FACTORS AFFECTING PRE-SERVICE SCIENCE TEACHERS' LEVEL OF AWARENESS ON SAFETY, HEALTH MEASURES AND RISK MANAGEMENT DURING SCIENCE LABORATORY PRACTICAL

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Abstract

Science laboratory practical work is part of the secondary school curriculum. However, it is critical that the pre-service science teacher is provided with knowledge, skills and competencies that allows teachers to have the requisite level of awareness on safety, health measures, and to be able to manage risks, associated with science laboratory practical work. This study aimed to determine pre-service secondary school science teachers' level of awareness on safety and health measures and the resultant risk management application in science practical work based on selected variables. The study design includes descriptive and cross-sectional survey methods. A sample of 84 pre-service science teachers picked using random sampling responded to a study questionnaire. Results showed that 58% of respondents were formally trained on safety and health measures and the Friedman test showed statistical differences in respondents' rankings depending on sources of safety information used. The results also showed medium levels of awareness on safety and health measures (44.60%); general laboratory practices (39.80%); practical risk management (50%) respectively. The results of *t*- test showed significant difference based on training. A positive low to medium correlation found between awareness on safety health measures and risk management. The study recommends the inclusion of safety and health module in the training of secondary school science teachers.

Keywords: Awareness, Pre-service science teachers, Risk management, Safety and health measures, and Safety in science practical

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Introduction

Background of study

Science laboratory practical work is important as it contributes to adequate understanding of the science discipline which includes the nature of scientific knowledge, enterprise, and methods. Many research studies have emphasized adequate understanding of the nature of science is important (Akerson, Buzzelli, & Donnelly, 2008; Dogan & Abd-El-Khalick, 2008; Khishfe, 2008; Schwartz & Lederman, 2008; Yalvac, Tekkaya, Cakiroglu, & Kahyaoglu, 2007; Martin-Diaz, 2006; Zeidler, Walker, Ackett, & Simmons, 2002; Bell & Lederman, 2002; Hassan, 2001; Bell, Lederman, & Abd-El-Khalick, 2000; Lederman, 1999, 1992; Abd-El-Kahlick, Bell, & Lederman, 1998; Abell & Smith, 1994; Bentley & Garrison, 1991; Lederman & Zeidler, 1987).

Firstly, science laboratory practical contributes to learners meaningful understanding of science concepts, principles, theories, and laws (Abrahams, Reiss, & Sharpe, 2014; Anne & Timothy, 2011) due to complexity and abstract nature of science subject (Muhammad, 2015).

Secondly, it is built on the principle of experiential learning (Helliar & Harrison, 2011) and develops adequate understanding of the process of science investigation and helps to train on scientific methods. Science practical help learners acquire the basic and integrated process skills which are very essential for science learning and future research (Hidayah & Rohaida, 2019; Zengele & Alemayechu, 2016).

Thirdly, it helps in developing scientific attitudes such as persistence, curiosity, skepticism, objectivity, and open-mindedness (Mutasa & Wills, 1994). The science curriculum also encourages discovery and exploration of the nature of science through science practical. Therefore, practical work occupies a central and crucial position in science pedagogy.

Teachers should have appropriate skills to plan, prepare, conduct, and manage laboratory activities inclusive of managing laboratory health and safety needs for their own and for students (Saunders, Dawson, Tripp, Pentecost, Chaloapka, Saunders, 1999). Therefore, pre-service teachers should acquire knowledge in curriculum development, pedagogy, learning styles and contexts as part of their training in effectively and safely execute laboratory practical work (Bishop, Denley, & Hill, 2007).

The teachers' ability to conduct science practical safely is of utmost importance because if they are conducted without regard to safety principles this may have adverse effect on learners' health and can also disrupt learning (Helliar & Harrison, 2011). Not only does it disregard of safety principles have health and educational implications, it can also have financial

implications and costs may be incurred as a result. Conversely, observance of safety measures during science practical work is essential for science teaching as it creates interest in science learning, motivates learners to pursue science related careers and develops a positive attitude among learners towards science. Therefore, safety and health measures in science practical are important in science teacher education. There is a dearth of research on the safety and health measures in science and this call for more research in this area.

Research problem

Among the key duties of science teachers in science practical work is to ensure that safety and health measures are observed in science laboratory practical, while at the same time facilitating learning and understanding for learners (Ken, 2010). Safety and health management in practical is essential for effective science teaching, to achieve science aims, goals and objectives, health and safety of science teachers, learners and the physical environment. Empirical research findings by Mogopodi, Paphane, and Petros (2015) indicated that science teachers lack knowledge and awareness on chemical management and therefore, recommended for the need for their training.The main research question for the present study is: Are pre-service science teachers well trained in safety and health measures for science practicals? In order to ensure safety and health measures in the science laboratory practical, pre-service teachers should have an understanding on safety policies, general laboratory rules, acceptable behavior in a laboratory, knowledge and understanding of safety and health measures in different practical, pedagogical content knowledge of safety and health measures, maintaining a safe laboratory environment, specific safety precautions involved in science practical and skills to identify, analyze and manage health and safety risks.

Although accidents resulting in serious health risks seldom occur in science laboratory practical work, the science practical work is associated with some degree of hazards and health risks (Mehrifar, Eskandarnia, Pirami, & Mardanparvar, 2016). However, safety and health risks involved in science practical work should not discourage learners from partaking in practical laboratory work. To avert these risks, teachers should be able to recognize potential health hazards specific to the practical. Science practical activities have some inherent risks and situational risks. The inherent risks are dependent on the materials use and activities being done. Situational risks depend on the procedures used, potential distractions or disruptions, organization, supervision, and guidance given during the practical work session. Effective identification of potential hazards depends on the science teacher's knowledge and awareness on safety and health. Although science activities selected depend on potential hazards having been identified, knowledge, skills, and maturity of the students; the experience and expertise of teachers, equipment, and facilities available to safely carry out the activity is of equal importance. Risk assessment of the practical is essential to guide teachers and several factors

should be considered among them nature of the practical activity involved, class size and nature of supervision needed.

For each practical science teacher should do risk assessment and take necessary preventive control measures to eliminate, prevent or reduce potential health and safety risks involved in the science practical (Ivana & Bogolovia, 2018; Yahea, 2018). The above-mentioned skills are important and need to be developed (Association for Science Education, 2013; Bishop, Denley, & Hill, 2007).To manage risk pre-service teachers need to do multiple tasks evaluate risks involved in the practical, developing attitude and behavior related to safety and maintaining safe environment etc. Therefore, the risk management is important in science practical activities.

These observations raise several questions: Whether science teacher training courses equip science learners with adequate understanding and awareness on safety and health risks involved in the science practical activities. The science pre-service teachers' awareness depends on the type of training involved on the safety and health risks, and the frequency of such trainings; What are the different sources of safety information used by science teachers?; What are the different levels of knowledge and awareness on different aspects of safety and health issues?. The safety awareness is an essential knowledge to be developed in pre-service science teachers training (Raymond, 2005). In addition to the above observations, this study also explores gender, age group, subject speciality, level of study and teaching experince assoicated with pre-service teachers awareness on safety, health measures and risk management. Different subjects provide different learning experiences, and pre-service teachers might be trained on different safety aspects. The increasing levels of education and teaching experiences of pre-service teachers have increased the frequency of training on safety and health aspects (Fagihi, 2018).

Considering the above discussion, the present study attempts to address the following research objectives and research Questions.

Research Objectives

- To find out the percentage of pre-service science teachers trained in safety and health measures practiced in science laboratories.
- To determine pre-service science teachers' preferences towards different sources of safety information used in science practical.
- To investigate pre-service teachers' level of awareness on safety, health measures and risk management practiced in science practical.
- To determine the difference among pre-service science teacher's awareness on safety and health measures and risk management based on training.

- To determine the difference between pre-service science teacher's awareness on safety and health measures and risk management based on gender, age group, subject specialization, year of study and teaching experience.
- To investigate the correlation between awareness levels on safety and health measures and risk management application in science practical.

Research Questions

The following research questions are considered for the present study:

1. What percentage of pre-service science teachers trained in safety and health measures practiced in science laboratories?
2. Is there any difference in pre-service science teachers' preferences towards the different sources of information on safety used in science practical?
3. What is the level of pre-service science teachers' Awareness on safety, health measures and risk management practiced in science practical?
4. Does pre- service science teacher's awareness on safety and health measures and risk management vary with training?
5. Is there any difference between the awareness on safety and health measures; and risk management based on pre-service science teachers' gender, age group, subject specialization, year of study and teaching experience?
6. Is there any correlation between pre-service science teachers 'awareness levels on safety and health measures and risk management in science practical?

The Research Hypotheses

The following null hypotheses were considered for the present study:

H_{01}: There is no significant statistical difference in respondents ranks on different sources of safety information used in science laboratories.

H_{02}: There is no statistically significant difference between the pre-service science teachers on safety and health measures based on the training.

$H_{03:}$ There is no statistically significant difference between the pre-service science teachers' awareness on safety and health measures; and Risk management based on the gender, age group, subject specialization, year of study and teaching experience?

H_{04}: There is no correlation between awareness levels on safety and health measures to risk management in science practical.

Significance of the Study

This study will give insight into the pre-service science teachers' frequency of training in safety and health measures. The results of the study are important for institutions to plan and organize subject specific safety and health awareness programmes. The results also give an idea of pre-service science teachers most frequently used information about safety and health measures. The results also help pre-service science teacher's current awareness levels on different aspects of safety and health measure practiced in laboratories. These results also give insight into areas of concentration of training on safety and health measure practiced in the science laboratory. The current study also indicates how science teachers manage risk in science laboratories. The results also predict current and future safety practices in science laboratories. The pre-service science teachers should also recognize the importance of safety and health aspects in science practical. These results also guide science curriculum developers and science teacher trainers to include safety and health aspects in science teacher training curriculum.

Literature Review

The results of the empirical study conducted by Fagihi(2018) shows that pre-service science teachers' awareness levels on safety measures are low in the aspects of laboratory risk management, proper laboratory practices and first aid. The empirical research results show less knowledge about the laboratory safety (Derman & Çakmak, 2016). The results of another empirical study shows that pre-service science has moderate awareness of science laboratory safety. This moderate awareness is based on their attitudes, skills and knowledge (Shamsudin, Mahmood, Rahim, & Dalim, 2018). Research on secondary school students showing Medium to high level of awareness on the safety aspects (Ali, et al., 2018). Pre-service teachers derived knowledge from the major sources like laboratory manuals, faculty members and less sources from the laboratory sources (Fagihi, 2018). The above indicates that laboratory training courses should be dire need of science teacher training courses for both inservice and preservice teacher to improve on practical activities in the classroom (Duban, Aydogdu, & Yuksel, 2019). Results of empirical study for undergraduate physics students shows that positive level of safety awareness contribute to the positive perception on management of laboratory risks ((Ivana & Bogolovia, 2018; Ponferrada, et al., 2017).

The results of empirical study based on undergraduate physics shows that there is a significant difference on awareness levels based on the gender and subject specialization (Ponferrada, et al., 2017). Although other factors such as age, teaching experience and year of study need to be investigated. The present study also identified a gap in research investigations based on previous training on health and safety. Many research studies recommended the inclusion of safety aspects in their training including risk assessment (Love, Duffy, Loesing, Roy, & West, 2020; Hill, et al., 2019; Fagihi, 2018;Ivana & Bogolovia, 2018; Schenk, Taheri, & Oberg, 2018; Shamsudin, Mahmood, Rahim, & Dalim, 2018; ;Jonathan & Mbogo, 2016; West,

2003; Saunders, et al., 1999). Some research studies recommended training on occupational health and safety (Ivana & Bogolovia, 2018;Borrows, 2008). Some researchers felt that Special training is required for science teachers to handling hazardous materials handling (Saunders, et al., 1999). Safety, health and risk management can be developed through formal training, workshops (Gentry, Lane, & Vanberkum, 1994), posters and videos (Love, 2015). Awareness on health and safety should be developed innovative ways such as computer-based games (Miliszewska & Sztendur, 2011) and flipped classrooms case studies and active learning techniques (Hill, et al., 2019).

Research Methodology

The purpose of the present study is to investigate pre-service science teacher's safety training, pre-service science teachers preferred sources of safety information, awareness on safety and health measures, and risk assessment and management in science practical work based on the gender, age, subject specialization, year of study, teaching experience and training. It also investigates correlation between the awareness on safety and health measures and risk management in science practical. In this study, quantitative research approach with cross-sectional survey was adopted.

Population, Sample, and Sampling Methods

The population of this study included secondary pre-service science teachers studying Bachelor of Education specialized in Secondary Science subjects. The sample was selected using the random sampling method. The sample included 100 pre-service secondary school science teachers. The simple random sampling method was used to select science teachers by grade level, subject specializations, year of study and teaching experiences (see appendix A). The sample is dominated by 61.9 % of female, 63.1% of 21-25 years age group, 47.6% being students of chemistry, 81% of 3rd year students, and 72.6% of pre-service science teachers with no teaching experience.

Research Instruments

Data collection tools comprised of the "Awareness on Safety and Health Measures and Risk Management in Science Laboratory Practical" questionnaire. To develop the questionnaire, authors reviewed past literature on safety and health issues and derived some questions from existing questionnaires such as the Development of Laboratory Safety questionnaire by Akpullukcu and Cavas, 2013. Nevertheless, most questions were developed to suit the context and conceptualization of the study. In the developmental stages of the questionnaire, questions were pooled and submitted to experts in this field of the study for content validation and relevance. The suggestions from experts and feedback from the pilot study were then incorporated to improve the quality of questions.

The final questionnaire consisted of four parts; A, B, C and D. Part A consisted of biographical information on pre-service science teachers which included gender, institution where they are studying, educational specialization, level of education, subject specialization, year of study, previous Educational qualifications, and teaching experience. Part B consisted of questions on frequency of safety training and sources of information on safety and health measures. Part C consisted of 10 questions on awareness on safety and health measures practiced in science laboratory practical and six questions on general laboratory safety practices. Part D contained 33 questions on risk management in science laboratory practical. The Likert rating scale of the 4- point continuum is used to record science teachers' responses in part C and part D questions. Numerical scores are attached to science teachers' responses. The questionnaire was accompanied by a covering letter to inform respondents on the purpose of the study and to solicit for participation in the study.

Research Instruments' Validity and Reliability

Content and construct validity of the questionnaire was maintained by an expert's perusal and analysis. A pilot study was also conducted to validate the questionnaire. The reliability of the questions was done using Cronbach's alpha – coefficient. The Cronbach's alpha value for awareness on safety and health measures is .925, .832 for general laboratory practice, and .919 for practical risk management. The total reliability of questionnaire was .938.

Data Collection Procedure

The research questionnaire was administrated in May 2019. The questionnaire was distributed to randomly selected pre-service science secondary teachers. The researchers personally administered the questionnaire to get immediate response rate. The average completion time was 15 minutes.

Ethical considerations

Pre-service science teachers were ensured of the privacy and confidentiality of their responses. Researcher ensured that participation in the research was voluntary and informed consent was obtained. The necessary permissions to conduct study were obtained from relevant departments.

Data Analysis methods

SPSS 25 version was used to record and analyze the data of returned questionnaire. The data analyzed was based on research questions, research objectives and formulated hypotheses. Percentage and frequencies used to find the safety trainings for research question one. For research question two and hypothesis one Friedman test is used to find difference in ranks on pre-service science teachers preferred sources of safety information used.

For research question three about the awareness levels on the safety and health measures in science laboratory practical their responses were categorized into low, medium, and high level. For this classification, the scores above 75th percentiles are considered as high and scores below 25 percentiles is considered as low and in between 26- 74 percentile is considered as medium. For research question four and hypothesis two independent sample *t*-tests is used to find the significance differences in pre-service science teachers' awareness of safety and health measures based on safety training.

For research question five and hypothesis three, to find the difference between awareness on the safety, health measures and risk management in science practical based on gender, age group, subject specialization, year of study and teaching experience, Analysis of Variance, and t-test is used. For research question six and hypothesis four, Pearson Product – moment correlation computed to determine the correlation between awareness on safety, health measures and risk management in science practical.

Research Results

The research results are presented according to Research questions and hypotheses.

Results presentation for research question one.

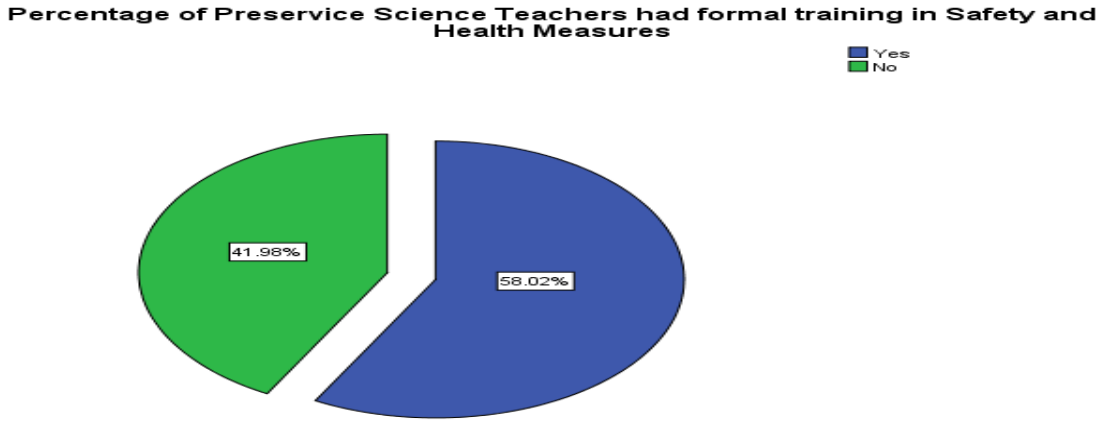

Figure 1 **Pie chart showing percentage of pre-service science teachers formal training in safety and health measures**

58.02% of pre-service science teachers (See Figure 1) have agreed they had formal training in safety and health measures.

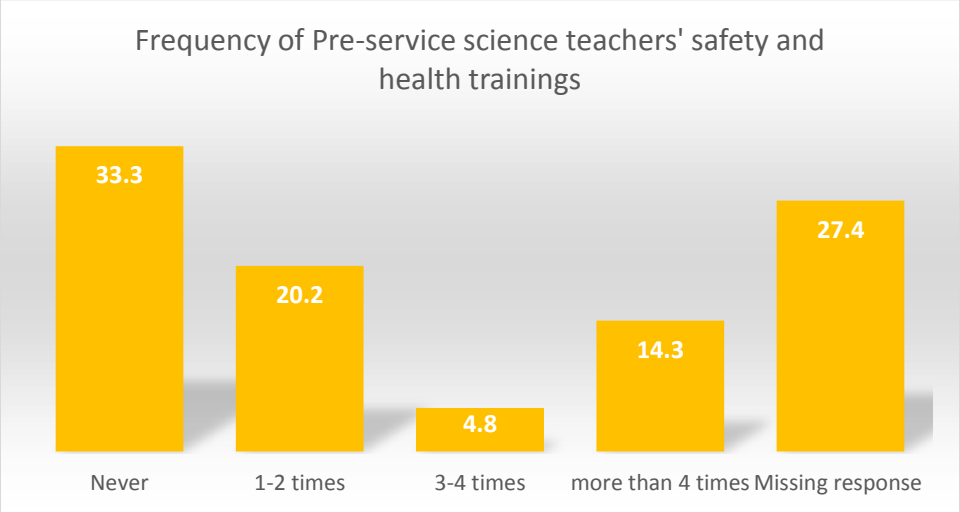

Figure 2 Percentage of pre-service science teachers on safety and health trainings

Figure 2 shows 20.2% pre-service science teachers had 1-2 times, 4.8 % of science pre-service teachers had 3-4 times, and 14.3 % of pre-service science teachers had more than 4 times training on safety and health trainings.

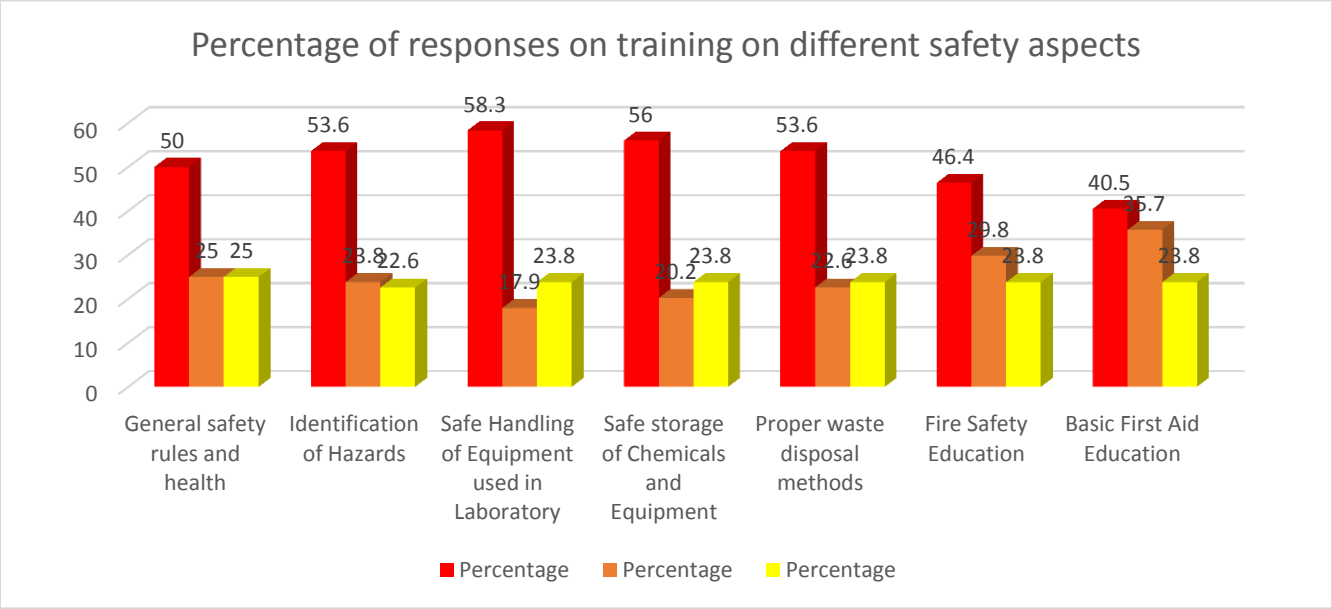

Figure 3 Pre-service science teachers formal training in safety and health measures

50% of science pre- service teachers had formal training in general safety and health risks, 53.6% agreed trained in hazards identification, 58.3% pre-service teachers knows safe handling of chemicals and materials, 56 % have safe storage of chemicals and equipment, 53.6 % were

trained on proper waste disposal methods, 46.4% pre-service science teachers were trained in fire safety Education and 40.5 % had Basic first aid education.

Analysis and interpretation of results for research question two and hypothesis one

H_{01}: Is there any statistical significance difference in respondents ranks on sources of safety information used in science laboratories.

Table 1

Showing Friedman test showing statistical significance difference in preference of different sources of information

Test Statistics	
N	54
Chi-Square	95.967
df	11
Asymp. Sig.	.000

a. Friedman test

Table 1 shows, there was a statistically significant difference, (See Table 1) in preference of different sources of information on laboratory safety and health measures $\chi^2(11) = 95.967$, $p = 0.000$.

Analysis and interpretation of results for research question three.

What is the pre-service science teachers' level of Awareness on Safety, health measures and risk assessment and management practiced in science practical?

Table 2

Pre-service science teacher's awareness levels on Safety, health measures and risk Management in science practicals

	N Statistic	Low	Medium	High
Awareness on safety and health issues	83	28.90	44.60	26.5
Awareness on general laboratory practices	83	31.30	39.80	28.9
Practical Risk assessment and management	82	26.80	50.00	23.2

Awareness on safety and health measures and risk management	83	25.30	50.60	24.1

Table 2 shows 44.60 %, 39.80%, 50 % and 50.60 % of Preservice secondary science teachers had medium levels of awareness on safety and health issues; general laboratory practices, practical risk assessment and management; and awareness on safety and health measures and risk management, respectively.

Analysis and interpretation of results for research question four and hypothesis two

$H0_2$: Is there any statistical significance differences in preservice science teacher's awareness of safety and health measures based on training.

Table 3

Pre-service science teacher's awareness levels on Safety, health measures and risk assessment and Management in science practical

Variable	***Formal training (n= 47)***		***No training (n= 33)***				***t (78)***	***Sig.***
	M	***SD***	***M***	***SD***	***Mean difference***	***SED***	***value***	
Awareness on safety and health issues	28.511	6.98	23.455	7.6161	5.0561	1.646	3.071*	0.003

Note. M = mean, SD = standard deviation, SEM = Standard error of mean, *t* = calculated t value, SED = standard error difference, n = number of health information learners.

*$p<.05$

There is statistically significant mean difference (see Table 3) on Awareness on safety and health issues between formally trained (M=28.511, SD=6.98) and not trained (M= 23.455, SD= 7.616), t (78) = 3.071, p=. 003.

Analysis and interpretation of results for research question five and hypothesis three

H_{03}: There is no statistically significant difference between the pre-service science teachers' awareness on safety, health measures; and Risk management based on the gender, age group, subject specialization, year of study and teaching experience?

Table 4

Independent t-Test analysis of difference in pre-service science teachers on awareness of safety, health measures, risk assessment and risk measurement based on Gender

Variable	Male (n= 31)		Female (n= 52)				t (83)	Sig.
	M	SD	M	SD	Mean difference	SED	value	
Awareness on safety and health issues	28.35	7.22	25.34	7.49	3.0087	1.6775	1.794	0.077
Awareness on general laboratory practices	20.68	2.98	19.94	3.21	0.735	0.709	1.036	0.303
Practical Risk assessment and management	109.86	13.55	107.34	11.48	2.521	2.814	0.896	0.373
Awareness on safety and health measures and risk management	156.13	22.73	152.63	17.45	3.494	4.442	0.787	0.434

***the mean difference is significant at the .05 level.**

There is no statistically significant mean difference (see Table 4) between male and female learners on Awareness of safety and health issues: male (*M*=28.35, *SD*=7.22) and female learners (*M*= 25.34, *SD*= 7.49), *t* (83) = .1.794, *p*=. 077; on Awareness on general laboratory practices: male (*M*=20.68, *SD*= 2.98) and female learners (*M*= 19.94, *SD*= 3.21), *t* (83) = .1.036, *p*=. 0.303; (Practical risk assessment and management: male (*M*=109.86, *SD*=13.55) and female preservice teachers. (*M*= 107.34, *SD*= 11.48), *t* (83) = 0.896 *p*=. 373; on Awareness on safety health measures and risk management between male (*M*=156.13, *SD*=22.73) and female preservice teachers. (*M*= 152.63, *SD*= 17.45), *t* (83) = 0.787 *p*=. 434. Therefore no statistical mean difference between male and female pre-service science teachers on awareness safety, health measures and risk management in science practical

Table 5

Results of Analysis of Variances on pre-service science teachers' differences on safety, health measures and risk assessment and management based on the Age group

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Awareness on safety and health issues	Between Groups	39.278	2	19.639	0.363	0.697
	Within Groups	3242.436	60	54.041		
	Total	3281.714	62			

Awareness on general laboratory practices	Between Groups	8.179	2	4.09	0.426	0.655
	Within Groups	575.472	60	9.591		
	Total	583.651	62			
Practical Risk assessment and management	Between Groups	196.628	2	98.314	0.613	0.545
	Within Groups	9461.049	59	160.357		
	Total	9657.677	61			
Awareness on safety and health measures and risk management	Between Groups	227.215	2	113.607	0.286	0.753
	Within Groups	23861.769	60	397.696		
	Total	24088.984	62			

***the mean difference is significant at the.05 level.**

The results of ANOVA analysis show that pre-service science teachers show no mean difference on awareness on safety and health issues F [2,60] = .363, p=.697, awareness on general laboratory practices F [2,60]= .426, p=.655 , Practical risk management F [2,59] = .613, p=.545; Awareness of safety , health measures and risk management F [2,60] = .286, p=.753, Therefore at 95% level of confidence that there is no mean difference on awareness of on safety, health measures and risk management based on age group (see Table 5).

Table 6
Results of Analysis of Variances on pre-service science teachers' differences on safety, health measures and risk assessment and management based on the subject specializations

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
Awareness on safety and health issues	Between Groups	279.592	2	139.796	2.587	0.082
	Within Groups	4323.083	80	54.039		
	Total	4602.675	82			
Awareness on general laboratory practices	Between Groups	4.722	2	2.361	0.237	0.79
	Within Groups	797.374	80	9.967		
	Total	802.096	82			
Practical Risk assessment and management	Between Groups	8.149	2	4.074	0.026	0.974
	Within Groups	12163.949	79	153.974		
	Total	12172.098	81			

Awareness on safety and health measures and risk management	Between Groups	284.891	2	142.446	0.368	0.693
	Within Groups	30985.808	80	387.323		
	Total	31270.699	82			

***the mean difference is significant at the .05 level.**

The results of ANOVA analysis show that pre-service science teachers show no mean difference on awareness on safety and health issues F [2,80] = 2.587, p=.082; awareness on general laboratory practices F [2,80]= .237, p=.790; Practical risk management F [2,79] = .026, p=.974; Awareness of safety and health measures and risk management F [2,80] = .368, p=.693, Therefore at 95% level of confidence that there is no mean difference on awareness of on safety, health measures and risk management based on subject specializations (see Table 6).

Table 7

Results of Analysis of Variances on pre-service science teachers' differences on safety, health measures and risk assessment and management based on year of study

ANOVA

		Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Awareness on safety and health issues	*Between Groups*	*5.67*	*3*	*1.89*	*0.032*	*0.992*
	Within Groups	*4597.005*	*79*	*58.19*		
	Total	*4602.675*	*82*			
Awareness on general laboratory practices	*Between Groups*	*26.483*	*3*	*8.828*	*0.899*	*0.446*
	Within Groups	*775.613*	*79*	*9.818*		
	Total	*802.096*	*82*			
Practical Risk assessment and management	*Between Groups*	*133.786*	*3*	*44.595*	*0.289*	*0.833*
	Within Groups	*12038.31*	*78*	*154.337*		
	Total	*12172.1*	*81*			
Awareness on safety and health measures and risk management	*Between Groups*	*249.603*	*3*	*83.201*	*0.212*	*0.888*
	Within Groups	*31021.1*	*79*	*392.672*		
	Total	*31270.7*	*82*			

*the mean difference is significant at the .05 level.

The results of ANOVA analysis show that pre-service science teachers shows no mean difference on awareness on safety and health issues F [3,79] = .032, p=.992, awareness on general laboratory practices F [3,79]= .889, p=.446 , Practical risk management F [3,78] = .289, p=.833; Awareness of safety , health measures and risk management F [3,79] = .212, p=.888, Therefore at 95% level of confidence that there is no mean difference on awareness of on safety, health measures and risk management based on Year of study (see Table 7) .

Table 8

Results of Analysis of Variances on pre-service science teachers' differences on safety, health measures and risk management based on teaching experience.

ANOVA

		Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Awareness on safety and health issues	*Between Groups*	*34.932*	*2*	*17.466*	*0.303*	*0.74*
	Within Groups	*4561.263*	*79*	*57.738*		
	Total	*4596.195*	*81*			
Awareness on general laboratory practices	*Between Groups*	*19.605*	*2*	*9.803*	*1*	*0.373*
	Within Groups	*774.651*	*79*	*9.806*		
	Total	*794.256*	*81*			
Practical Risk assessment and management	*Between Groups*	*438.25*	*2*	*219.125*	*1.462*	*0.238*
	Within Groups	*11694.07*	*78*	*149.924*		
	Total	*12132.32*	*80*			
Awareness on safety and health measures and risk management	*Between Groups*	*91.962*	*2*	*45.981*	*0.117*	*0.89*
	Within Groups	*31178.73*	*79*	*394.668*		
	Total	*31270.7*	*81*			

*the mean difference is significant at the.05 level.

The results of ANOVA analysis show that pre-service science teachers shows no mean difference on awareness on safety and health issues F [2,79] = .303, p=.740, awareness on general laboratory practices F [2,79]= 1.000, p=.373 , Practical risk assessment and management F [2,78] = .1.462, p=.283; Awareness of safety , health measures and risk management F [2,79] = .117, p=.890, Therefore at 95% level of confidence that there is no mean difference on awareness of on safety, health measures and risk management based on teaching experience.

Therefore, Null Hypothesis is retained and There is no statistically significant difference in pre-service secondary science teacher's awareness on safety and health measures and risk management based on the gender, age, subject specialization, year of study and teaching experience.

Analysis and Interpretation of results for research question six and hypothesis Four

Table 9

Results of Pearson's correlation analysis on Relationship between Awareness of safety and health measures and risk management in science practical

Descriptive Statistics			
	Mean	*Std. Deviation*	*N*
Awareness on safety and health measures	*26.47*	*7.492*	*83*
Practical risk management	*108.2683*	*12.25858*	*82*
		Awareness on safety and health issues	*Practical risk management*
Awareness on safety and health measures	*Pearson Correlation*	*1*	*.270**
	Sig. (2-tailed)		*0.014*
	N	*83*	*82*
Practical Risk management	*Pearson Correlation*	*.270**	*1*
	Sig. (2-tailed)	*0.014*	
	N	*82*	*82*

**. correlation is significant at the 0.05 level (2-tailed).*

A Pearson product-moment correlation was computed to assess the relationship between the pre-service science teacher's awareness on safety and health measures and practical risk management. There was a positive (low to moderate) correlation between the two variables, r = .270, n= 83, p =.014 (see Table 9).

Discussion of the Results

The results of this empirical study show that 58.02% of pre-service science teachers have received formal training on safety issues in science laboratories. The pre-service science teachers were further probed on the frequency of the safety trainings; 33.3% had never had training on safety, 14.3% attended more than four times, 4.8% attended three to four times, and 20.2% attended one to two times. It should be noted that 27.4% pre-service science teachers' responses are missing. From the above results there is evidence of conflicting responses on the frequency of training.

The results also indicate that pre-service science teachers were trained on general safety rules (50%), identification hazards (53.6%), safe handling of equipment used in the laboratory (58.3%), safe storage of chemicals and equipment (56%) and proper waste disposal methods (53.6%). Only 46.4 % of pre-service science teachers had fire safety education and 40.5% had basic first aid education. A notable percentage of pre-service science teachers are not trained on different safety aspects. These results clearly indicate a need to provide training that covers different aspects of safety.

The results also indicate a significant difference in pre-service science teacher's preference to use various sources of information on safety, hence the need to consider multiple sources of information and methods such as case studies, discussions, pedagogical tools including active learning and teaching group activities etc (Hill, et al., 2019).

Also indicated by the results is that most of the pre-service science teachers had medium level of awareness on safety and health issues (44.6%), general laboratory practices (39.80%) and practical risk management (50%). This result is clearly indicative of the need for proper training on safety (Borrows, 2008). This result is consistent with the research results of Ali, et al (2018); Shamsudin, Mahmood, Rahim, & Dalim, 2018; and Ponferrada, et al.,(2017) where respondents had medium level of awareness on laboratory safety and constracts research results of Fagihi (2018),Derman and Çakmak, (2016)which found that pre-service science teachers awareness is low. The results also indicate that there is statistical difference in the pre-service science teacher's awareness on safety aspects based on the training. These clearly indicate the impact of the safety training on awareness levels. It is obvious that education and training should improve understanding on safety aspects thereby improving awareness levels (Ivana & Bogolovia, 2018). The research results of Saunders, et al., (1999) indicates that knowledge of hazadous materials management and laboratory safety skills were of utmost importance to science teachers. Research results of Jonathan and Mbogo (2016) indicated that majority of teaching staff were not involved in training programs that give necessary skills to maintain safety thereby compromising on safety and having a deleterious effects on health and safety of laboratory users (Jonathan & Mbogo, 2016).

The results also show that there is no significant difference on awareness on safety based on gender, age, subject specialization, teaching experience and level of study. These results are divergent from research results of Ponferrada, et al. (2017) on gender and subject specialization (Fagihi, 2018; Ponferrada, et al., 2017). Which found gender subject specialization and high performance level shows the difference on pre-service science tea**c**hers awareness levels on safety measures. However, these results may be affected by the unequal sample size based on gender, age group, subject specialty, and teaching experience. The previous empirical research results indicated that most science teachers had problems with risk management in science practical (Schenk, Taheri, & Oberg, 2018).

The results are also indicative of a positive low to medium correlation between awareness on safety, health measures and practical risk management. Although the results have showed consistency with research results of Ivana and Bogolovia (2018); Ponferrada, et al. (2017) on positive correlation, they also show low to medium correlation due to having awareness may not be translated to the risk management. Previous empirical studies corroborated these findings that inclusion of safety education in teacher education is important (Love, Duffy, Loesing, Roy, &West, 2020; Duban, Aydogdu, & Yuksel, 2019; Fagihi, 2018;Ivana & Bogolovia, 2018; Shamsudin, Mahmood, Rahim, & Dalim, 2018; Ponferrada, et al., 2017; Love, 2015; Alaimo, Langenham, Tanner, & Ferrenberg, 2010**;** Roy, 2010; West, 2003) . The various techniques might be used to develop the safety awareness such as active learning techniques (Hill, et al., 2019) and through computer games etc. (Milliszewska & Sztendur, 2011). Safety, health and risk management can be developed through formal training, workshops (Gentry, Lane, & Vanberkum, 1994), posters and videos (Love, 2015) and innovative ways such as computer-based games (Miliszewska & Sztendur, 2011)

Conclusions

This study reveals that 58.02% of pre-service science teachers had formal training in safety and health measures. Yet, 20.2 % pre-service science teachers had 1-2 times, 4.8 % of science pre-service teachers had 3-4 times, and 14.3 % of pre-service science teachers had more than 4 times training on safety and health trainings. According to the study, pre-service science teachers show a statistically significant difference, in preference of different sources of information on laboratory safety and health measures. Pre-service secondary school science teachers had medium levels of awareness on safety and health issues (44.6%); general laboratory practices (39.80%), practical risk management (50%); and awareness on safety and health measures and risk management (50.60%) respectively. There is no statistical significant difference between pre-service secondary science teacher's awareness on safety and health measures and risk management based on the gender, age, subject specialization, year of study and teaching experience. However, a positive low to medium correlation between pre-service

secondary science teacher's awareness on safety and health measures and practical risk management was observed. This study recommends the formulation of safety and risk management policies for science education teaching laboratories.

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APPENDICES

Appendix A

Table A1

Frequency and Percentage of Returned Questionnaires by Gender, Age, subject specialisation, year of study, and Teaching Experience

Variable	Frequency	Percent
Gender		
Male	32	38.1
Female	52	61.9
Total	84	100.0
Age Group		
15-20 years	9	10.7
21-25 years	53	63.1
26-30 years	1	1.2
Missing	21	25.0
Total	84	100.0
Subject Specialization		
Biology	30	35.7
Chemistry	40	47.6
Physics	14	16.7
Total	84	100.0
Year of Study		
2nd year of study	4	4.8
3rd year of study	68	81.0
4th year of study	12	14.3
Total	84	100.0
Teaching experience		
No teaching Experience	61	72.6
0-1 years of teaching experience	17	20.2
2-5 years of teaching experience	5	6.0
Missing	1	1.2
Total	84	100.0