

# Radiation Hazard Identification and Risk Controls in Marine and Fisheries Research Laboratories in Kenya

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## Abstract

To ensure a safe and healthy work environment for employees, the Occupational Safety and Health Act 2007 was enacted in Kenya, and employers are required to comply with the act. Laboratory personnel are exposed to health hazards even with the safety measures in place. This study evaluated chemical health hazards among laboratory staff in Marine and Fisheries Research (MFRI) in Kenya. The aim of the study was to assess Occupational Safety and Health awareness, PPE usage and exposure to radiations on laboratory staff. The study employed cross-sectional research survey design. Structured questionnaires, observation, checklists, and analysis of radiation badges were used for data collection from the target population of 110 personnel from ten (10) laboratories. The data was analyzed using Statistical package for Social Sciences (SPSS) version 26.0. The study found a significant positive relation between Occupational safety and Health awareness ( $r = 0.945$   $N = 97$   $P < 0.01$ ), PPE Usage ( $r = 0.883$   $N = 97$   $P < 0.01$ ), Exposure to radiation ( $r = 0.955$   $N = 97$   $P < 0.01$ ) and exposure to radiations. The Analysis of Variance also depicted a strong positive relationship between OSH awareness, PPE usage, and exposure to radiation health risks. The study further revealed non-compliance to the set standards and lack of OSH awareness among staff. The radiation exposure was found to be 3 - 4 units which are within the WHO set limits of 20 units per year. The badges also revealed that there was risk of exposure in the long run, hence laboratory personnel should be continuously sensitized on OSH awareness and proper use of PPEs.

## Keywords

Radiation, Hazard, Health, Exposure, Occupational Safety, PPE, Compliance

## 1. Introduction

Chemical health risks are hazards from chemical substances organic and inorganic in nature. Occupational Health and Safety Administration (OSHA) has categorized chemical health risks into two categories: physical risks, which include flammability, explosibility, and corrosion, and health risks, which include sensitivity, irritation, and carcinogenicity [1]. According to ATSDR [2], exposure to chemical health risks occurs when one comes into contact with chemicals. Laboratory personnel are potential candidates of laboratory incidents and accidents that could involve exposure to carcinogens, mutagenic and toxicity of chemical substances [3]. These chemical health risks have been on the rise in the recent past, owing to the global increase in the production and use of chemicals and biological reagents. This report asserts that to ensure minimal exposure to health hazards, laboratories handling or processing chemical agents must be responsible to their personnel.

The International Labor Organization (ILO) reports that occupational illnesses and accidents claim the lives of over 2.78 million workers globally each year [4]. According to United Nations (UN) a worker dies every 30 seconds due to chemical exposure, resulting in occupational accidents of about 860,000 persons daily [5]. Reference [3] reports that about 3 million laboratory personnel are exposed to blood pathogens, infections of which 90% occur in developing countries, as cited in [6]. Over 500,000 medical injuries have been reported to occur in Germany annually, whereas in the United Kingdom, at least 100,000 needle stick injuries occur in the laboratories [7]. While laboratories are designed to be safe workplaces by default, some hazards are inevitable. According to [4], Indonesia experiences massive occupational accidents with up to 86.35% deaths. In Kenya, laboratory injuries have happened to at least 58% of laboratory workers [6].

The risks that laboratory workers are exposed to are detrimental to their health and well-being. According to [8], over 71% of medical waste handlers across Kenya lack appropriate PPE, such as respirators and gloves, which exposes them to health risks. These infections and potential health risks are preventable if stringent measures are put in place. Handling radioactive substances or working in radiation laboratories can also pose a great health risk to laboratory personnel. A radiation safety course is recommended and laboratory induction is recommended to all persons working in radiation laboratories, according to the International Atomic Energy Agency (IAEA)'s radiation protection safety standards [9]. The level of exposure to any chemical health hazard and an evaluation of involved risks should, therefore be a subject of concern to all lab oriented institutions. Reference [8] intimates that all potentially contagious materials should be handled as infectious hazardous at all times, in order to control infections.

The danger factor theory postulates that accidents happen at the meeting point of a worker and the danger factor itself, causing injury to the worker. Mostly based on practical experience, the theory was proposed by Skiba in 1973 [10] who stated

that the probability of accidents is determined by the danger factors. This theory aided the study in the identification of the danger factors present at the MFRI laboratories and how they contributed to the chemical health risks of the laboratory staff. A danger factor that came out during the study was congestion in the laboratories and storage that did not conform to the set standards at MFRI. This increased the chances of exposing the laboratory staff to accidents or incidents that can translate to health risks, as depicted in the findings of the research. The likelihood of putting the staff in danger in the event of a small mishap, such as a spill, was found to be extremely high.

Behavioural change theory has been used to enhance OSH in relation to health care workers, according to [11]. The researchers suggest that behavioural theory can be applied to design interventions that prevent or minimize workplace injuries and illnesses. The theory helps explain why workers engage in certain behaviours or avoid others. When workers are made to understand and believe the benefits of their behaviour in safety and health promotion, they are more likely to re-adjust their attitudes and behaviour accordingly. This study assessed the extent to which this theory is true in the case of MFRI laboratory staff and revealed that while there were necessary standard operating procedures in place for the laboratory personnel, some behavioural factors like lack of accountability for self and others exposed the staff to health risks to a great extent. This according to the findings could be enhanced by holding each staff and the management accountable for their behaviour as far as safety is concerned, in order to minimize the exposure to chemical health risks amongst themselves. The majority of lab employees who took part in the study said they understood that it was their duty to ensure their own safety while working in the lab. Sociological theory reiterates that social relations at workplaces generate errors that eventually lead to occupational injuries. For safety management and prevention of occupational injuries, this theory can be used to put worker behaviour under control. Employees' acts should be checked in order to eliminate or reduce occupational accidents [12]. This study unveiled how the interrelationships amongst laboratory workers at MFRI contributed to their exposure to chemical health risks. The findings further revealed that social interactions inside the laboratories could lead to errors in handling of the chemicals, posing potential risks to the lab workers and its environs and therefore a stop to social interactions in the laboratory should be emphasized. Therefore, it is the responsibility of employers to educate and raise awareness on the need to prioritize safety in order to reduce potential chemical risks at the work place. Employees on the other hand must comply with the set regulations during their interactions at the work place, and raise alarm when their safety needs are not met. Mandatory OSH awareness and training for all staff, standard-compliant PPE, and tight controls to reduce or eliminate exposure to radiation will go a long way in alleviating exposure to potential hazards. This study sought to identify radiation hazards and risk controls by evaluating chemical health hazards among laboratory staff in Marine and Fisheries Research (MFRI) in Kenya.

## 2. Literature Review

### 2.1. Exposure to Workplace Hazards in Laboratories

Despite the guidelines on control and preventions of occupational accidents, laboratory personnel still risk being exposed to hazards that are detrimental to their health. Associated with consequential exposures to health hazards, laboratories happen to be very dangerous places to work in [13]. Biological and chemical hazards are bound to happen in any laboratory facility. Reference [8] adds that laboratory work environments are demanding, complex and pose significant safety risks. According to OSHA 2022 guidelines, risks to workers safety and general hazards should be assessed and identified on an ongoing basis [14]. Even in countries with high levels of compliance with OSH regulations, [15] indicates that occupational accidents still occur. Elimination of risks and hazards, control or minimizing risks and provision of appropriate PPE are recommended preventive and protective measures.

An evaluation of occupational safety and health management systems was conducted by [16] seeking to evaluate the state of OSH management in Egerton university in Nakuru Kenya. The study determined the types and sources of hazards at the university, the level of implementation and influencing factors. Cross-sectional descriptive survey research design was employed in the study. Collection of data was done using structured questionnaires, interview schedules and observation lists. The study identified numerous sources of hazards with chemical hazards accounting for the majority 32% of the identified types, mechanical (23%), ergonomics (16%), physical (13%), biological (11%) and psychosocial (5%). The study further revealed that there was no OSH policy in place, and that implementation was majorly influenced by lack of training, inadequate resources and failure to carry out medical examinations. The creation of an OSH policy document, frequent medical examinations of employees, and OSH training for workers were among the recommendations made. In contrast to this study, the MFRI laboratories followed policy guidelines, with compliance being the only issue. Reference [6] sought to determine the outcomes of control measures against occupational hazards resulting from needle stick injuries and medical sharps in sub county hospitals in Mombasa County. The researcher was specific to determining the available control measures, knowledge and training on control measures and adherence to safety guidelines by laboratory workers (HCW). The study revealed that safety features in the medical facilities significantly reduced exposure to injuries. Lack of safety training was found to be a leading contributor to experienced injuries and incidents. The study further found out that PPE usage had a positive impact on reducing exposure by up to 35%. The study recommended training on safety guidelines, sustainable supply of required PPE and surveillance or potential injury causes.

Occupational hazards and their impacts were assessed by [17] using a case study of metal workers in Nakuru town. Survey research design was used and Yamane 1967 formula employed in determining a sample size of 288 respondents. Data

was collected using a combination of observation guides, measurements, and questionnaires. Descriptive and inferential statistics were used in data analysis. The main chemical hazards in the jua kali establishments were found to be solvents and paints, accounting for 35% of the occupational hazards in the sector. The study revealed that most of the hazards were related to the workplace activities, like use of uninsulated electrical cables and worn-out insulations. The study found that the workers' awareness of OSH was low and that they had received little training in the subject. Enhancing hand tool safety, enhancing ergonomics and hygiene, and providing OSH awareness training were among the suggested interventions. The findings relate to this study, as it was observed that a considerable number of the laboratory staff had not participated in any awareness campaign or training in handling of the chemical health risks in case of exposure.

A similar study conducted by [5] investigated the factors affecting the occurrence of laboratory accidents in food laboratories in Mombasa County. The study indicated that lack of awareness on occupational, health and safety practices resulted in the exposure of most laboratory staff to accidents and incidents. The study also revealed that substance abuse was also a key contributing factor and recommended screening of workers before reporting to their work areas to minimize such accidents. It was further recommended that all laboratory workers undergo a mandatory safety training programme prior to employment. Laboratory staffs in the laboratories at MFRI were candidates of exposure to health associated risks and hazards. The study revealed an existing gap on prevention, preparedness, and response to hazards and chemical health risks among the laboratory staff. The assessment of human health risks requires identification, compilation, and integration of information on chemical health hazards according to [18]. These elements were found to be missing in the MFRI laboratories, as there was lack of compilation on the available communication methods as far as the indicators were concerned.

## **2.2. Occupational Safety and Health Awareness**

Safer workplace practices can be brought about by familiarity with potential health risks and hazards. To eliminate the risks and hazards employers should ensure appropriate training on safety and health aspects of daily operations [14]. The OSH act outlines that clear communication must be laid out across different organizational levels while ensuring that workers' ideas and concerns are addressed effectively. Poor communication across the divide negatively affects appreciation of safety practices. Reference [12] highlights that employees who are well communicated to tend to be more satisfied in their work environment and thus significantly drive organization's success. Other workers including laboratory personnel should thus be made aware of OSH by training, involvement, and proper communication. The encouragement of health practitioner's involvement in health and safety procedures improves the employee acceptance of OSH policies.

A study on factors affecting occupational safety and health performance in

public dispensaries and health centres was conducted by [18] in Machakos County, Kenya. The research assessed the adequacy of OSH awareness in the health management and workforce, and workers participation in OSH practices. A strong positive relationship between OSH performance and worker awareness was found to exist. The study's null hypothesis was also rejected. It was concluded that OSH awareness among laboratory workers, management commitment and workers participation influenced the performance of OSH in public health facilities. The study recommended training of workers in OSH, and workers taking the initiative to improve OSH performance.

An assessment of the effects of geothermal well drilling occupation on the safety and health status of workers in Kenya was conducted by [19] in order to check the adequacy of the onsite safety programmes. The study employed descriptive and inferential statistics to assess the components of OSH management in place at GDC. The OSH management system was found to be 60% effective, made possible by effective communication and reviewing. Findings of a study on determinants of effective control of occupational accidents unveiled training gaps on OSH awareness and hazard prevention [20]. To find ways to improve efficient control and management of incidents in Mombasa port areas, the study used structured questionnaires for data collection. Out of the 650 workers in the population, 248 respondents arrived at via random sampling. An underlying poor safety culture was identified, and chemical spillages found to be among the reported occupational accidents.

### **2.3. PPE Usage Awareness in Workplaces**

Personal protective equipment is required by laboratory personnel and researchers for protection against exposure to potential hazards, lack of which puts them at the risk of infections and health risks. According to [21], PPE usage is vital to protection from and interruption of the exposure occupational hazards that result in injuries or illnesses. PPE minimizes the likelihood of exposure to hazards by providing a barrier between a hazard and worker [6]. According to [3], PPE could include and is not limited to masks, goggles, respirators, safety glasses, gowns, lab coats, body-suits and protective footwear. PPE usage was found to play a critical role in exposure to chemical health risks among MFRI laboratory staff. While PPE was relatively available for use, not all laboratory staff wore them appropriately and for the intended purpose. It was proposed that enough resources be employed to ensure proper PPE selection, quality provision, and compliance with standards. According to [19], employers must implement an appropriate system for PPE selection with regard to hazards, correct usage and protection level provided.

Appropriateness of PPE against bio-hazards exposure in public primary laboratory facilities in Mombasa Kenya was investigated by [8]. The study's main objective was to investigate the efficacy of personal protective against exposure to bio-hazards. The study found a significant relationship between PPE usage and availability and recommended training on usage and availability. PPE must be made accessible to all workers to enhance safety. According to [14], the type of

PPE to be used varies depending on the exposure risks involved, thus effective PPE usage and compliance to all other OSH regulations. It is recommended that PPE be selected based on the worker's specific duties and reflect the identified risk of exposure. While PPE can be effective if properly used, it does not eliminate the hazard and only protects the person wearing it [3]. It is therefore key that PPE be appropriately used for maximum protection. Centres for Disease Control and Prevention (CDC) recommends a PPE program that addresses; employee training on PPE selection and use, workplace hazard assessment, replacement of worn out PPE and continuous monitoring for effectiveness [21].

An investigation on occupational safety and health status in medical laboratories was conducted in Kajiado County by [13]. The research aimed at establishing physical, chemical and biological hazards encountered in the laboratories and reviewing the set control measures in the laboratories. The study revealed that biological hazards made up to 80% of the hazards that happened in the labs, while chemical and physical hazards followed closely. Handling of unlabelled and unmarked chemicals contributed to 38.2% of laboratory hazards and 49.5% of the hazards were as a result of poor laboratory equipment storage. The study also revealed that the following control measures were used by laboratory staff; PPE usage, PEP provision, BCG and hepatitis B vaccination and HIV screening. Lack of awareness and training on OSH, lack of OSH policies in the laboratories, inadequate laboratory infrastructure and negative OSH attitudes were found to hinder the implementation of good OSH practices. The study recommended training on PPE usage and provision of the same among other measures in controlling laboratory hazards.

#### **2.4. Exposure to Ionizing Radiations**

Exposure to radiation and radioactive substances is a major risk that laboratory personnel are likely to face in their line of duty. According to a WHO 2000 hazard datasheet on occupation, laboratory workers are exposed to different hazards ranging from accident hazards, chemical, biological, ergonomic and physical hazards [22]. Depending on equipment types and laboratory processes, laboratory personnel are exposed to various radiation types which could be ionizing (x-rays, gamma rays, alpha or beta particles) or non-ionizing (ultra-violet light, infrared, visible light or laser radiation). Reference [23] indicates that depending on amount of received radiation, excessive exposure to radiation has a damaging effect to organs and living tissues. Adverse effects of radiation are likely to be caused by exposure to higher doses beyond acceptable limits. In order to identify and evaluate any hazard in the laboratory, an integration of the scientific method and basic hazard identification method is proposed by [24], which could also be borrowed in the case of radiation hazards.

The risk of exposure to radiation to laboratory personnel was studied by [25]. They aimed at heightening awareness of potential radiation hazards and the measures that can be implemented to reduce the likelihood of exposure to laboratory personnel. The researchers made use of radiation badges and rings to

monitor hospital laboratory personnel. These rings and badges were worn by the laboratory personnel whenever they entered radioactive sections or the blood bank. Quarterly analysis of the badges and rings was done for a period of 2 years. Dosimeter readings were used to tabulate the risks of external exposure to radiation for different occupants. The results of the dosimeter indicated that the technologists who worked in radioimmunoassay laboratories received more external radiation than those who worked in the general laboratories, but less than the nurses who were involved with radioactive cervical cancer implants in the gynaecology ward. The study presented that there was a risk of cancer from ionizing radiation; they however reiterated that was not yet possible to distinguish radiation induced cancers from cancers of the unexposed. While the study focused on hospital laboratory personnel, this study was limited to MFRI laboratories. From the recorded dosimeter results, it was worth noting that the staffs were exposed to radiation within the acceptable dose limits. There's however a suggested area for further study on how much radiation in a lifetime can be hazardous, in order to keep the relevant personnel abreast.

The likelihood of exposure and the number of people exposed to radiations in the laboratories should be kept low as reasonable achievable, taking societal and economic factor into account. The IAEA safety standard for protecting people and the environment on occupational radiation protection recommends the optimization for safety and protections in all exposure cases [26]. According to [27], laboratory personnel could be unintentionally exposed to radiation due to lack of understanding of involved compounds and thus an underestimation of potential risks. The researchers investigated radioactive sources in chemical laboratories in Slovenia. They sought to assess laboratory personnel's awareness of precautions and the implementation of safety measures. The study found out that most laboratory users were not aware of chemicals that were radioactive and thus in case of spills the persons and equipment in use could easily be contaminated leading to exposure. In order to optimize the implementation of safety measures in the laboratories, the researchers recommended that the establishment of a laboratory's organizational structure should engage qualified experts including a competent radiation officer. They further stressed that contaminated equipment must be handled with special precautions and that safety guidelines must be adhered to strictly. The study presented a geographical gap, hence this current research sought to ascertain whether the same results would be realized in MFRI, Mombasa County.

### **3. Materials and Methods**

#### **3.1. Research Design**

Descriptive cross-sectional survey research design was used in this study. Questionnaires, observation checklists and radiation badges aided the researcher in data collection. The study collected data on OSH awareness, PPE usage, exposure to radiation and chemical health risks among laboratory staff in MFRI.

### 3.2. Research Methods

Stratified random sampling was employed in the selection of the laboratory technicians from the 10 laboratories, whereas purposive sampling was used in hand-picking the laboratory managers and their assistants. MFRI has a total number of 10 laboratories namely Organic, inorganic, environmental pollution, microbiology, fisheries, post-harvest, Mariculture, biological, molecular and chemistry preparation. There were 8 laboratory technologists/technicians in each one of the laboratories. All the laboratory staff were eligible to take part in the study as they were directly involved in the laboratories, the laboratory managers with their assistants were also interviewed. The target population, therefore consisted of 80 laboratory technicians 10 laboratory managers and their two assistants; a total target population of 110 laboratory personnel.

Stratified random sampling was employed to determine the lab technician's sample size using Yamane's 1967 formula. This formula was preferred because of its simplicity and ease to understand and apply in determining reasonable sample presentation.

The laboratory personnel's awareness of occupational safety and health practices and guidelines was assessed through self-administered questionnaires.

The questionnaire had both closed and open-ended questions. A 5-point Likert scale type of questionnaire was designed as follows: 1) Strongly disagree, 2) Disagree, 3) Neutral (Neither agree nor disagree) 4) Agree, 5) Strongly agree. Owing to the nature of work of the laboratory staff that were interviewed, the questionnaire was found to be time saving. Descriptive statistics from the opinion Likert scale statements was utilized to determine the level of awareness on OSH practices.

To assess the PPE usage among laboratory staff, both questionnaires and observation guides by help of a checklist were employed. The observation guide aided in monitoring the laboratory staff's usage of PPE during their operations to ascertain the effect of compliance or non-compliance on exposure to chemical health risks. Pilot testing of both research instruments was conducted on 10 laboratory staff who were exempted from taking part in the main study.

The levels of radiations in the bodies of the laboratory staff were examined to ascertain whether or not they are within the acceptable limits. This was done by help of dosimeter badges placed in the laboratory for daily measurement of radiation levels, and documenting the radiation doses they were exposed to. The results were tabulated and dose limits compared to the acceptable ranges. Data was cleaned and coded for analysis. Statistical Package for Social Sciences (SPSS) Version 26.0 was used to analyze the gathered data. The computed statistic for every variable was tabulated using a frequency distribution table. To evaluate the importance of the chosen model and variables, the researcher employed regression and correlation analysis. A 95% confidence level and a 5% significance level were used to test the study.

The following was the regression equation that was chosen:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \quad (1)$$

where:  $Y$  = Exposure to chemical health risks,  $\beta_0$  = Y intercept;  $\beta_1, \beta_2, \beta_3$  = the slope of the regression line for each independent variable,  $X_1$  = OSH awareness;  $X_2$  = PPE Usage;  $X_3$  = Exposure to radiation;  $\varepsilon$  = Stochastic disturbance error term.

The research instruments were tested for validity by help of two experts in the area of study, where questions were reviewed and revised before use in data collection. A pilot study was conducted on 10 laboratory personnel in order to improve the quality and efficiency of the main study [28].

## 4. Results and Discussions

### 4.1. Response Rate and Reliability Statistics

Out of the 100 administered questionnaires, 97 responses were received, translating to a return rate of 97% as tabulated below. This return rate is an excellent response rate for analysis, reporting and making inferences [29].

**Table 1.** Reliability statistics.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	No of Items
0.981	0.982	3

The reliability of all the items was calculated as shown in **Table 1**. According to Kothari and Garg [30] reliability is the extent to which the estimating tools can produce accurate and dependable results. The findings indicate that the research items were excellent for data collection and as a result they assessed the constructs they were intended to assess. Strong correlation between items is indicated by a high Cronbach's alpha coefficient (above 0.7), which also indicates consistency in the items (Mugenda & Mugenda, 2003).

### 4.2. Occupational Safety and Health Awareness

**Table 2.** Descriptive statistics for OSH awareness.

Statements	5	4	3	2	1
Laboratory staff participate in OSH awareness campaigns	30.9%	27.8%	32%	7.2%	2.1%
Employers are held accountable for their safety and that of staff	27.8%	32%	28.9%	8.2%	3.1%
Staff are encouraged to report safety and health concerns	41.2%	23.7%	21.6%	10.3%	3.1%
There is a mandatory OSH training for laboratory staff	8.2%	7.2%	20.6%	28.9%	35.1%
Laboratory staff are trained to check and spot incidents of safety and health concern	11.3%	8.2%	15.5%	25.8%	39.2%
Follow-up is done after training to assess implementation	15.5%	7.2%	13.4%	29.9%	34%
Storage areas (rooms, refrigerators, freezers, cupboards) where infectious and/or toxic materials are kept are labeled accordingly.	26.8%	29.9%	33%	8.2%	2.1%
Chemicals and hazardous materials are clearly labeled	34%	27.8%	30.9%	5.2%	2.1%
Laboratory equipment are covered by safety instructions	7.2%	8.2%	25.8%	30.9%	27.8%

**Table 2** reveals that staff education regarding occupational health and safety (OSH) was found to be lacking, as only 15.4% of respondents agreed to have participated in training; even among those who did, implementation was not guaranteed, with a significant 77.3% majority reporting no follow-up after training. This is in contrast to the majority of MFRI laboratory personnel (58.7%) who participated in OSH awareness campaigns, at least 9.3% of whom were left out. More than half of the respondents strongly agreed (27.8%) and agreed (32%) that employers were responsible for their safety and that of the laboratory staff. While a majority of the respondents agreed that they were encouraged to report health and safety concerns, there were no procedures for how the reporting ought to be done. The above findings agree with the study of Kiogora (2023) who identified training gaps in various contexts as a majority of respondents had not undergone any training or awareness on occupational hazard prevention or handling.

The storage areas in the laboratories where toxic materials were kept were labelled, as agreed by 56.7% of the respondents. This however was not the case in all laboratories as evidenced by the observation guides during the walkthrough. While the chemical and hazardous materials were labelled as indicated by at least half of the respondents, it was evident that laboratory equipment were not covered by safety instructions. This was also supported by nearly 60% of the respondents.

**Table 3.** Correlation for OSH awareness.

		Chemical Health Risks
OSH Awareness	Pearson Correlation	0.945**
	Sig. (2-tailed)	0.000
	N	97

\*\*Correlation is significant at 0.01 level (2 tailed)  $r = 0.945$ ,  $N = 97$ ,  $P < 0.01$ .

The Pearson Moment Correlation Coefficient, a statistic that indicates the strength of a relationship between two variables, was used to investigate the relationship between OSH awareness and exposure to chemical health risks among MFRI laboratory personnel. OSH scores were used as the independent variable and chemical health risks as the dependent variable in order to calculate this correlation. The findings from **Table 3** demonstrate a significant positive correlation ( $r = 0.945$   $N = 97$   $P < 0.01$ ) between OSH awareness and exposure to chemical health risks. The findings concur with those of [15], who discovered a substantial, positive, and strong correlation between occupational safety and health awareness and exposure to workplace accidents.

### 4.3. PPE Usage

The majority of respondents indicated poor PPE usage at the MFRI laboratories, as shown in **Table 4** For example; over 80% of respondents don't agree that PPE was used appropriately for the intended purpose in the fifth construct. Conversely, fewer than 18% of staff members had their worn-out personal protective

equipment (PPE) replaced. This suggested that a significant portion of the staff used worn-out PPE, which raised the possibility of exposure to chemical health risks. Only 25% of the participants concurred that PPE was acquired in accordance with established guidelines, an indicator that PPE usage was not effectively implemented. The observation checklists also demonstrated the ineffectiveness of the PPE administration. While the PPE procurement procedure was not clearly laid out during the study, the researcher counter checked the quality of the administered PPE and found out that they met acceptable KEBs quality standards, but availability was an area of concern due to inadequate resources for provision of quality PPE, leading to purchase of low quality PPE that didn't comply with the required standards. A similar study on PPE usage was conducted by [8] and found a significant association between utilization of available gear and PPE range.

**Table 4.** Descriptive statistics for PPE usage.

Statements	5	4	3	2	1
PPE is readily accessible to all laboratory staff	17.5%	20.6%	21.6%	23.7%	16.5%
All laboratory personnel appropriately wear personal protective equipment	19.6%	18.6%	23.7%	25.8%	12.4%
Replacements for worn out PPE are available	8.2%	9.3%	13.4%	30.9%	38.1%
Selected PPE is adequate for infection control	9.3%	9.3%	11.3%	34%	36.1%
PPE is used appropriately (for their intended use)	5.2%	11.3%	13.4%	29.9%	40.2%
Chosen PPEs are not affected by the laboratory chemicals	7.2%	10.3%	19.6%	29.9%	33%
High quality PPE is provided to the laboratory staff	13.4%	11.3%	25.8%	21.6%	27.8%
PPE is purchased in compliance with standards	14.4%	10.3%	23.7%	22.7%	28.9%
There are adequate resources for quality PPE provision	16.5%	18.6%	13.4%	25.8%	25.8%

**Table 5.** Correlation for PPE usage.

		Chemical Health Risks
PPE Usage	Pearson Correlation	0.883**
	Sig. (2-tailed)	0.000
	N	97

\*\*Correlation is significant at the 0.01 level (2-tailed).  $r = 0.883$ ,  $N = 97$ ,  $P < 0.01$ .

To ascertain the association between PPE usage and exposure to chemical health risks, Pearson Moment Correlation Coefficient was used to calculate the scores for PPE usage as an independent variable and chemical health risks as a dependent variable. The results showed that there was a strong positive association ( $r = 0.883$   $N = 97$   $P < 0.01$ ) between PPE usage and exposure to chemical health risks as in **Table 5**. These findings relate with a study by [16] who found a significant correlation between use of PPE and occupational illness of workers.

These findings further resonate with the results of [6] who found out that that use of personal protective equipment contributed positively towards the reduction of exposure to laboratory hazards.

#### 4.4. Exposure to Radiation

**Table 6.** Descriptive statistics for exposure to radiation.

Statements	5	4	3	2	1
Hazard symbols and warnings are posted as required for radiation, biohazard, high voltage, laser, unattended operations, and other hazards.	40.2%	29.9%	8.2%	10.3%	11.3%
There's an inclusion of written Standard Operating Procedures (SOPs) for chemical procedures in the laboratory	11.3%	24.7%	9.3%	20.6%	34%
Screening for exposure is continuously done	34%	20.6%	6.2%	20.6%	18.6%
Emergency showers/iodine/chelating agents are available when required	9.3%	13.4%	11.3%	29.9%	36.1%
A trained fast-aider is available on standby	9.3%	5.2%	13.4%	30.9%	41.2%
Emergency procedures and emergency contacts are accessible to all staff	13.4%	15.5%	16.5%	23.7%	30.9%
Risk assessments are conducted to identify potential risks associated with laboratory chemicals, equipment, materials, and procedures.	23.7%	20.6%	13.4%	21.6%	20.6%
There are hazard assessment tools in place to keep track of identified risks	22.7%	16.5%	42.3%	10.3%	8.2%
Material Safety Data Sheets are available for all hazardous substances used in the lab	41.2%	34%	9.3%	6.2%	9.3%

N = 97.

**Table 6** makes it clear that the MFRI laboratories had warning signs and hazard symbols, as most respondents agreed to the first construct and strongly agreed with it. For every hazardous material used in the lab, material safety data sheets were in place, according to more than 75% of respondents. However, almost half of the respondents stated that no hazard assessment tools were in place to monitor the risks that were identified, and 13.4% of respondents were unsure about whether risk assessments were carried out or not. The survey also showed that, with over 70% of respondents' indications, there was no trained fast aider available to handle emergencies. The dosimeter readings obtained during the study period revealed that radiation levels were within permissible bounds, which was determined to be consistent with earlier measurements considered standard at MFRI. Personnel entering high dose rate areas, such as the radioisotope laboratory, were wearing personal dosimeters, which was a great indication that standard operating procedures were being followed.

**Table 7.** Correlation for exposure to radition.

		Chemical Health Risks
Exposure to Radiation	Pearson Correlation	0.955**
	Sig. (2-tailed)	0.000
	N	97

\*\*Correlation is significant at the 0.01 level (2-tailed).  $r = 0.955$ ,  $N = 97$ ,  $P < 0.01$ .

Pearson Moment Correlation Coefficient was used to calculate the scores for PPE usage as an independent variable and chemical health risks as a dependent variable. These results were analyzed and summarized as shown in **Table 7** above.

There was a strong positive association ( $r = 0.955$   $N = 97$   $P < 0.01$ ) between exposure to radiation and chemical health risks among laboratory staff.

#### 4.5. Chemical Health Risks

**Table 8.** Descriptive statistics for chemical health risks.

Work surfaces are cleaned and decontaminated after use	25.8%	19.6%	11.3%	17.5%	25.8%
Laboratory has appropriate ventilation for the work being performed (chemical fume hood, snorkel, canopy hood, biosafety cabinet, etc.).	41.2%	28.9%	10.3%	12.4%	7.5%
A current chemical inventory listing the chemicals used in the laboratory especially the toxic, mutagens and carcinogens is available	43.3%	37.1%	3.1%	10.3%	6.2%
Laboratory staff know what they have to do to keep themselves and others safe	27.8%	21.7%	3.1%	22.7%	24.7%
Laboratories are well equipped to attend to exposed staff	28.8%	19.6%	5.2%	25.8%	20.6%
Adequate plans are in place to handle exposure cases	26.8%	20.6%	5.2%	21.6%	25.8%
Lab personnel know what to do in case of a chemical emergency e.g. if chemicals are accidentally spilt	28.9%	22.7%	10.3%	13.4%	19.6%
Lab personnel know what to do in case of a chemical emergency e.g. if chemicals are accidentally spilt	8%	7%	20%	28%	34.0%
There's adequate clinical support for staff who get exposed	28.9%	23.7%	3.1%	16.5%	27.8%
Clear warnings and communication is passed across to staff in case of exposure	28.9%	21.6%	4.1%	15.5%	29.9%

**Table 8** indicates that the MFRI laboratories had an inventory of the chemicals they used, and that the rooms were reasonably ventilated, as reported by over 60% of the respondents. More than 50% of respondents disagreed that the laboratories were well-equipped, and a majority of 52.6% reported insufficient staff support in the event of exposure, indicating a lack of adequate laboratory control measures. Less than 30% of laboratory staff members were aware of what to do in the event of an exposure, according to nearly 50% of respondents who reported inadequate

communication regarding chemical health risks. The OSHA laboratory standards state that workers in the lab must follow the right procedures to guarantee that chemical exposures are kept below permissible limits and as low as practically possible [14]. Employees must be shielded from chemical exposure that exceeds permissible limits and given additional information about the risks associated with chemicals in the workplace. The study's results made it clear that more work needs to be done to ensure that established OSH standards are followed. A study by [13] also showed how disregarding safety regulations and guidelines could lead to exposure to chemical hazards.

**Table 9.** Analysis of variance.

	Model	Sum of Squares	df	Mean Square	F	Sig.
1	Regression	230.553	9	25.617	415.486	0.000b
	Residual	5.364	87	0.062		
	Total	235.918	96			

a. Dependent Variable: Chemical Health Risks; b. Predictors: (Constant), OSH awareness, PPE Usage, Exposure to Radiation.

From **Table 9**, the ANOVA findings [F (9, 87) = 415.486, P < 0.05] where the significance value of 0.00 depicts that there exists a significant influence of the predictor variables (OSH awareness, PPE Usage and Exposure to radiation) on the response variable (Exposure to Chemical Health risks). Multiple regression was also performed to ascertain the influence of predictor variables on the response variable.

**Table 10.** Coefficients of the regression equation.

	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	0.135	0.110		1.237	0.219
	OSH awareness	0.475	0.125	0.425	3.796	0.000
	PPE Usage	-0.307	0.102	-0.267	-3.014	0.003
	Exposure to radiation	0.829	0.126	0.796	6.592	0.000

a. Dependent Variable: Chemical Health Risks.

The multiple regression was used in order to determine the relationship between exposure to chemical health risks and the other variables which were OSH awareness, PPE Usage and Exposure to radiation. From **Table 10**, the multiple linear regression equation model that was fit for this study is,

$$Y = 0.425X_1 - 2.67X_2 + 0.796X_3 + 0.110$$

From the linear regression equation, the coefficients indicate how much the independent variables vary with exposure to chemical health risks when all other

variables are kept constant.  $\beta_0 = 0.135$  shows that even if OSH awareness, PPE usage and exposure to radiation were all to be rated at zero, exposure to chemical health risks would be at 0.135. The constant was statistically insignificant and was thus excluded from the model equation.  $\beta_1 = 0.425$  shows that an increase in a unit of OSH awareness results in 0.425 increase in exposure to chemical health risks. From the model, this predictor is statistically significant and was used to fit the model.  $\beta_2 = -0.267$  depicts that an increase in a unit of PPE usage results in a decrease of 0.267 in exposure to chemical health risks. From this model this variable was statistically significant; hence, it was fitted in the model.  $\beta_3 = 0.796$  shows that an increase in a unit of exposure to radiation results in 0.796 increase on chemical health risks. From the model, this predictor was statistically significant hence it was used in model fitting. From **Table 10**, it is evident that the independent variables were statistically significant and would highly influence exposure to chemical health risks.

#### 4.6. Discussion

The findings of the study established a strong positive relationship between OSH awareness and exposure to chemical health risks among laboratory staff. The variable was found to be statistically significant to chemical health risks, hence would highly influence the exposure to chemical health risks. Most of the respondents agreed that laboratory personnel participated in OSH awareness campaigns. There was however a number of staff who reported having not participated hence a disparity on the level of awareness of staff. More than half of the respondents strongly disagreed and disagreed that there was a mandatory OSH training for laboratory staff while another more than half of the respondents disagreed that laboratory equipment were covered by safety instructions. More than half of the respondents disagreed that there was follow-up after training to ascertain implementation of the safety guidelines. The correlation indicated that there was a strong positive association ( $r = 0.945$   $N = 97$   $P < 0.01$ ) between OSH awareness and exposure to chemical health risks. It was also revealed by the multivariate regression that OSH awareness is statistically significant in predicting exposure to chemical health risks. OSH awareness therefore influences the exposure to chemical health risks among laboratory staff. Several studies are in agreement that OSH awareness plays a critical role through training and communication [15] [16].

A strong correlation existed between PPE Usage and exposure to chemical health risks. An increase in PPE usage resulted in a decrease in exposure to chemical health risks. PPE usage therefore is a significant determinant of exposure to chemical health risks. According to the descriptive statistics, a majority of the respondents disagreed that PPE was appropriately worn by the laboratory staff, while only less than half agreed that PPE was readily accessible to all staff. The results also revealed that there were hardly any replacements for worn out PPE, as indicated by over 80% of the respondents. More than 50% of the respondents agreed that the chosen PPE were likely to be affected by the laboratory chemicals

in case of exposure. Regarding quality of PPE used, the study found out that there were inadequate resources for provision of quality PPE leading to purchase of low quality PPE that didn't comply with the required standards. The Pearson moment correlation coefficient indicated a strong positive association between PPE usage and exposure to chemical health risks. PPE usage was found to be statistically significant in the exposure to chemical health risks among laboratory staff. Reference [6] records similar findings where he recorded a positive impact of PPE in reduction of exposure to chemical hazards, as the percentage of those who were exposed was higher for those who didn't have protective equipment.

The findings indicated a positive relationship between exposure to radiation and chemical health risks. Additionally, there was high statistical significance between exposure to radiation and chemical health risks. From the findings, many of the respondents strongly agreed that hazard symbols and warnings were appropriately indicated for safety optimization. There was however divided responses on whether standard operating procedures were included in laboratory chemical procedures. Another majority of the respondents agreed that screening for exposure was continuously done for staff that accessed high risk areas. Nearly 20% of the respondents were neutral to the statement that risk assessments are conducted to identify potential risks associated with laboratory chemicals, equipment, materials, and procedures. On the other hand, more than half of the respondents agreed that there were hazard assessment tools in place, with material safety data sheets for all hazardous substances used in the laboratories. The Pearson moment correlation established that exposure to radiation had a strong positive correlation with exposure chemical health risks. The multiple regressions also deemed exposure to radiation as statistically significant in relation to chemical health risks.

## 5. Conclusion

The study evaluated chemical health risks among laboratory staff at MFRI laboratories in Mombasa County, Kenya. The study found out a significant positive relation between Occupational safety and Health awareness, PPE Usage, Exposure to radiation and exposure to chemical health risks among laboratory staff. The Analysis of Variance also depicted a strong positive relationship between OSH awareness, PPE usage, exposure to radiation, and chemical health risks. The variables were found to be statistically significant and would greatly influence exposure to chemical health risks, that is, OSH awareness, PPE usage and exposure to radiation to a great extent contributed to exposure to chemical health risks among the laboratory staff. This study further revealed non-compliance to the set standards, leading to laboratory staff being exposed to potential chemical risks. The study findings further indicated that OSH awareness was not effectively done; hence a majority of the laboratory personnel were not privy to what was expected of them in terms of ensuring their occupational safety. Exposure to radiation was found to be minimum, as the staffs were exposed to radiations within acceptable limits.

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## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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