

a) The Occupational Safety and Health Act of 1994, as amended, and its regulations.

b) The Factories and Machinery Act of 1967, as amended.

b) Part of the Petroleum Act (Safety Measures) of 1984 and its regulations.

Conduct research and technical analysis on issues concerning workplace occupational safety and health.

To promote and raise awareness of occupational safety and health among employers, workers, and the general public through promotional and publicity activities. To serve as the National Council on Occupational Safety and Health's secretariat (Health, 2021).

2.3.2. DOE background and function

On April 15, 1975, the Ministry of Local Government and Environment established the Department of Environment as the Environment Division. In March 1976, the Environment Division was transferred to the Ministry of Science, Technology, and Environment. The Environment Division was raised to a department known as the Department of Environment on September 1, 1983, due to the importance of environmental protection and conservation. DOE was transferred to the Ministry of Natural Resources and Environment in March 2004. The Environmental Quality Act of 1974, which was enacted in March 1974 and went into effect on April 15, 1975, is the foundation for the Department of Environment (Water, 2021).

2.3.3. Define self-regulation in organization

Self-regulation, which was based on the Robens Report, was a key concept in OSHA 1994. According to this research, individuals who create risks and those who work with risks bear responsibility for managing safety and health. Self-regulation, according to Gunningham (2011), is the control of a process or activity by the people or organisations participating in it rather than by an outside agency such as the government. Self-regulation can be implemented in three different ways: voluntary self-regulation, mandated full self-regulation, and mandatory partial self-regulation.

In voluntary self-regulation, a private corporation or industry sets the regulations and enforces them without the intervention of the government. Both rulemaking and enforcement are carried out by the firm or industry in mandated full self-regulation, but the programme is also legally sanctioned by the government, which oversees the programme and, if necessary, takes steps to assure its effectiveness. In mandated partial self-regulation, the firm or industry either creates or enforces the rules, but not both, i.e., public enforcement of privately authored rules or governmentally enforced internal enforcement of publicly written regulations.

The first example is a type of 'pure' self-regulation, but the second and third are co-regulation examples. (a) Negligence, (b) Contributory Negligence, and (c) Vicarious Liability are important legal terminology in OSH prosecution. Negligence is defined as a failure to take reasonable precautions to prevent inflicting foreseeable harm to another, with the failure being the cause of the harm. Contributory negligence occurs when a person fails to take care of oneself, resulting in an injury (Bahrin, 2016).

2.3.4. Competent person and function relate to chemical laboratories

There are a number of competencies appointed by DOSH and DOE related to chemical laboratories. Among them are Assessor, Hygiene Technician 2, Hygiene Technician 1, Indoor Air Quality Assessor, Occupational

Health Doctor, Safety and Health Officer, Certified Environmental Professional in the Operation of Industrial Effluent Treatment Systems (Physical Chemical Processes), Certified Environmental Professional in Scrubber Operation (CePSO) and Certified Environmental Professional in Scheduled Waste Management (CePSWaM).

The task of a competent person is to run inspections and tests on specific matters of expertise after being given training and passed the examinations by the relevant departments. Laboratory equipment or conditions will be tested for effectiveness and suggestions for improvement will be given to laboratory users.

2.4. Higher Learning Institutions (HLI)

Malaysia is home to over 100 governmental and private institutions, including international branches of famous universities from the United States, the United Kingdom, Australia, and Ireland (M. o. H. E. Malaysia, 2021). The Ministry of Education Malaysia oversees public institutions, which are government-funded higher education institutions. They can be classified into three major groups, as follows:

1) Undergraduate and postgraduate programs, as well as pre-university foundation year and diploma programs, are available in public universities. Research universities, focused universities, and comprehensive universities are the three types of universities. Currently, there are 20 such institutions.
2) Polytechnics and community colleges that offer certificate and diploma programs.
3) Certificate and diploma programs are available in public colleges.

2.5. Laboratory in Higher Learning Institutions (HLI)

2.5.1. Type of laboratory and definition

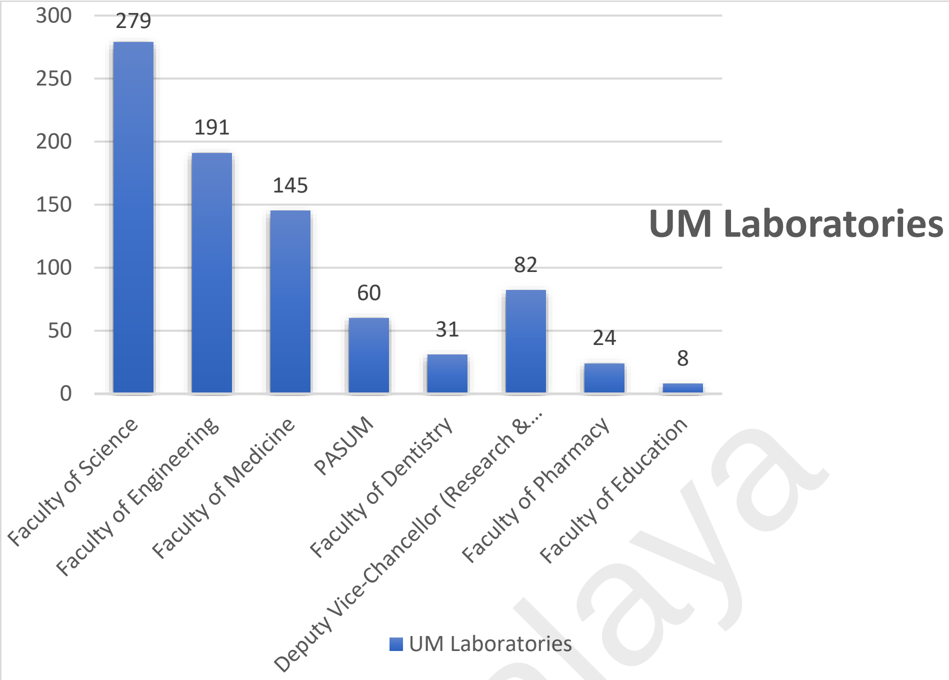
A laboratory is a building that allows scientists and engineers to conduct scientific or technological study, experiments, and measurements under controlled conditions. Laboratory services are available in a variety of locations, including doctor's offices, clinics, hospitals, and regional and national referral centers.

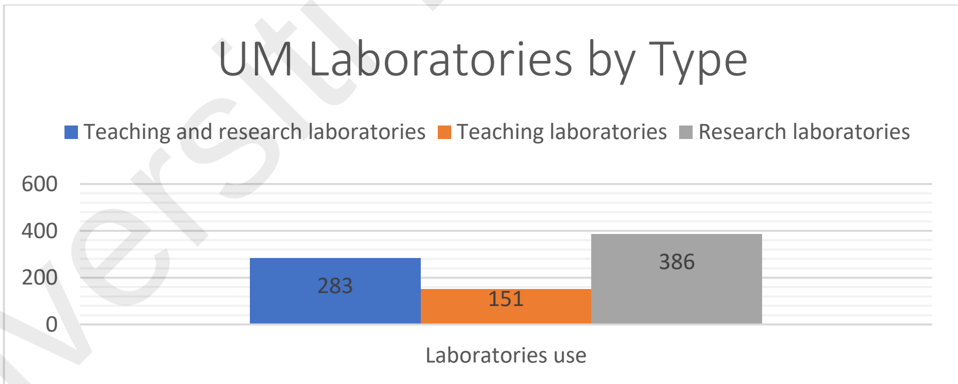
At HLI there are various types of laboratories and various uses. Among them are Workshops, Biology Laboratories, Chemistry Laboratories, Physics Laboratories, Teaching Laboratories, Geology Laboratories and many more. Each laboratory has different hazards and requires specific working methods to ensure the safety of employees and students. At the Universiti Malaya in particular, the chemistry laboratory is the largest number of laboratories, which is almost half of the total number of laboratories.

2.5.2. Total laboratory in UM

Universiti Malaya has total 820 laboratories consist of Faculty of Science (279), Faculty of Engineering (191), Faculty of Medicine (145), PASUM (60), Faculty of Dentistry (31), Deputy Vice-Chancellor (Research & Innovation) (82), Faculty of Pharmacy (24) and Faculty of Education (8) based on information collected from Faculties and related PTj as shown at Fugure 2.1..

Figure 2.1.: Total UM Laboratories & UM Laboratories by Type





Teaching and research laboratories (283), Teaching laboratories (151) and Research laboratories (386).

2.5.3. Hazards related with laboratories

There are several common hazards in the laboratory, among them are chemical hazards, biological hazards, electrical hazards and physical hazards. (InterFocus, 2021)

Chemical Hazard:

Chemical handling is a common component of many lab employees' daily routines, but the dangers and hazards remain the same. Many organic and inorganic compounds are poisonous and damaging to the skin and eyes. Any members of the team handling chemicals should be given with full protective gear, and there should be provisions in the laboratory to treat any exposure or clean up spillages.

Chemical interactions that generate heat can cause thermal burns as well, so it's not just direct touch that's dangerous. This emphasizes the necessity of ensuring that the skin's surface is protected from the risk of burns and exposure.

Similarly, improper laboratory ventilation might be dangerous. A distillation or chemical reaction in the lab could result in an explosion if proper ventilation is not provided. This might be extremely dangerous for the crew and the facility, depending on the size of the explosion and the materials involved.

Inhaling certain chemicals can be hazardous, and several of the most used solvents have been shown to be exceedingly poisonous. These dangers can be immediate or develop over time, therefore it's critical that the research team is shielded from the toxic fumes produced by these compounds.

In many laboratories, ingesting chemicals is a big risk owing to contamination on hands, food, and drink. This emphasizes the significance of storing all food and drink items in a safe and secure manner, away from chemical exposure. Furthermore, all members of the research team who are exposed to hazardous substances should have access to complete hand-washing and sanitation facilities.

Electrical Hazard:

When dealing with electricity, even the most seasoned research worker can miss basic safety standards, therefore it's critical to take precautions throughout the lab. Electrical units near liquid are more dangerous, so they should be equipped with ground-fault circuit interrupters to cut the circuit if any current flows to ground.

Another typical laboratory hazard is electrical fires, which can occur when improper or unsafe cords and plugs are utilized. Before they are employed in the laboratory, all electrical equipment should be fit for purpose, up to date, and correspond to connected devices. Any electrical apparatus that hasn't been safety inspected, from adaptors to cables, could jeopardize the lab's and research team's safety.

Biological Hazard:

In the lab, the use of bacteria, viruses, blood, tissue, and/or physiological fluids might result in biological risks. All of these items have the potential to carry illness or dangerous allergies, putting the lab crew at risk. The consequences of illnesses and allergens can be instantaneous or take a long time to appear, emphasizing the significance of providing adequate protection to all members of the lab team, even if the threats are unknown. Viruses carried by humans and animals utilized in study can be passed on to the team, who may then become carriers. This means that biological risks could pose a serious threat to not only lab workers handling the materials, but also to everyone they come into touch with outside of work. Biological hazards (biohazards) are among the most dangerous threats in today's research labs; thus, every precaution must be taken to ensure that the team and the general public are safe from contagious materials.

Physical Hazard:

And, with so many distinct risks at play in today's lab, it's easy to ignore the more mundane physical dangers. In busy, buzzing labs, trip hazards and mishandling blunders abound.

Handling is a primary concern for all lab managers, with members of the research team at risk of injury if proper handling procedures are not followed. The health and safety of members of the research team can be jeopardized by hot, heavy, and sharp apparatus. This necessitates the provision of complete and appropriate handling equipment, such as safety gloves. Furthermore, proper lifting training should be provided so that the entire crew can lift and carry without danger of damage.

Because of the length of time researchers spend on their feet and the variety of materials present, laboratory slips, trips, and falls are more common than in many other jobs. To safeguard themselves and other members of the team, every member of the team must exercise due care and attention in reducing the existence of slip and trip hazards. All essential and non-essential objects kept in the laboratory must have enough storage space to keep them out of the way of the crew.

Finally, the modest glass tube is possibly the most ubiquitous of all hazards and threats in the science lab. When inserting a rubber stopper into a glass tube, many a seasoned lab expert has sliced their finger or hand. While this may always happen, the risk can be lowered by encouraging proper stopper replacement by applying light pressure while rotating the glass tube.

2.5.4. Challenges in applying safety management in HLI laboratories

Academic research risks are frequently viewed as being significantly lower than those connected with large-scale process industry activities. While stocks of hazardous materials and the quantity of risks may be reduced in the university setting, factors such as laboratory building materials and researchers' proximity to their equipment may result in significant individual risk for lab personnel. The number of recorded lab incidents that have resulted in fatalities, serious injuries, and financial losses shows that stronger risk management techniques are needed in academic teaching and experimental research labs around the world.

Universities' academic and research facilities contain a wide range of dangers, and the risks connected with these hazards can be severe if they are not effectively controlled. Because of a lack of hazard awareness, the misconception that university labs have "low risks" and "inherently safer" persists within and outside academia (Olewski & Snakard, 2017).

2.6. Strategies in managing safety-audit in Higher Learning Institutions (HLI) laboratory

For laboratory administration, there is already a complete legislative structure in place. This framework demands businesses to plan and manage their actions in order to foresee and prevent situations that could lead to workplace injury, illness, or environmental harm. This chapter aims to help firms enhance their safety performance by providing information on how to combine safety management with other elements of the business.

Many aspects of good safety management are similar to management approaches promoted by quality assurance and business excellence advocates. The safety self-audit is based on general management concepts and is intended to incorporate safety management into an entire management system that includes laboratory personnel. Safety hazards are controlled in a systematic proactive manner by implementing a safety self-audit.

Some aspects of safety management, such as policies and risk assessment records, are already in place in many firms, while others must be developed. It is critical that the safety management system incorporates all of the features listed above. Individual elements' use depends on a variety of criteria, including the size of the organization, the nature of its activities, the threats it faces, and the environment in which it operates. All organizations that do not have an established safety management system should conduct an initial status evaluation. The scope, adequacy, and implementation of the project will be discussed in this initial status review (Laboratory, 2011).

2.7. Case Studies on Safety Audit for Higher Learning Institutions (HLI) laboratory

Department of Occupational Safety & Health (DOSH) Malaysia has established a self -audit of occupational safety and health management system under the Occupational Safety Health Act (OSHA) 1994 called Occupational Safety and Health Workplace Assessment (OSHWA) and every organization must register online and need to register the workplace using the MyKKP portal. This self -audit involves various elements related to safety and health in the workplace. This self -audit covers all aspects of safety in general. Universiti Malaya has implemented this OSHWA and collected centrally by Department of Occupational Safety, Health & Environment (OSHE UM) and sent through the MyKKP portal in 2020

While Princeton University the Office of Environmental Health and Safety (EHS) at New Jersey USA has created a Health and Safety Laboratory developed Self-Audit Checklist to make a self-audit in the laboratory. It uses a laboratory audit approach in general and gives a brief description of each element examined. The audit is conducted by a representative of Safety staff in each department.

In relation to the incident that occurred at the Universiti Malaya, based on the NADOPOD report (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) which has been reported to OSHE UM in 2021, most accidents at the Universiti Malaya are from laboratory areas and the laboratory consists from a chemistry lab. Some of the accidents reported in 2021 as shown at Table 2.2..

Table 2.1.: OSHE UM Laboratories Incident/Accident Statement 2021

No.	Date	PTj	Accident	Noted	Cause Of Accident	OSHE Follow-Up Actions
3	20-Oct 2021	UMX	Laboratory fume chamber space fire	No injury	Safe work practices are not implemented	Reminder to the relevant PTj to determine the safety aspects that need to be complied with for the relevant test or experiment
5	2-Nov 2021	Faculty of Dentistry	The X-ray machine fell on the patient	Light injury	There is no regular safety inspection system for installation of tools on the wall/unsafe installation methods	Reminder to PTj to make regular inspections involving such installations
9	19-Dec 2021	Stesen Penyelidikan Marin, IOES, UM Bachok	There was a strong and heavy rain that caused a lot of damage. Some of the dormitory roof ceiling had fallen and others almost fell. While the roof of the administration building was torn off and broken. Part of the roof of the catchment pond was torn off. While part the roof, nursery and hatchery were uprooted.	No injury	Natural disasters	Based on the information of the incident report, OSHE supported and agreed to the immediate action taken by IOES to ensure that no staff/individuals were injured during the incident. OSHE will arrange a special visit in the near future. JPPHB representative to assess the degree of damage to identify actions that need to be taken for the safety and health of staff/students at IOES

Existing safety audits are good and practicable but audits conducted by external parties or 3rd parties require specific time and cost. This can cause the existing safety environment is not monitored at all times. With the existence of this safety self-audit mechanism, safety will be monitored by the person closest to the laboratory and any non-compliance or unsafe conditions in the laboratory will continue to be reported for improvement.

2.8. Literature review summary

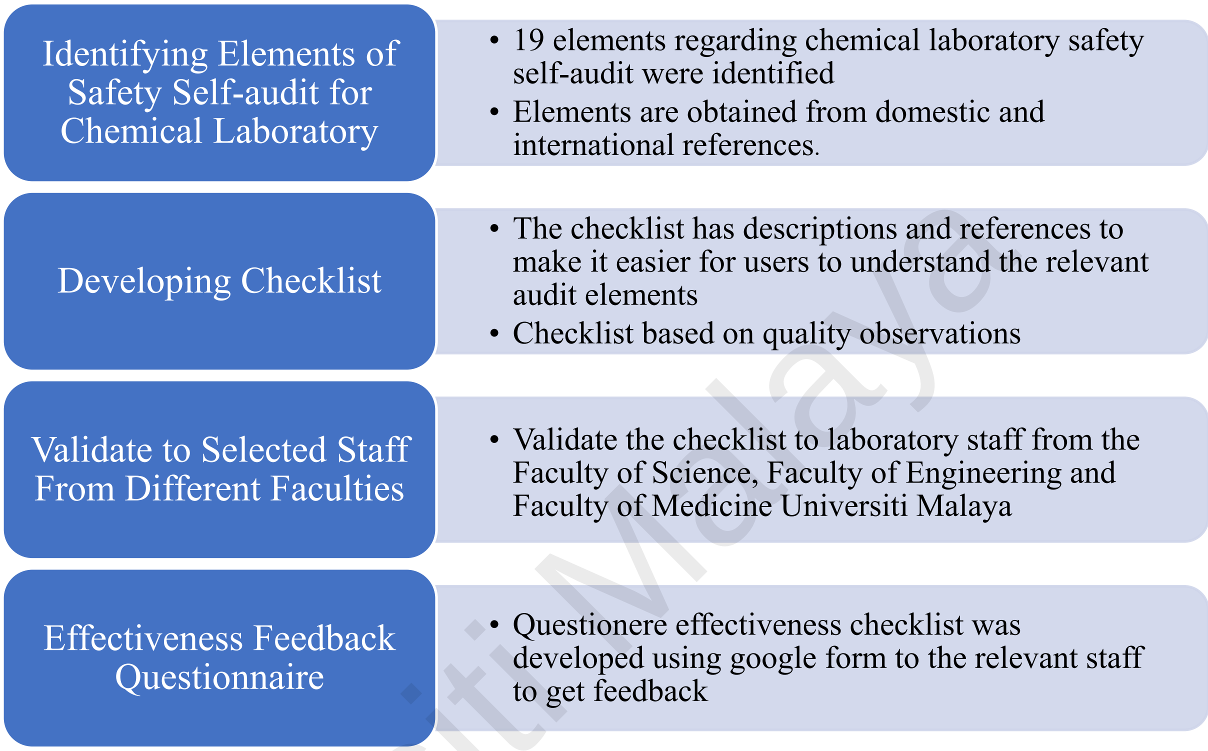
Various hazards exist in chemical laboratories will pose a risk of injury to the laboratory users. Accident/incident can happen at any time if safety is not emphasized and monitored continuously. From previous accident record, there was an accident/incident caused by unsafe condition and unsafe act in one of the laboratories in UM.

Malaysian regulations will be used as a reference for development of safety self-audit checklist. Examples of safety audit checklists from governmental organizations such as DOSH and other higher learning institutions will also be used as guidance in the development of safety self-audit checklist.

CHAPTER 3: METHODOLOGY

3.1. Overall methodology

Figure 3.1.: Overall Methodology



3.2. Identification the elements of audit

3.2.1. General work environment

The physical place where work is done, the culture that a company cultivates, and the general working conditions of employees make up a work environment. Physical space, facilities and hardware, working conditions, and business culture are all factors that influence a person's work environment (Zippia, 2021).

3.2.2. Emergency planning & Fire Safety

An emergency plan lays out methods for dealing with abrupt or unexpected events. The goal is to be ready to: Prevent fatalities and injuries from occurring. Reduce the amount of damage to buildings, inventory, and equipment (Canadian Centre for Occupational Health & Safety, 2019a).

3.2.3. Required Information/Posting

Each jurisdiction and territory's employers are required by law to post certain documents and notice to protect workers' health and safety. Employers are required by law to display this information in visible areas where workers can easily obtain it, as well as in places where it is likely to be noticed by workers (Canadian Centre for Occupational Health & Safety, 2019a).

3.2.4. Hazardous Chemical

Hazardous chemicals are substances that can cause adverse health effects such as poisoning, breathing problems, skin rashes, allergic reactions, allergic sensitization, cancer, and other health problems from exposure.

Dangerous items include a wide range of hazardous chemicals. If not handled properly, these can result in flames, explosions, corrosion, and hazardous reactions (Queensland, 2019).

3.2.5. Flammable Liquid

Liquids that can burn are flammable and combustible. The flashpoints of these materials determine whether they are flammable or combustible. At normal operating temperatures, flammable liquids will generally ignite (catch fire) and burn easily. Combustible liquids can burn at temperatures that are typically higher than operating temperatures.

For identifying flammable and combustible liquids, there are numerous technical criteria and test methods. Flammable liquids have a flashpoint below 37.8°C (100°F) according to the Workplace Hazardous Materials Information System (WHMIS) 1988. The flashpoint of combustible liquids is above 37.8°C (100°F) and below 93.3°C (200°F).

Almost every workplace contains flammable and combustible liquids. Solvents, thinners, cleansers, adhesives, paints, waxes, and polishes are just a few examples of flammable or combustible substances. Everyone who works with these liquids has to be informed of the dangers and how to handle them safely (Canadian Centre for Occupational Health & Safety, 2008).

3.2.6. Compressed Gases

A compressed gas is defined as a gas or mixture of gases having an absolute pressure exceeding 40 psi in a container at 70 degrees F (21.1 degrees C); or a gas or mixture of gases having an absolute pressure exceeding 104 psi in a container at 130 degrees F (54.4 degrees C) regardless of the pressure at 70 degrees F (21.1 degrees C); or a liquid having a vapor pressure exceeding 40 psi at 100 degrees F (37.8 degrees C).

Toxic, combustible, oxidizing, corrosive, or inert gases can all be found in compressed gas. In the event of a leak, inert gases can swiftly displace air in a vast area, resulting in an oxygen-deficient atmosphere, whereas toxic gases can produce poisonous atmospheres, and combustible or reactive gases can cause fires and explode cylinders. In addition, the pressure of the gas and the physical weight of the cylinder pose risks. A falling gas cylinder can shatter containers and crush feet. If the cylinder valve is broken, the cylinder can become a missile (System, 2021).

3.2.7. Waste Management

Waste management refers to the collection, transportation, handling, and disposal of human waste as a whole. Waste management is a broad term that encompasses all aspects of human waste management, including waste minimization (Sofeopedia, 2018).

3.2.8. Radiation Safety

Radiation safety refers to safeguarding personnel against the detrimental effects of ionizing radiation by ensuring that they are not exposed to excessive doses of radiation and monitoring all sources of radiation to which they may be exposed (Health Online Unit, 2016).

3.2.9. Noise Management

Vibrations or aerodynamic systems can cause sound to be created.

Noises caused by vibrations are made by Mechanical shocks and component friction (e.g., hammering, pressing, running gears, bearings, cutting tools, chutes, hoppers, etc.), moving parts that are out of whack (e.g., unbalanced rigid rotors), Large-scale structures vibrate (e.g., ventilation ducts, guards on machines, equipment supporting structures, etc.), Reflective surfaces that surround the gadgets may amplify the sound. Air or fluid flows through pipes and fans, or pressure drops in the air distribution system, are all examples of aerodynamic sources of noise

(Canadian Centre for Occupational Health & Safety, 2017).

3.2.10. Ergonomic

Ergonomics is a science-based profession that combines knowledge from a variety of disciplines, including anatomy and physiology, psychology, engineering, and statistics, to guarantee that designs complement people's strengths and skills while minimizing the consequences of their limitations. Ergonomists and human factors specialists aim to understand how a product, workplace, or system may be created to suit the people who need to use it, rather than expecting people to adapt to a design that requires them to work in an unpleasant, stressful, or dangerous manner (Factors, 2017).

3.2.11. Ventilation

Laboratory ventilation systems have two main goals: to create a safe, comfortable, and breathing atmosphere for all lab users, and to reduce exposure to harmful air contaminants (California, 2021).

3.2.12. Electrical Hazard

Electrical risks such as electric shock, arc bursts, electro- cautions, flames, and explosions can occur in the laboratory. Faulty electrical equipment/instrumentation or wiring, broken receptacles and connectors, or unsafe work practices can all lead to electrical dangers (United State Department of Labor, 2021).

3.2.13. Pressure/Vacuum System

Mechanical vacuum pumps, water aspirators, and steam aspirators are commonly used in vacuum systems. High-pressure systems, on the other hand, operate at pressures more than one atmosphere (WISCONSIN–MADISON, 2021).

3.2.14. Environmental Safety

Environmental safety is defined as methods, rules, and processes that safeguard the safety and well-being of anyone in the local vicinity. This can encompass everything from proper waste disposal to the containment and storage of potentially dangerous compounds (spokaneenvironmental.com, 2021).

3.2.15. Personal Protective Equipment

Personal protective equipment, or "PPE," is clothing that is worn to reduce exposure to a number of risks. Gloves, foot and eye protection, protected hearing equipment (earplugs, muffs), hard helmets, respirators, and complete body suits are examples of PPE (U.S. Department of Labor, 2004).

3.2.16. First Aid

First aid is quick medical attention given to a person who has been hurt. The goal of first aid is to prevent damage and incapacity in the future. First aid may be required in critical circumstances to keep the person alive(Canadian Centre for Occupational Health & Safety, 2018).

3.2.17. Security

The laboratory manager should train employees to follow these fundamental guidelines for working safely and securely with chemicals in the laboratory. Many chemicals, on the other hand, have the potential to damage people if they are overused, whether purposefully or unintentionally. It is the responsibility of laboratory directors to foster a culture of safety and security in the laboratory so that teaching, learning, and working can take place in a safe atmosphere.

Controlling access to buildings and laboratories is the most typical laboratory security technique. Lighting for locations where persons might access a secure area, as well as boundary walls, fences, and shrubs, window shades, and badges or other forms of identification (Sciences, 2011).

3.2.18. Training/Awareness

Every employee must be aware of the importance of safety at all times. It extends beyond what employees learn in the classroom during safety training and at morning safety briefings. In order to mitigate safety-related risks, employees must be continually aware of how they operate at work and be able to spot hazards.

Furthermore, safety awareness encompasses more than just the obvious dangers such as machines, ergonomics, and electrical safety. The term ‘safety' refers to a wide range of hazards that can result in a tragedy or accident, including physical hazards, occupational, natural, and social risks (E. I. Resources, 2018).

3.2.19. Record Keeping

For a variety of reasons, recordkeeping is an essential component of an employer's safety and health efforts: Keeping records of work-related injuries and illnesses might aid in future prevention. Data on injuries and illnesses can be used to identify problem regions (Services, 2021).

3.3. Developing Checklist

A safety audit checklist is a document used by employers to ensure that their workplaces meet industry health and safety regulations. This document is used to detect any potential hazards or risks in the workplace and to promote a safe working environment (DeviceMagic, 2021).

The checklist was developed using the concept of qualitative observation in which the user did not use any specific tools to conduct the audit. Each Description of the audit element is provided for the understanding of the user and also refers to the reference of the relevant acts and regulations.

3.4. Validation of mechanism

Meetings with staff are arranged. A description of the safety self-audit mechanism for chemical laboratories is done to understand the user or laboratory supervisor. The user or laboratory supervisor was given several days to complete the safety self -audit trial using the constructed checklist. Once the checklist is collected, observations of the answers are made and any suggestions for improving the checklist from users are taken into account.

Six (6) laboratories were selected for validation of this self-audit safety mechanism. The laboratory is selected from 3 different faculties but is a laboratory involved with the use of chemicals. The faculties are Faculty of Science, Faculty of Medicine and Faculty of Engineering. Details of laboratories by faculty are as shown at Table 3.1..

Table 3.1.: Laboratories Detail

No.	Faculty	Laboratory Name	Research or Teaching	Maximum Capacity (Staff & Student)	Major Equipment
1.	Science	Makmal Sains Biokesihatan 1,2 & 3	Teaching	40	Fume Hood, Autoclave, Rotary Evaporator, Centrifuge, Microscope, Laminar Flow.
2.	Science	Makmal Histo Teknik	Research	10	Fume Hood, Microscope,
3.	Science	Makmal Mikrobiologi Molekul dan Toksikologi	Research	10	Fume Hood, Autoclave, Centrifuge, Biosafety Cabinet.
4.	Medicine	Makmal Kaji Tisu 2	Teaching	6	Microtome, Water Distiller.
5.	Medicine	Makmal Penyelidikan 3	Research	7	Chemical room
6.	Engineering	Makmal Termodinamik	Teaching	15	Fume hood, HPLC, ICP OES.

3.5. Safety aspect during validation of checklist in case study laboratory

During checklist validation is made in the selected laboratory. The safety aspect is emphasized to all involved. Before entering the laboratory, each person will be required to wear complete PPE such as face mask, covered shoes and lab coat if the laboratory is conducting a chemical experiment. Face masks are required because at the time of validation is the COVID-19 Pandemic period.

Laboratory safety briefings were given by the laboratory supervisor on action in the event of an emergency such as fire, emergency telephone number, position of fire extinguisher and position of first aid box. Air condition and exhaust fan are turned on to ensure general ventilation in the laboratory works properly.

After all safety warnings have been delivered, a checklist is used and each safety element of self-audit is inspected in the laboratory. The checklist is attached at the APPENDIX A.

3.6. Data analysis from distribution of checklist

An appointment is made with the person in charge of the laboratory to agree on the date of the visit, this is to ensure the visit time no classes are in progress. During the visit, laboratory users were briefed on the purpose of safety self-audit, and a description of each element was given. Users are given time to examine each given element. After the information on the checklist, a walk-through visit in the laboratory was done to identify the hazards and research the laboratory area. Users are given one (1) week to complete the checklist provided. After the checklist is submitted by the user, a satisfaction questionnaire and suggestions for improvement are given in google form. Questionnaire developed to elicit feedback from users' safety self -audit is used to improve the checklist. Google form will be used as a questionnaire.

CHAPTER 4: RESULTS AND DISCUSSION

The safety self-audit checklist was successfully constructed using 19 audit elements comprehensively. Each element has a number of sub-elements and a specific description. Acts and regulations applicable in Malaysia are also used to provide a comprehensive understanding to checklist users. Each answer from the user and followed by a comment is intended for an explanation in the event of non-compliance or the absence of an element or sub -element in the laboratory.

4.1. Checklist users

Based on the objectives of the study, this safety self-audit checklist was created to provide exposure to users of chemical laboratories in conducting safety audits on their respective laboratories. This method can provide an awareness and sensitivity to safety issues in the laboratory for daily use and for the preparation of external audits that may be conducted. So, the users of this safety checklist are the lab users themselves.

4.2. Use of checklist

Laboratory users need to prepare this checklist in hardcopy and need to go through a walk-through visit in the laboratory to do safety self-audit. Users need to mark 'Y' for Yes if they agree with the given description and 'N' for NO if they do not agree. 'NA' stands for Not Applicable if the laboratory has nothing to do with the given description. Comments are provided if there is any additional information that needs to be specified by the laboratory person in charge.

Safety Self-audit requires only one auditor who is the staff of the laboratory. This facilitates the audit work because the staff knows all the ins and outs of the laboratory and all the information about the laboratory is easy to find and access. With this, the audit time is shorter compared to audits conducted by external parties which require more auditors and need to ask questions to some laboratory users for the laboratory information. To perform this self-audit, supporting documents are not required as each component provided is accompanied by a reference and if the reference is not available, the auditor needs to revert to the basic act for safety i.e., section 15 OSHA 1994 on the role of employers to keep the workplace and employees safe.

The recommended audit frequency is four (4) times a year to ensure that the safety rate in the laboratory is in optimal condition.

4.3. Objective of audit

The objective of the audit conducted by the users of the laboratory itself is;

a) To learn about safety in the chemical laboratory

b) An initial step in ensuring that safety in the laboratory is monitored and supervised while awaiting a more expert external audit.

4.4. Scope of Audit

This self-audit only focused on the chemistry laboratory under the care of the staff. So, each laboratory staff has at least 1 laboratory to conduct safety self-audit.

4.5. Safety Self-audit Mechanism for chemical laboratories

The safety self-audit checklist has nineteen (19) elements to be scrutinized and checked by chemical laboratory users. It forms a mechanism in which each element describes in detail the element to be examined and is guided by relevant references. This checklist should be reviewed and verified by the department or program coordinator for the laboratory. The proposed frequency of inspections is quarterly meaning four (4) times a year. with this if there is a small occupational health safety meeting in the department, the issue regarding the problematic chemical laboratory can be raised.

4.5.1. General Work Environment

For this element, it is divided into several subs which have their own descriptions. Work areas are well-lit. Appropriate illumination should be provided depending on the work at hand. Recommended lighting requirements for laboratories in the range of 500 lux. As references from Occupational Safety and Health (OSH) Guidelines for Workplace Lighting. Storage of combustible materials is kept to a minimum. Keep storage and materials that would add fuel to a raging fire to a minimum. Paper items, plastic containers, things housed in boxes, and empty containers are all examples. The relevant reference is Section 15 (2)(a) OSHA 1994 & Section 11 (Safety, Health & Welfare) FMA 1967.

Wastes are disposed regularly. Trash removal should be done at least once a day, which is the duty of Building Services. Aisles and corridors were kept free of obstructions. Surfaces that are wet are coated with a non-slip substance. Heavy objects should be kept on the lower shelves. This is all self-explanatory.

For Sharp object, user need to reduce exposure to sharp objects or use relevant personal protective equipment when dealing with sharp objects. Hot surface for example hot plate, oven etc. It needs to place in a suitable location away from flammable materials. A warning symbol is shown.

Accessibility to the shelves above shoulder level. Where things are housed above shoulder level, a warehouse ladder, step stool, or other appropriate methods should be provided. The relevant reference is Section 10 (Safety, Health & Welfare) FMA 1967. Storage at least 18 inches below sprinkler head as refer to Uniform Building By-Laws 1984. Without a sprinkler system, storage must be at least 24 inches below the ceiling in any space. Laboratory exits, illuminated signs working, paths that are not blocked, there are alternative exits accessible, fire doors are not obstructed or stuck open in any way and doors not locked which is during normal business hours, exit doors, particularly those that open directly from lab spaces onto stairwells, must not be locked. After hours, security measures are permitted with the agreement of the local fire officer.

For certain materials, security/controls are required. Access to some items, such as control chemicals, is restricted by sophisticated security systems or controls.

Covered or secured pits and floor openings to prevent falls, every floor opening or pit that is deeper than 4 feet must be closed or guarded (i.e., barriers, railings, etc.). Lastly for general work environment is the pest control which is needed to periodically conduct a pest control or when required. Findings from audit activities are as in Table 4.2..

4.5.2. Emergency Planning & Fire Safety

In term of facilities aspect, Extinguishers are placed near the doorway. Unobstructed access to fire extinguishers. Fully charged fire extinguisher where pressure gauges are seen on some types of fire extinguishers. Make sure the extinguisher is completely charged by checking these. Only trained Building Services staff can inspect fire extinguishers without pressure gauges. A tamper indicator for fire extinguishers has been installed, contact Building Services if the fire extinguisher tamper indicator is missing. Eyewash and safety showers are conveniently located and unobstructed. Unobstructed fire alarm pulls stations / break glass. Emergency lights functional, on the power supply of the unit, press the self-test button.

In term of inspections aspect, inspection of the fire extinguisher, Building Services should test fire extinguishers on a monthly basis and record the results on an inspection card. Inspection of self-contained breathing apparatus (SCBA), At least once a month, self-contained breathing devices must be inspected. Special Facilities (Maintenance) staff are normally in charge of these inspections. If your laboratory area's SCBA hasn't been inspected, contact them. Eyewash and a safety shower have been tested, at least twice a year, eyewash and safety showers should be evaluated, with the results noted on the attached inspection card. Special Facilities (Maintenance) staff conduct inspections.

In term of procedures, plan for spill containment has been finished, it is critical to plan ahead of time when dealing with a chemical spill. For each laboratory, a detailed Spill Control Plan should be available, taking into account the volumes and types of chemicals used or stored in the lab. Spill-control products should be readily available and sufficient to cover any potential spills, spill control materials that are appropriate for the type and amount of chemicals used or stored in the lab should be available to lab staff. Spill control products are kept in a central place in several departments.

All of the above regarding Emergency Planning & Fire Safety are referenced from Section 15(2)(d) OSHA 1994 & Fire Service Act 1988. Findings from audit activities are as in Table 4.2..

4.5.3. Required Information and Posting

In term of information, Emergency Action Plan in writing, every department must have an Emergency Action Plan that outlines processes for emergency reporting, escalation pathways, and staff assembly and responsibility as refer to Section 15 (2)(b) OSHA 1994. Safety Data Sheets (SDS) easily obtainable, each laboratory must keep the Safety Data Sheets (SDSs) that come with chemical shipments as stated in Regulation 5 USECHH 2000. In the lab, there is a written Chemical Hygiene Plan, each department is required to develop and maintain a Chemical Hygiene Plan that includes information on hazard communication, exposure determination, medical consultation and exams, training and information, safe work practices and procedures, and provisions for working with particularly hazardous substances. Personal protective equipment and exposure controls, fume hoods and ventilation, emergency procedures, waste disposal, and facility-specific systems and response plans are all things to consider. Each laboratory must have a copy of the Chemical Hygiene Plan on hand at all times, it all to make sure safety in the lab as refer Section 15 (2)(b) OSHA 1994. Respiratory Protection Program in writing, if respirators are used, including self-contained breathing apparatus, the department must have a written Respiratory Protection Program that outlines the procedure for respirator selection, medical evaluation of respirator user health, training, proper fitting, respirator inspection and maintenance, and recordkeeping. Personal Protective Equipment Hazard Assessment and training documentation, to identify which forms of personal protective equipment (e.g., eye and face protection, gloves, etc.) should be utilized, departments must conduct a hazard assessment. Workers must get proper training in the selection and usage of personal protective equipment. It is necessary to keep track of the danger assessment and training as stated Regulation 16 USECHH 2000.

Posting is required in safety, Emergency Information Posters accurate and current, emergency contact information and specific laboratory dangers must be posted at each laboratory's main door for use by emergency responders. OSHE provides emergency information posters and instructions for completing them. OSHA poster, a poster labelled Job Safety & Health Protection, also known as "the OSHA poster," must be prominently displayed where employee notices are normally posted. 5S poster, maintaining an organized workplace and employing visual signals to achieve more consistent operational results has been shown to reduce waste while increasing productivity. Posting of emergency phones, emergency contact information and specific laboratory dangers must be posted at each laboratory's main door for use by emergency responders. Posting of laboratory person in charge and organization chart, posted at each laboratory's main door for use by emergency responders. Posting of

Building Evacuation Routes, as part of the Emergency Action Plan, it is recommended that evacuation routes be posted. Postings of ice-making machinery this product is not suitable for human consumption, ice from devices designed to provide ice for scientific research. Because such ice has the potential to be chemically or biologically polluted, it should not be consumed. Signs should be placed near the equipment to indicate that it is being used for a certain purpose. Permits for the Fire Code have been posted (when required), according to the local fire official's instructions included with the permit, a copy of the fire code permit must be posted. All of the above is to keep the workplace safe based Section 15 (2)(c) OSHA 1994. Safety signage such as PPE signage, chemical hazard, emergency signage and other related as stated to Regulation 29 USECHH 2000. Findings from audit activities are as in Table 4.2..

4.5.4. Hazardous Chemical

Consists of several sub -elements namely labeling according to the Occupational Safety and Health Regulations (CLASS) 2013. Risk control, all controls according to CHRA report as there are SOPs for the use of chemicals and trained workers, or there is appropriate PPE provided to employees, or install engineering controls & maintain according to schedule, or Control is implemented based on a hierarchy of control, or control based on HIRARC/JHA/JSA that has been developed as stated Regulation 15 USECHH Regulations 2000. Warning sign, white background of red writing on warning sign as stated Regulation 29 USECHH Regulations 2000. Storage, there is a store room dedicated to chemicals, and chemicals need to be separated from other items, and

Safety Data Sheet (SDS), and fire extinguishers are provided, and warning signs according to hazard category, and control systems are provided such as: bund wall, leak alarm (leak detector), eye wash, emergency shower and others, and good ventilation system. Safety Data Sheet (SDS), chemicals are ensured to have a safety data sheet (SDS) from the chemical supplier, displayed near the chemical and readily available as stated Regulation 24 USECHH 2000 & Regulation 13 CLASS 2013. Scheduled waste, there is a store room dedicated to scheduled waste, and scheduled waste should be segregated with other items, and scheduled waste information and chemical Spill kits are provided, and warning signs according to hazard category, and control systems are provided such as: bund wall, leak alarm (leak detector), eye wash, emergency shower and others, and good ventilation system based on Section 34 (b) EQA 1974 & Environment Quality (Scheduled waste) Regulation 2005. Findings from audit activities are as in Table 4.2..

4.5.5. Flammable Liquid

Suitable for use in a fume hood or a well-ventilated location. Refrigeration units permitted for the storage of flammables; refrigerators intended for residential usage should not be used to store flammable liquids. Instead, a refrigerator for flammable items should be used & refrigerators that are explosion-proof are not required. Strong oxidizers were segregated from flammables. A fire extinguisher of class ABC or BC is available, Flammable liquids should be labelled with a "B" class designation. Flammable liquids should not be kept near hot plates or other sources of ignition, while this is true for all container types, it is extremely dangerous when flammable substances are squeezed into plastic squeeze bottles in hoods with hot plates. Findings from audit activities are as in Table 4.2..

4.5.6. Compressed Gases

Used in a well-ventilated environment. In a fume hood, toxic, flammable, and corrosive gases are employed, this is not a reference to the cylinder itself. Instead, the gas should be delivered through a fume hood. Minimized storage amounts, the quantity of compressed gas cylinders on hand should be consistent with the lab's short-term needs, just as it should be with other chemicals. When in use, it is kept from tipping over, while in storage or usage, compressed gas cylinders must be safely secured in an upright position. Gas cylinder-compatible regulators, Regulators are made to work with specific gases and at specific pressures. regulators' cylinder valve outputs and inlet connectors are designed to reduce the risks of selecting the incorrect regulator. The wrong regulator is being used if the connections do not fit together easily. For transportation, cylinder carts are employed, large compressed gas cylinders are cumbersome to transport. The process of moving cylinders is made easier and safer with a cylinder cart. Valve caps are in place to protect the valves, valve caps should be placed on cylinders that do not have associated regulators. Gas cylinders that are empty or unusable must be returned to the provider as soon as possible, it's tough and expensive to get rid of old cylinders. Findings from audit activities are as in Table 4.2..

4.5.7. Waste Management

Except during the transfer, containers are maintained sealed, all trash containers must be sealed, except during transfers. Hazardous Waste containers with the words "Hazardous Waste" on the label. Constituents of the waste described on the container label, contents and approximate % composition must be listed on containers. The common or IUPAC chemical nomenclature should be used. Avoid using symbols or structural formulas and this is related to Environment Quality (Scheduled Wastes) Regulations 2005. Acutely hazardous waste storage is limited to 1 quart, within a lab work space, no more than one quart of "acutely hazardous waste". Secondary containment and segregation for the chemical waste / schedule waste, incompatible chemical wastes (strong acids and strong bases, organics and oxidizers, and so on) must be separated into separate secondary containers. They must not share a secondary containment tray or tub to comply Environment Quality (Scheduled Wastes) Regulations 2005. Glass chemical containers are recycled according to industry standards, a system for disposing of empty glass chemical containers has been devised to promote recycling and reduce waste disposal expenses. Broken glass can be disposed of in separate containers, Broken laboratory glassware should be disposed of in a cardboard Glass Waste receptacle or as Medical Waste. It should not be recycled or thrown away as laboratory waste. Containers that can handle garbage, chemical containers should be made of materials that will not be harmed by the chemicals that are kept within. Glass will be etched by hydrofluoric acid. Many metals are corroded by acids, and certain organics are softened by them. Findings from audit activities are as in Table 4.2..

4.5.8. Radiation Safety

Radioactive symbols are displayed, used on sealed radiation sources, is aimed at alerting anyone, anywhere to the danger of being close to a strong source of ionizing radiation. Area classification marks are displayed, to determine the boundaries of each area (clean area, supervised area and controlled area) for implementation of radiation protection and safety procedure based on magnitude of potential radiation exposure. Radiation detectors are ready to use and are on schedule, Sense and measure radiation emissions or levels of radiation produced by a source. To measure external radiation levels and contamination levels at specified places, times and frequencies to evaluate the radiological conditions from radiation source. Exposure dose examination personnel/area as per schedule, assessment and personal monitoring of occupational exposure received by workers using personal dosimetry approved by authority. Use armor and safety equipment lead apron to reduce the dose of exposure received by workers, to reduce the dose of exposure received by workers. Need to consider any additional exposure that could result in the additional time or inconvenience that might be associated with performing the task while using protective equipment. Workers working with radiation registered with the Licensing Board Atomic Energy (LBAE) as Radiation Workers (except students), no worker, unless duly authorized by the licensee, shall interfere with, remove, alter or displace any safety device or other equipment furnished for his protection or the protection of others, or interfere with any method or process adopted for the control of exposure to ionizing radiation. Unused radioactive material, stored in lead containers in the store, lead is highly effective in providing protection from sources of radiation. Radioactive material / irradiation apparatus license is contras display, the license determine that the radiation source is justified and authorized to use within a practice that produce sufficient benefit to the exposed individuals or to society compare to the radiation harm that it might cause. All of the above are guided by Radiation Protection Program, Atomic Energy Licensing Act 1984 and Atomic Energy Licensing (Basic Safety Radiation Protection) Regulations 2010. Findings from audit activities are as in Table 4.2..

4.5.9. Noise Management

Risk control, has taken ONE of the following control actions namely noise source (Removal/Replacement), sound intermediaries (Engineering control/Administrative control), noise receiver (Administrative control/PPE) as refer to Occupational Safety & Health (Noise Regulations) 2019. Warning sign, Noisy work areas are marked with warning signs. Findings from audit activities are as in Table 4.2..

4.5.10. Ergonomic

Employers identify ergonomic problems, among the examples of ergonomic problems and manual handling such as repetitive motion, or Forceful exertions, or Awkward Posture, or Static posture (static posture), or Tactile stress (contract stress), or Temperature Extremes, or Vibration with Scoring notes if the employer has identified the problem = 'YES', if the employer does not identify the problem but there is a problem = 'NO', if the employer identifies no problem and is confirmed by the examiner = 'NA' as refer to Guidelines for Manual Handling at Workplace 2018.

Control measures, workstations are designed taking into account ergonomic factors, or the seat is height adjustable with back support, or the computer is equipped with a screen protector or low radiation, or other ergonomic related control measures. Findings from audit activities are as in Table 4.2..

4.5.11. Ventilation

Each chemical fume hood has been thoroughly examined annually by IHT2 and monthly by user, every twelve months, IHT2 inspects and grades each chemical fume hood. The most recent survey results are shown on the hood face. Monthly checklist by user every month based on Regulation 17, 18 USECHH 2000. Unobstructed fume hood vents (baffles), at the back of the work surface, there are exhaust slots. Airflow can be hampered and containment compromised when containers and equipment are obstructing it. Fume hoods are worn with the sash in the proper position, hood sashes should be lowered when not in use. Sashes should be positioned at or below the position stated on the Standard Operating Configuration label posted on the hood face during chemical manipulations. In actively utilized hoods, chemical storage is strictly limited, Materials should not be stored under an operational hood. A chemical accident is more likely to happen in the hood than anywhere else in the lab. The presence of stored items can enhance the risk of a more significant event. Other local exhaust devices (such as gas cabinets and elephant trunks) were also examined by IHT2, check for proper operation of gas cabinets, elephant trunks, and other local exhaust ventilation utilized to manage airborne pollutants. Cabinets for Laminar Flow were published, in laminar flow cabinets that are not connected to the building exhaust ventilation system, volatile organics or dangerous gases should not be employed as referred American Conference of Governmental Industrial Hygienists (ACGIH). Findings from audit activities are as in Table 4.2..

4.5.12. Electrical Hazards

Cords that are flexible and in good working order, frayed wires or torn insulation in electrical cords pose a substantial risk of electrical shock and fire. Any electrical cord that is damaged should be replaced or repaired. Cover plate for outlets and switches in position, to prevent unintentional contact with electrical wiring, cover plates must be fitted on all electrical outlets and switches. Unobstructed circuit breaker panels, circuit breaker panels must have a clearance of at least 30 inches. Access panels for machines and instruments are in place and electrical conductors are not exposed (50 volts or more). Overload protection is built into multiplug adapters, the usage of unfused multiplug adaptors is prohibited. There were no extension cords used, extension cords should not be utilized as a substitute for permanent wiring; additional electrical outlets should be provided to meet equipment needs. For wet/outdoor application, ground fault circuit interrupters (GFCI) are utilized. Electrophoresis device guards and coverings, electrophoresis equipment that operates at 50 volts or higher should be protected with guards or coverings. The majority of new devices come with coverings. Shields made of Plexiglas or another suitable material can be used to protect older gadgets that may not have covers. All above can refer to Section 15 (2)(a) OSHA 1994. Findings from audit activities are as in Table 4.2..

4.5.13. Pressure/Vacuum Systems

Properly designed system components, system design documentation should be easily accessible. Provided and examined pressure relief devices, self-explanatory, Take into account the effects of pressure-relief discharge locations. Corrosion prevention is taken into account, internal corrosion is one of the most typical reasons for failure. Operating procedures are available in writing and a procedure for inspection and maintenance has been established. Documented failure analysis and hazard control, all failure modes and their corresponding controls should be documented and made available. Shielded/enclosed glass vessels and operators who have been trained and approved. All above can refer to Section 15 (1) OSHA 1994. Findings from audit activities are as in Table 4.2..

4.5.14. Environmental Safety

Air; Processes and operations on the premises are independent of unhealthy and harmful air emissions. Premises are free of products or materials that can produces uncontrollable dust or fibers. All sources of emissions into the air have been authorized (if required). Processes on the premises involving metal heating and fuel combustion equipment that emit dust, solid cumin, soot, ash have taken appropriate control measures at the point of discharge including air pollution control system equipment. Equipment or equipment related to air pollution control is monitored performance to ensure that it runs and operates properly. No open burning was carried out. All above refer to Regulation 7, 9, 10, 21; P.U (A) 151 Environmental Quality (Clean Air) Regulations 2014

Water; The flow of effluents containing any parameter (Fifth Schedule) to the ground, water surface including rivers, streams and lakes or underground is controlled and does not exceed the permissible limits. Water has been treated in any way prior to discharge to prevent oils and harmful chemicals from entering the drainage system. All drainage from the premises is in good condition and channeled to permitted places. All inadvertent spills or discharges are recorded and records are kept properly. All above refer to Regulations 11, 12, 13, 20; EQA 1974, P.U (1) 434 (Regulations Environmental Quality (Industrial Effluent) 2009. Findings from audit activities are as in Table 4.2..

4.5.15. Personal Protective Equipment

Body protection like a lab coat ("Lab coat"), "coverall" or others available as refer Regulation 32, Factories and Machinery (Safety, Health and Welfare) Regulations 1970. Wherever needed, eye and face protection are accessible; Goggles and face shields for corrosives chemical, for flying particles, wear industrial safety eyewear. Consult the department's Personal Protective Equipment Hazard Assessment to determine the appropriate eye protection. Areas where eye protection is required are marked, eye Protection Required signs should be put at the entrance to the area where eye protection is required. In regions where corrosives are utilized, open toe shoes are forbidden. Respirator use; Appropriate respirator and cartridge were used, a user who has signed up for a respiratory protection programmed. Respirators, as well as their cartridges and filters, come in a variety of styles. For protection against the anticipated concentration of the hazardous material, the right mix of respirator type and cartridge or filter is required. Findings from audit activities are as in Table 4.2..

4.5.16. First Aid

First aid kit is provided, Complete, easily accessible and the ingredients in it are endless period, any medicines are prohibited to be placed in the first aid kit in accordance with the guidelines for the preparation of the first aid kit as refer to Regulation 38, Factories and Machinery (Safety, Health and Welfare) Regulations 1970. Findings from audit activities are as in Table 4.2..

4.5.17. Security

The lab's doors open, close, and lock appropriately, it self-explanatory. Problems should be reported to the Maintenance Supervisor. Windows function properly when they open, close, and lock, it self-explanatory. Problems should be reported to the Maintenance Supervisor. The alarm systems are in good working order, if at all possible, test any alarm systems. Keys and access cards are stored in a safe, out-of-sight location, to help avoid theft, keep keys and access cards out of sight. Notify the Department Manager right away if you lose your keys or access cards. Findings from audit activities are as in Table 4.2..

4.5.18. Training/Awareness

Training; Laboratory Safety Training has been completed by the employees. OSHE requires that all laboratory personnel (including faculty, staff, graduate students, and undergraduates who work independently) complete Laboratory Safety Training. Induction, Once for ALL employees (Record of Attendance). On-Job Training, attendance Record (Refers to SOP implementation training). ERP, training records that include first aider/ fire fighter/ fire drill/ use of ERP equipment and how to act during an emergency (emergency exit plan, gathering place, emergency telephone number, etc.) as refer to Section 15 (2)(c) OSHA 1994 and Fire Service Act 1988. Laboratory safety and handling of hazardous chemicals, training related to ergonomic management is implemented every (2) years. (Refer to record) as refer Regulation 23 (3)(a) USECHH 2000. Ergonomic management, training related to the handling of hazardous chemicals is conducted every (2) years. (Refer to record). Noise exposure management, training related to noise exposure management is implemented every one (1) year to employees who are exposed to 'excessive noise' as refer to Occupational Safety & Health Regulation (Noise Exposure) 2019. Training to contractors, visitors and others other than employees, training records such as safety briefings or others as refer to Section 17 OSHA 1994.

Emergency Action Plan Training has been completed by employees, The department shall train all personnel within a department or building on the Emergency Action Plan. These covers notifying public safety in the event of a fire or injury, as well as what to do if a fire alarm goes off (evacuation routes, where your group is to congregate, accounting for all building occupants, etc.) For more information, consult the department's documented Emergency Action Plan. Laboratory security training has been completed by employees, all laboratory workers must either attend Public Safety's Laboratory Security training or finish the on-line training available on the Public Safety website. Workers have gone through a lab orientation, all laboratory workers should be given a tour of the facility, which should include information such as where the Chemical Hygiene Plan is kept, how to use laboratory equipment, how and when to use personal protective equipment, where emergency equipment such as eyewashes and safety showers is kept, who to contact in an emergency, where SDSs are kept, spill control procedures, emergency procedures, and incident reporting. Workers have received additional training in addition to SHE training, the Laboratory Requirement SHE provides generic training that does not include specific chemicals or experimental procedures, departmental personnel must provide further training. There is documentation of training, all training, must be documented. The laboratory worker's records must be retained.

Awareness; these questions could be asked of a sample of laboratory personnel to determine their degree of knowledge on health and safety issues. Additional training may be required based on their responses to these questions. OSHE may be able to help the department establish such training. What to do in the event of a disaster, such as a fire or an injury, as well as evacuation routes, information on emergency response, such as evacuation routes, phoning, and assembly sites, should be provided in departmental Emergency Action Plan training. How to deal with a chemical spill, Workers in the lab should be aware of where spill control materials are kept and how to use them. Laboratory safety training covers the fundamentals of clearing up chemical spills. On request, OSHE can provide a more comprehensive training session for departments or groups. The location of the Chemical Hygiene Plan and its components, during

Laboratory safety training, a brief overview of the contents of the model Chemical Hygiene Plan is provided. The department must provide more particular information. The department's Chemical Hygiene Officer and Safety Manager, during laboratory safety training, a list of Chemical Hygiene Officers for various departments is reviewed, and the department should confirm it. The Department Manager is usually also the Departmental Safety Manager in most departments. What is an SDS and where can I find one, as well as other safety information, during Laboratory Standard training, an overview of the types of information available in MSDSs is given. Departments must describe where SDSs can be found as well as the procedure for obtaining and maintaining SDSs within their own organization. When to use personal protection equipment and what kind to use, in Laboratory Safety Training, general information about the usage of personal protective equipment is presented. The department must provide explicit information regarding what personal protective equipment must be used for certain chemicals or processes. What is the best way to dispose of chemical waste, In Laboratory Standard training, chemical waste processes are examined. The department must clarify specific departmental or laboratory practices. What are the most hazardous products utilizing, and how should handle them, chemical waste processes are looked at in Laboratory Standard training. Specific departmental or laboratory procedures must be clarified by the department. If any of the lab's materials contain carcinogens, highly toxic agents, or reproductive toxins. Have filled out a prior approval form if that's the case, carcinogens, extremely toxic compounds, and reproductive poisons are among the most dangerous chemicals? Within the department, a previous approval process should be in place. Completing a form and obtaining specific approval from the Principal Investigator and/or Chemical Hygiene Officer may be part of this process. Where should safety showers and eyewash stations be used, and how should they be used, before an emergency arises, lab staff should know where to look for emergency equipment. To interrogate uninvited visitors in the lab, the Laboratory Security Policy requires that visitors be questioned to confirm that they are at the facility for legitimate reasons. Any concerns should be brought to the attention of Public Safety. The Laboratory Security Policy's contents. If there are any unlawful research activities going on in the lab, without the knowledge and agreement of the appropriate Principal Investigator, any research or other activity requiring the utilization of lab space, materials, or equipment are strictly banned. If you break this rule, you could face disciplinary action, up to and including termination. Public Safety should be notified of any odd or suspicious situations or security events. Findings from audit activities are as in Table 4.2..

4.5.19. Record Keeping

Risk Assessment, Tick Yes, if: A risk assessment is made for all activities (including confined space work). For example: HIRARC / JSA / other risk assessment methods. Tick No, if: No risk assessment performed / incomplete assessment / only performed for some activities / no risk assessment for confined space work as refer to Section 15 OSHA 1994.

Hazardous chemicals; List of Hazardous Chemicals, all hazardous chemicals are registered. Risk Assessment Report for Chemicals Hazardous to Health (CHRA), made by the Clamp and if there is a change of processes and chemicals as well as every 5 years need to conduct a re - assessment. Chemical Exposure Monitoring, based on the clamp recommendations in the CHRA. Engineering Control, based on the clamp recommendations in the CHRA. Medical Surveillance, Medical Transplant Coverage. Safety Data Sheet (SDS), all hazardous chemicals must have an SDS. All above refer to USECHH 2000. Scheduled waste, all scheduled waste information is listed according to EQA 1974 (Scheduled waste) 2005.

Noise Exposure Management; Noise Risk Assessment, Noise Risk Assessor. Tick no, if: Does not conduct a Noise Risk Assessment by the Noise Risk Assessor. Mark NA, if: The workplace is free of excessive noise. Note that a noise risk assessment is carried out if the results: Excessive Noise Identification Checklist indicate there is excessive noise. Excessive Noise in ICOP for Management of Occupational Noise Exposure and Hearing Conservation 2019. Excessive Noise means the Daily Noise Exposure Level exceeds: Leq-82 dB (A), or Daily self -noise dose - 50%, or Max SPL - 115 dB (A), or Peak sound pressure level - 140 dB (C).

Audiometric Test, Mark Yes, if: Audiometric tests are conducted annually on employees who are exposed to excessive noise in excess of the noise exposure limit. Based on the recommendation of a competent person. Audiometric Testing is conducted by an Audiometric Testing Center approved by DOSH; and the audiogram is interpreted by an Occupational Health Physician.

Mark No, if: Do not perform audiometric tests. Mark NA, if: The workplace is free of excessive noise. There is no need to perform audiometric tests as no worker is exposed to excessive noise beyond the noise exposure limit. Note: Noise Exposure Limit means the Daily Noise Exposure Level is exceeded Leq-85 dB (A), or Daily self -noise dose - 100%, or Max SPL - 115 dB (A), or Peak sound pressure level - 140 dB (C). All above are refer to Occupational Safety and Health (Noise Exposure) Regulations 2019.

Machinery / Plant Management; Maintenance, records regarding plant and machinery maintenance. Certificate of Eligibility, all CF Machinery must have a valid Certificate of Eligibility. competent persons such as Steam Engineer, Driver Engine (Boilerman)/IPD, Crane Operator and Seasoning Operator must follow legal requirements FMA 1967.

Emergency Response Plan (ERP); ERP Procedure, procedures related to emergency actions such as fire/chemical spill/bomb threat/evacuation etc. Emergency Route Plan, it needs to be there and on display. Emergency Response Team (ERT), Refer to the ERT organization chart. Emergency line list and fire certificate, it needs to be there and on display.

Contractor management; Contract agreement involving OSH, costs allocated for OSHE. Contractor monitoring, any way/method such as Permit to Work/Checklist/Tool box and others.

NADOPOD; JKKP 6/JKKP 7, in the event of an accident of sick leave for more than 4 days/dangerous incident/employee poisoning/occupational disease that causes death or bodily injury. JKKP 8; Before January 31 of the following year. All above refer to Section 32 OSHA 1994 & Guidelines on Safety and Health (Notification of Accident, Dangerous Occurrence, Occupational Poisoning and Occupational Disease) Regulations 2004.

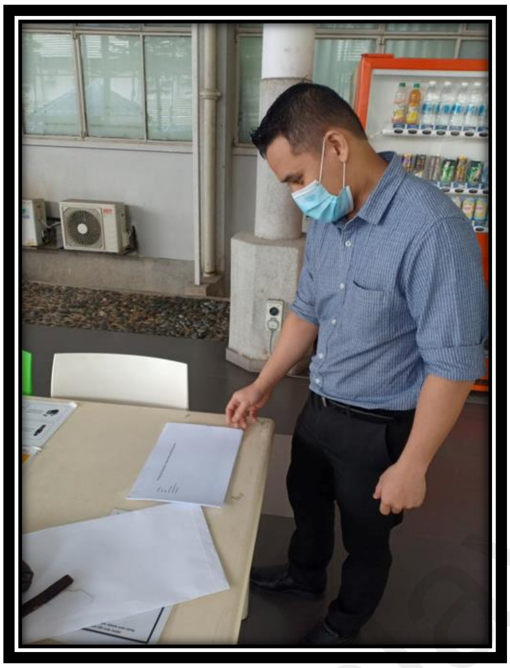
Management of Personal Protective Equipment; PPE records, Mark Yes, if: The provision of PPE (Personal Protective Equipment) is recorded and PPE is approved by JKKP. Mark No, if: The grant of PPE is not recorded or PPE is not approved by the DOSH and Mark NA, if: No need to use PPE. All above refer to Regulation 32, Factories and Machinery (Safety, Health and Welfare) Regulations 1970. Findings from audit activities are as in Table 4.2..

4.6. Validation of checklist using case study laboratories

A meeting with the person in charge lab was held, a briefing on the purpose of the safety self-audit form was created. Laboratory users are given time to examine each element listed on the form and each description. Any questions about misunderstandings will be raised by laboratory users. After the briefing and question and answer on the form, a safety walk-through visit session in the laboratory was held to better understand the elements stated in the safety self-audit form. After the walk-through visit, users are given a maximum of one week to complete the form and the completed form will be collected. Feedback forms on the implementation of safety self-audit are given to users to provide opinions and suggestions for improvement on the safety self-audit form that has been used. The samples of completed audit checklist form are attached in APPENDIX A.

Figure 4.1.: Briefing and Checklist Testing

Faculty of Science UM



Faculty of Medicine UM

Faculty of Engineering UM

Figure 4.2.: Laboratories Walk-Through Visit

Chemical storage

Compressed gas

Hot Plate

Water Distiller

Chemical waste storage

Chemical storage

Hot Water Bath

Table 4.1.: Checklist Validator Detail

Laboratory name	Date Briefing and time	Staff name
1) Makmal Sains Biokesihatan 1,2 & 3, Institut Sains Biologi, Fakulti Sains, Universiti Malaya	9 December 2021 (Thursday) 10 am	Mohamad Fakhrul Hisham bin Hashim
2) Makmal Histo Teknik, Institut Sains Biologi, Fakulti Sains, Universiti Malaya	9 December 2021 (Thursday) 11 am	Norzuliana binti Ismail
3) Makmal Mikrobiologi dan Toksikologi, Institut Sains Biologi, Fakulti Sains, Universiti Malaya	9 December 2021 (Thursday) 12 pm	Siti Rugayah binti Mohd Hashim
4) Makmal Kajitisu 2, Fakulti Perubatan, Universiti Malaya	16 December 2021 (Thursday) 10 am	Muhammad Amri bin Salim
5) Makmal Penyelidikan 3, Fakulti Perubatan, Universiti Malaya	16 December 2021 (Thursday) 11 am	Siti Noor Rabiatul Madia Binti Malek Razuan
6) Makmal Termodinamik, Fakulti Kejuruteraan, Universiti Malaya	22 December 2021 (Wednesday) 10 am	Fazizah binti Abdulllah

Table 4.2.: Summary of Findings from Audit Activities

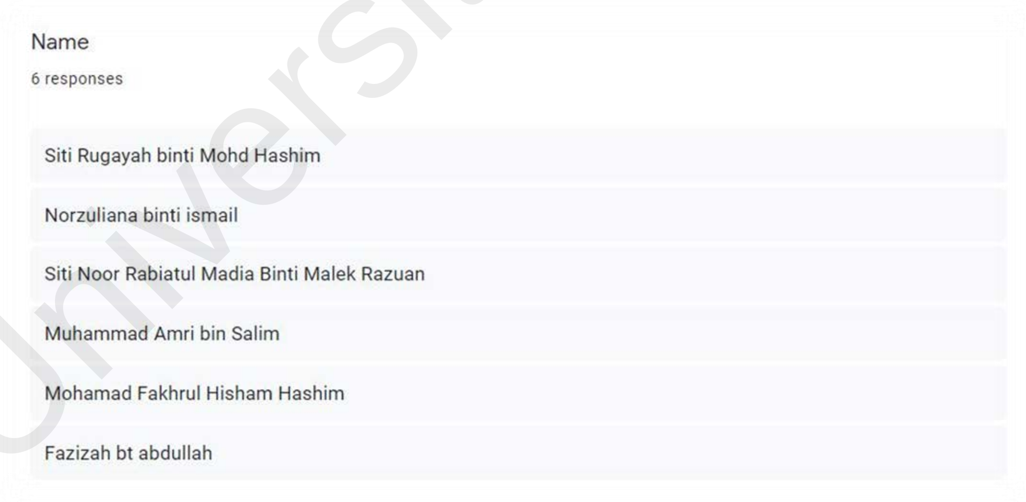
No.	Faculty	Laboratory Name	Not Meet Requirement (N)	Not Applicable (N/A)	Safety Issue
1.	Science	Makmal Sains Biokesihatan 1, 2 & 3	-	Radiation Safety, Noise Management, Pressure/vacuum Systems.	Most of the hazards found in this laboratory are chemical hazards and physical hazards
2.	Science	Makmal Histo Teknik	Ergonomic	Compressed Gases, Radiation Safety, Noise Management, Pressure/vacuum Systems.	Most of the hazards found in this laboratory are chemical hazards and physical hazards
3.	Science	Makmal Mikro biologi Moleku l dan Toksikolo gi	Ventilation	Compressed Gases, Radiation Safety, Noise Management, Pressure/vacuum Systems.	Most of the hazards found in this laboratory are chemical hazards and ventilation unsafe condition
4.	Medicine	Makmal Kaji T isu 2	PPE	Compressed Gases, Radiation Safety, Noise Management, Pressure/vacuum Systems.	Most of the hazards found in this laboratory are chemical hazards, biological hazards, ventilation not comply regulation and PPE is not suitable for work.
5.	Medicine	Makmal Penyel idikan 3	General Work Environment	Compressed Gases, Radiation Safety, Noise Management. Pressure/vacuum Systems	Most of the hazards found in this laboratory are chemical hazards, physical hazards. The chemical room under construction.
6.	Engineering	Makmal Termo dinamik	-	Radiation Safety Pressure/vacuum Systems	Most of the hazards found in this laboratory are chemical hazards, physical hazards.

4.7. Feedback and recommendation for implementation mechanism

A Google form for the effectiveness study of safety self-audit was created to be given to checklist users. Among the contents of the google form are Username, Email, Position, Faculty, Laboratory Name, Level of knowledge on aspect safety in Chemical Laboratory before & after using the checklist, useful of the checklist to implement, User understanding and suggestion for improvement to the checklist.

Overall, feasibility of safety self-audit checklist by selected chemical laboratory users, they are satisfied with the checklist that covers all aspects of safety that can be audited qualitatively in chemical laboratory. The applicability of this safety self-audit is necessary in the chemistry laboratories of higher learning institution. Questionnaire responses from all persons in charge of the laboratory are as below

Figure 4.3.: Safety Checklist Feedback Summary


Name

6 responses

Siti Rugayah binti Mohd Hashim

Norzuliana binti ismail

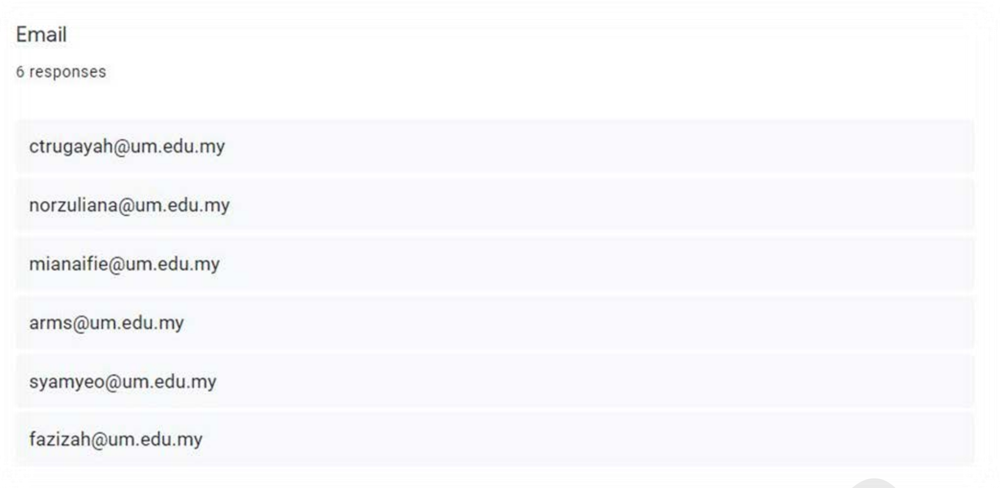
Siti Noor Rabiatul Madia Binti Malek Razuan

Muhammad Amri bin Salim

Mohamad Fakhrul Hisham Hashim

Fazizah bt abdullah

Names


Email
6 responses

ctrugayah@um.edu.my

norzuliana@um.edu.my

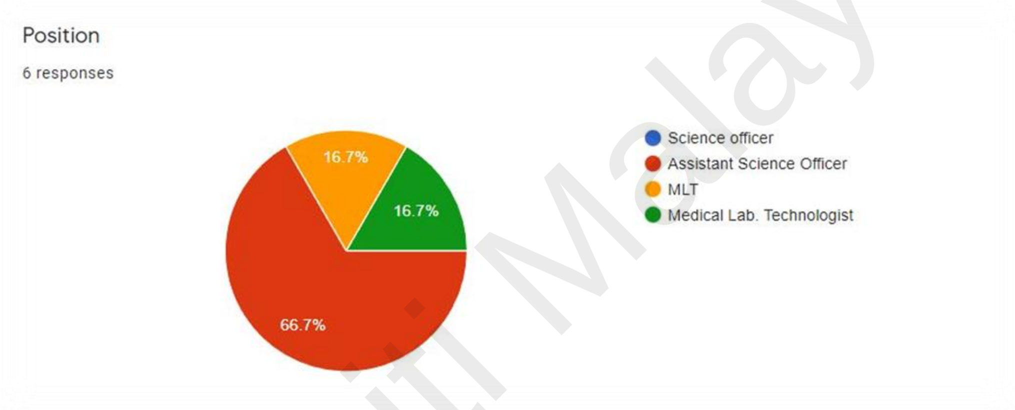
mianaifie@um.edu.my

arms@um.edu.my

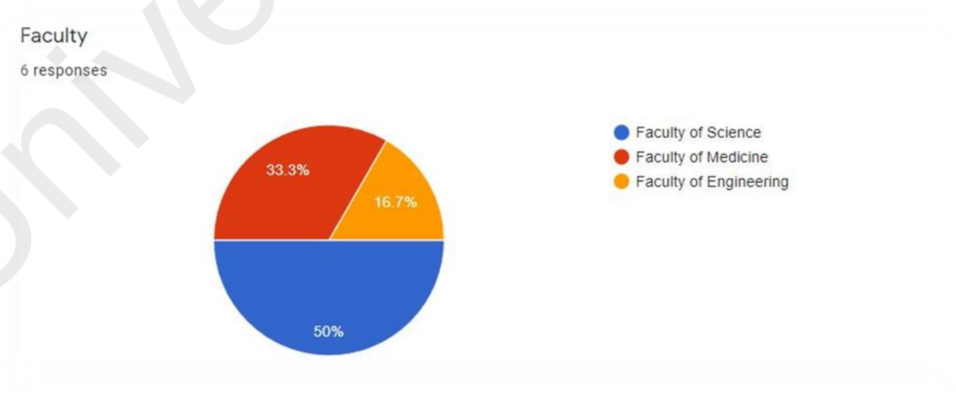
syamyeo@um.edu.my

fazizah@um.edu.my

Emails



33.4% (2 persons) is Medical Laboratory Technologist and 66.7% (4 persons) is Assistant Science Officer



16.7% (1) from Faculty of Engineering, 33.3% (2) from Faculty of Medicine and 50% (3) from Faculty of Science

Laboratory Name

6 responses

Makmal SBK 1,2,3

Histo teknik

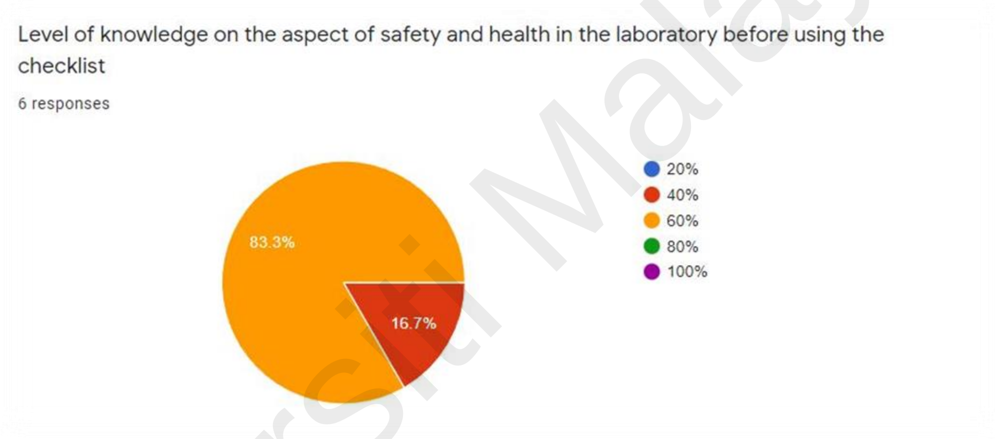
Research Laboratory 3

Makmal Kajitisu 2.

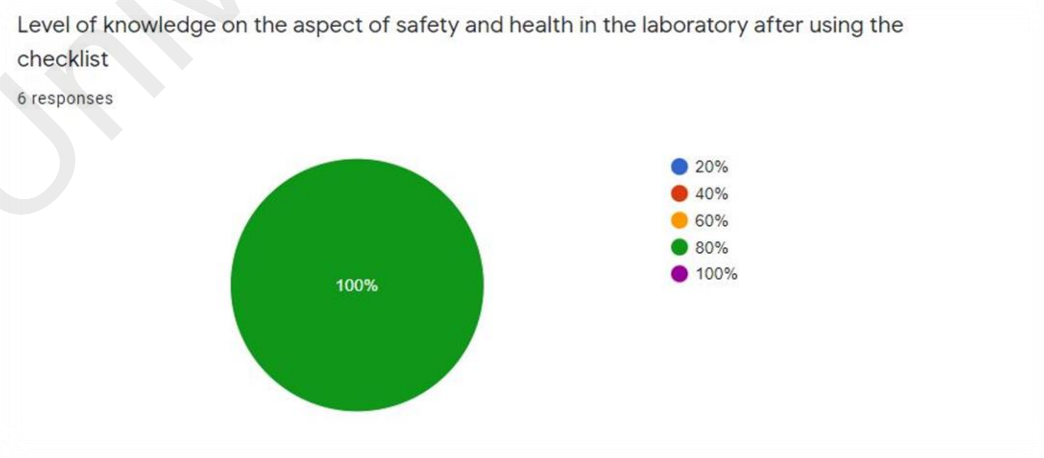
Ummbtl

Thermodynamic laboratory

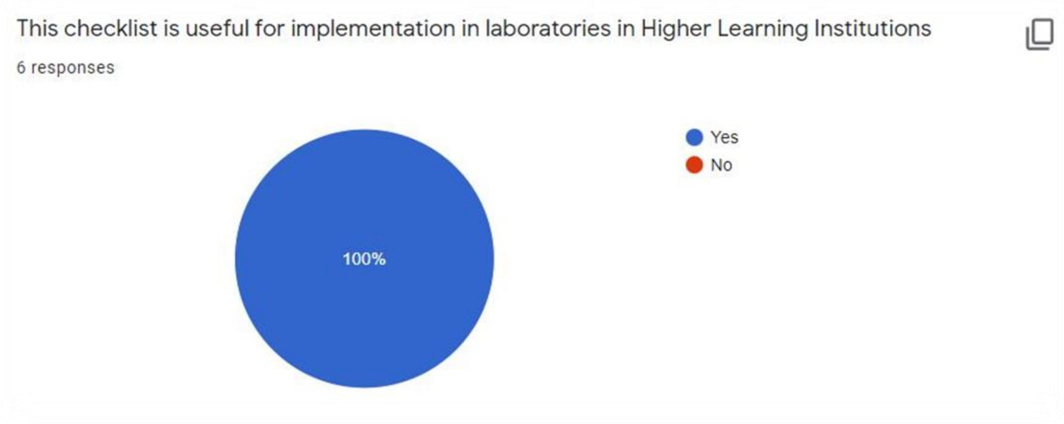
Laboratory names



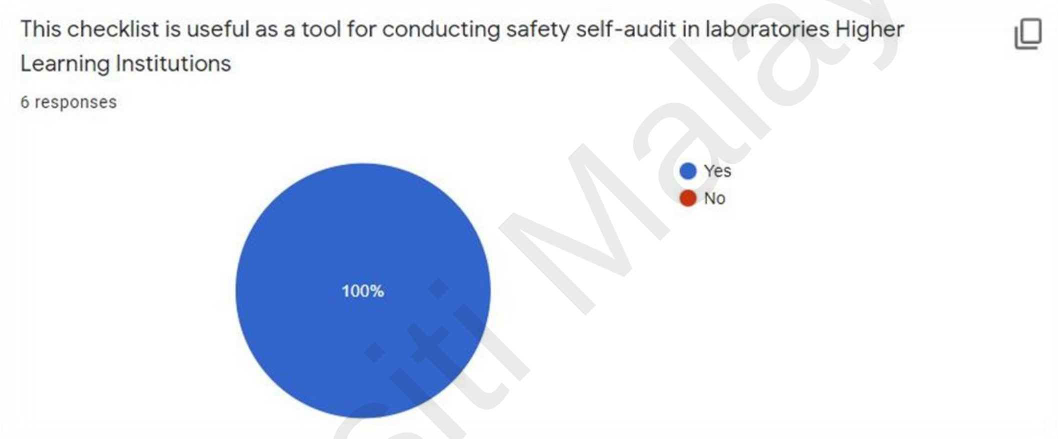
16.7 % response for 40% and 83.3% response for 60% for Level of Knowledge on the aspect of safety and health in the laboratory before using the checklist



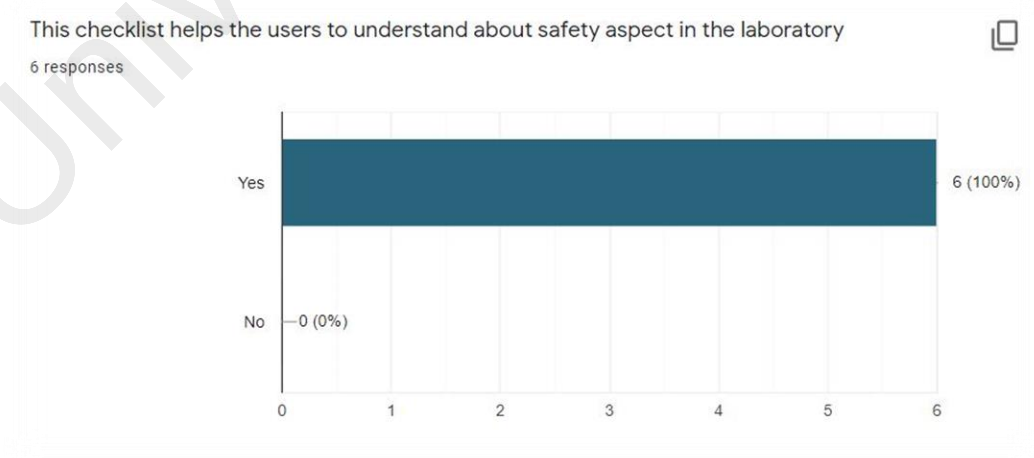
100% response for 80% for Level of knowledge on the aspect of safety and health in the laboratory after using the checklist



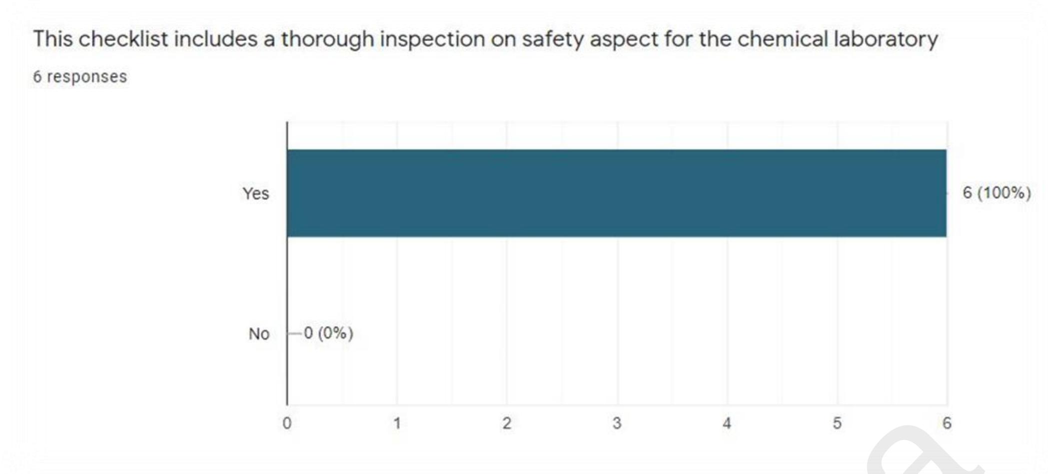
100% response Yes which this checklist is useful for implementation in laboratories in Higher Learning Institutions



100% response Yes which this checklist is useful as a tool for conducting safety self-audit in laboratories Higher Learning Institutions



100% response Yes which this checklist helps the users to understand about safety aspect in the laboratory



100% response Yes which this checklist includes a thorough inspection on safety aspect for the chemical laboratory

Suggestions for improvement

6 responses

Make checklist in dwibahasa and make the form in digital or online based. thank you.

Lebih membantu sekiranya borang disediakan dalam dwi bahasa.

Description should be clear in terms of explaining what is needed

Gunakan terma dan nama pihak berwajib dalam persekitaran kerja universiti. Sebagai contoh, pemeriksaan tahunan oleh Bomba untuk alat pemadam api.

Is better if can be simply as possible

Need to be practice in the lab

Suggestion for improvement from the responders. Among the essence is bilingual, online database, description clearer, simply the form, practice in all laboratories

4.8. Time and resources required to conduct the audit

The time required for an audit to be conducted by a laboratory user is one day for one laboratory. this is because this checklist only focuses on qualitative rather than quantitative aspects and does not use any measurement tools. The resources required are checklists that have been printed and the lab users themselves, do not involve external resources that require specific costs and time.

CHAPTER 5: CONCLUSION AND RECOMMENDATION FOR FUTURE WORK

5.1. Conclusion

In this work, a self-implementable methodology for conducting safety audit at chemical laboratories was developed. The methodology aims to identify safety risks from various educational activities and facilities in chemical laboratories. Subsequently, the methodology consists a comprehensive self-audit checklist together with a guideline to use the checklist. The self-audit checklist consists 19 key safety audit elements, of which each of the element provides its sub-elements that comprehensively describes the aspects to be evaluated mainly related with the risks that occurs from the use of facilities and activities in the chemical laboratories. Whereas, a guideline was also developed to support and assisted respective auditors on conducting safety audit systematically.

The practicality of the developed safety self-audit checklist was successfully validated in 6 chemical laboratories in University of Malaya. Furthermore, the validation exercises showed positive feedbacks from the respective laboratory personnel, where most of them agreed that the self-audit checklist is required as a tool that can helps them to conduct safety audit regularly with minimum time, human and financial requirement. Some suggestions for improvements from the laboratory personnel are also taken into account for self-audit checklist future improvement. Therefore, it can be concluded that the safety self-audit methodology developed can be used to conduct safety audit for any chemical laboratory in higher learning institutions.

Chemical laboratory safety self-audit is very beneficial to laboratory users where the user or laboratory supervisor himself finds hazards and examines the safety aspects of the laboratory via qualitatively assessment and will indirectly make improvements if there are deficiencies and non-compliance.

5.2. Recommendation for future work

It is recommended to develop a checklist in an online system and to store the data in a secure online database. It is also suggested to create a bilingual checklist so that the items on the checklist are easily understood by all levels. It would be beneficial if the checklist can be customized for use in other types of laboratories such as biology laboratory, physics laboratory and workshops.

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