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Status of Safety Provision in Science Laboratories at Secondary Level

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Abstract

The study was carried out to determine the status of safety provision in science laboratories in government high schools for boys at secondary level in district Lakki Marwat by assessing the availability and functionality of safety equipment according to the required quantity. A descriptive survey research design was adopted in carrying out the study. The population of the study consisted of science laboratories in all the 62 government high schools for boys in district Lakki Marwat. A total of 46 government high schools for boys were selected randomly to make sample of the study. A validated and reliable check list was used to observe the availability and functionality of essential safety equipment according to the required quantity in science laboratories of government high schools for boys included in sample. The data collected through checklist were analyzed using frequency counts and percentages. The major findings of the study were; safety provision was totally ignored in the laboratories; majority of the laboratories did not possess the required quantity of acid cabinets, fire extinguishers, and first aid kits. Moreover, no laboratory possessed eye wash station, fire blankets, fire proof cupboards, gas masks, hand gloves, laboratory coats and safety goggles according to the required quantity. It was recommended that laboratories should be made well equipped in respect of safety equipment. Moreover, immediate reforms in policy, budgeting training, and monitoring should be ensured to provide safety provision in schools at the secondary level

***Keywords*:** Safety Provision, Science Laboratories, Secondary Level

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Introduction

Safety provision means arrangement and maintenance of safety measures in a science laboratory. It refers to the availability and proper functioning of specific tools/equipment according to the required quantity and adopting certain practices to avoid danger during laboratory activities (National Research Council, 2011). In secondary school laboratories, where science students regularly handle various chemicals, specimens, and instruments, safety arrangements are indispensable for ensuring a secure learning environment. It is mandatory to provide complete safety to science teachers and students in order to avert any danger in the laboratory, while performing laboratory work.

Science education is recognized globally as a cornerstone of technological and national development. At the secondary school level, laboratory work plays a vital role in developing scientific literacy, critical thinking, and inquiry skills among students (Saputra & Lael, 2024, OECD, 2022). And, science education and laboratory work cannot be separated from one another. Laboratory work has positive effects on learning process in science education (Hofstein &Lunetta, 2004; Shana and Abulibdeh, 2020; Shahzadi, Iqbal and Zahid, 2023). Rehman (2004) viewed that teaching of science requires laboratory work. Practical activities should be given preference rather than rote memorization in order to increase students' interest and achievement.

Science is a practical subject. Science curricula should give students the opportunity to practice the process of investigation in authentic contexts, and in secondary schools this should involve working in well-equipped and supported laboratory environment. Practical activities are essential in all level of science education and in particular it is highly significant in secondary schools to help students in internalizing and understanding the theoretical knowledge of science fields such as chemistry, biology and physics. (Zengele and Alemayehu, 2016; Sroczynski, 2023).

The secondary science curriculum in Pakistan also emphasizes experimentation and hands-on learning as essential components for achieving national education goals National Curriculum Framework (NCF) and Single National Curriculum (SNC) (Government of Pakistan, Ministry of Federal Education and Professional Training [GoPMoFEPT], 2017, 2020). Secondary stage of education in Pakistan ranges from class 9^{th} to 12^{th}. Science group students start studying science subjects like chemistry, biology and physics from class 9^{th}. For all these subjects a

combined science laboratory was provided in government high schools. However, there might be some schools where separate laboratories were available. Moreover, science teacher for chemistry and biology were separate from that of physics and mathematics.

However, while at national level the policy documents and curriculum (GoPMoFEPT, 2006, 2017, 2020,) and similarly at provincial level in KP, educational plan (Anjum & Ayaz, 2024) encourage active and inquiry-based science learning, it gives limited explicit guidance on laboratory safety provision. Consequently, many teachers and students are exposed to potential health risks during laboratory sessions due to inadequate facilities and poor maintenance (Rafique, Dayan and Asma, 2024).

Laboratory work requires great care. Science teachers and students have some responsibilities in order to avoid any sort of danger in the laboratory. Laboratory safety is not merely an administrative requirement. But, it is a prerequisite for meaningful and sustained science learning. A safe laboratory environment ensures that students and teachers can focus on experimental accuracy rather than personal risk (Hussein & Shifera, 2022).

The matter demands more attention in rural areas such as district LakkiMarwat, where various factors including insufficient apparatus and materials, congested area due to non availability of separate laboratories and lack of fund were some hurdles faced by science teachers and students' in science laboratories (Shahzadi et al., 2023). Since, majority of the related research studies were conducted in urban areas. Moreover, existing studies about safety in science laboratories were limited. This gap highlighted the need for a study about safety provision in rural context to inform policymakers and educational planners about the ground realities of safety provision implementation in science laboratories at secondary level. Therefore, this study was designed to determine the status of safety provision by assessing the availability and functionality of laboratory safety equipment according to the required quantity in science laboratories in government high schools for boys at secondary level in district LakkiMarwat, Khyber Pakhtunkhwa.

Literature Review

Laboratory is potentially a dangerous place, where experiments are conducted with chemicals, glassware, and instruments. Improper handling or misuse can result in injury or property damage. Therefore,

familiarity with safety procedures and equipment use is crucial (Baily and Barwick, 2007; Nwele, 2013; American Chemical Society [ACS], 2021). Safety provision ensures protection from laboratory hazards and is a prerequisite for productive experimentation. There are various reasons that cause dangerous situation in the laboratories. Nwele (2013) mentioned that majority of the accidents in the laboratories occur due to lack of care, improper storage of materials and equipment and lack of knowledge about the use of protective items of safety.

Adams and Salome (2014) discussed key measures to minimize laboratory hazards, including good judgment, careful manipulation of apparatus, proper supervision, and knowledge of safety materials and their use. Moreover, adherence to safety rules and proper training for both science teachers and students can significantly reduce such accidents. Science teachers are expected to model safety practices, ensure regular inspection of equipment, and restock supplies such as first aid kits, fire extinguishers, and protective gear. Similarly, students should wear laboratory coats, gloves, and goggles, avoid eating or joking in the laboratory, and handle all materials under teacher supervision (ACS, 2021; NSTA, 2015; Adams and Salome, 2014: Schweingruber, Hilton and Singer, 2006; Bairly and Hardwick, 2007).

Safety instruments such as fire extinguishers, first aid box, hand gloves, fume cupboards, laboratory coats, fire blankets, gas masks, eyewashes, acid cabinets, safety glasses, face shields, protective foot wear, respirators should be available and functional in science laboratories(ACS, 2021; Nwele, 2013). Among these, the first aid kit is considered an indispensable safety tool containing items for immediate medical response to minor injuries or burns.

Research revealed that safety provision in school laboratories in some developing countries were insufficient. Adams and Salome (2014) conducted a study in Nigeria and found that although teachers and students were aware of safety practices; most laboratories lacked safety gadgets and had inadequate first aid kits. Similarly, Nwele (2013) reported that safety equipment in Nigerian secondary school laboratories was available only to a low extent, with none meeting high safety standards. In Pakistan, Awan (2015) found that while science laboratories existed in many Punjab schools, most lacked safety equipment.

However, Hussain, Irshadullah, and Shahzad (2024) found that biology labs have enough space, light, proper hygiene, experimental tables, whiteboards, safety kits, microscopes, beakers, test tubes, funnels,

magnifiers, and balances in Mardan, particularly concerning first aid and emergency safety kits. It was recommended that biology laboratories be upgraded according to the teachers & students' needs on a regular basis. Furthermore, Teachers & students may be properly trained to use laboratory items. But, Shahzadi, Hassan, and Zahid (2023) revealed that no separate laboratories for science subjects existed and materials were insufficient at secondary level in public schools.

Policy and curriculum documents in Pakistan lacked a clear and comprehensive safety provision framework (GoPMoFEPT, 2017). And, secondary schools faced challenges including those of maintenance of safety materials and safety practices. Studies (Muzammal & Hashmi (2024) found urban-rural disparity, with few rural laboratories facing shortages of essential safety equipment and regular inspections.

These research studies revealed that safety provision in science laboratories in schools was unsatisfactory in developing countries including Pakistan. No prior study in rural area investigated the availability and functionality of safety equipment in science laboratories according to the required quantity in rural districts like LakkiMarwat.

Given the scarcity of empirical data from rural areas of Khyber Pakhtunkhwa, the present study was designed to determine the status of safety provision in science laboratories in government high schools at the secondary level in district LakkiMarwat. It assessed the availability and operational condition of safety equipment, providing district-level evidence aligned with national and global safety standards.

Purpose of the study

The purpose of the study was to determine the status of safety provision in science laboratories in government high schools for boys at secondary level in district LakkiMarwat by assessing the availability and functionality of safety equipment according to required quantity.

Research Question of the Study

What was the status of availability and functionality of safety equipment according to the required quantity in science laboratories in government high schools for boys at secondary level in district Lakki Marwat.

Significance of the study

The study found that safety provision in science laboratories at secondary level in district Lakki Marwat was totally ignored. Therefore, the study might convert the attention of policy makers and higher authorities towards the improvement of safety provision in the science laboratories not only by designing and integrating safety provision framework in policy documents and curriculum but also by providing resources to school. Moreover, the study might provide knowledge to science teachers, laboratory assistants and students regarding safety equipment required for science laboratories at secondary level. Furthermore, it might be helpful for heads of the school to handle the situation and to ensure provision of safety equipment in the laboratories.

Delimitation of the study

The proposed study was delimited to lower secondary level, and population included government high schools for boys. And safety provision was delimited to the availability and functionality of safety equipment according to the required quantity in science laboratories.

Research Methodology

The study was descriptive in nature and employed a survey design. It was designed to determine status of safety provision in science laboratories in government high schools at secondary level in district Lakki Marwat by assessing the availability and functionality of safety equipment according to the required quantity.

Population of the Study

The study was conducted in district LakkiMarwat. It is one of the southern districts of Khyber Pakhtunkhwa. There were total 62 government high schools for boys in district LakkiMarwat. All the government high schools had science laboratories. Population of the study consisted of science laboratories in all the 62 government high schools for boys in district LakkiMarwat. These government high schools represented the lower secondary level as the study was delimited to lower secondary level.

Sample and Sampling Technique

Forty six (46) government high schools for boys were selected through random sampling technique to make sample for the study. In this

way, science laboratories of the 46 government high school for boys formulated sample of the study, which represented approximately 75 % of the total population.

Research Instrument

The instrument for data collection was a structured observation checklist developed by the researcher after reviewing relevant international and national factual documents, safety standards, and related literature on laboratory safety. The checklist was specifically designed to assess the availability and functionality of safety equipment according to the required quantity in science laboratories of government high schools for boys. It included a list of ten key safety items along with their required quantities per laboratory accommodating 20 students, based on recognized laboratory safety guidelines. These safety equipment included acid cabinets two per laboratory, eye wash station one per laboratory, fire blankets two per laboratory, fire extinguishers two per laboratory, fire-proof cupboards two per laboratory, first aid kits one per laboratory, gas masks one per student and one for each lab staff member including teacher, hand gloves one pair per student and one for each lab staff member including teacher, lab coats one per student and one for each lab staff member including teacher, and safety goggles one per student and one for each lab staff member including teacher. All safety equipment was carefully selected to maintain a safe and secure environment in science laboratories. The checklist enabled systematic observation and recording of whether each safety equipment item, according to the required quantity, was available and functional or not available. It provided a clear assessment of the status of safety provision in the observed science laboratories of government high schools for boys in the district LakkiMarwat.

Validity and Reliability of the Instrument

Three experts having specialty in science education, educational research, and laboratory management reviewed the observation checklist to ensure validity of the instrument. The method of seeking expert opinion was adopted as used by Qamar (2023) The suggestions of experts were incorporated.

Pilot testing was conducted in two government high schools that were not included in sample of the study. This practice determined the feasibility and clarity of the instrument in the actual school context.

Based on the pilot findings, slight refinements were made to improve the observation procedure.

Inter-rater reliability was established by observing and recording the availability and functionality of safety equipment by the researcher and a trained assistant independently, during pilot testing. The high degree of agreement indicated that the observation checklist was a reliable tool for assessing laboratory safety equipment in government high schools.

Data Collection Procedure

The researcher obtained proper permission from the District Education Officer (DEO) and the respective school heads before visiting the institutions for the purpose of data collection. The researcher personally visited each school present in the sample to collect data. During each visit, the science laboratory was inspected using the prepared observation checklist. Each of the ten safety equipment items was carefully observed to determine whether it was available and functional according to the required quantity or not available. The observation checklist was filled on-site to ensure accuracy and authenticity.

In science laboratories, where a safety equipment item was present but not in working condition, it was recorded as not available, in accordance with the operational definition of safety provision adopted in this study. The direct observation method enabled the researcher in getting firsthand and reliable data regarding the actual safety provision in science laboratories of government high schools for boys in district LakkiMarwat. The checklists were compiled for data analysis and interpretation after completion of all visits

Results

The data obtained through checklists were analyzed using frequency counts and percentages. It described the availability and functionality status of each safety equipment item according to the required quantity across the government high schools for boys present in sample of the study. The results were presented in tabular form, showing the percentage of schools where each equipment item was available and functional according to the required quantity.

Table 1

Structured Observation Checklist Results for Science Laboratory Safety Equipment

S.No.	Safety equipment	Required Quantity per Lab (of 20 students)	Available and Functional (Frequency & %)	Not Available (Frequency & %)
1	Acid cabinets	2	14 (30%)	32 (70%)
2	Eye wash station	1	0 (0%)	46 (100%)
3	Fire blankets	2	0 (0%)	46 (100%)
4	Fire extinguisher	2	9 (20%)	37 (80%)
5	Fire proof cupboards	2	0 (0%)	46 (100%)
6	First aid kits	1	8 (17%)	38 (83%)
7	Gas masks	One Per student and one per each lab staff	0 (0%)	46 (100%)
8	Hand gloves	One pair Per student and one per each lab staff	0 (0%)	46 (100%)
9	Lab coats	One Per student and one per each lab	0 (0%)	46 (100%)

		staff		
10	Safety goggles	One Per student and one per each lab staff	0 (0%)	46 (100%)

The data presented in Table 1 showed that the availability and functionality of safety equipment according to the required quantity in science laboratories was very low and alarming. Out of 46 observed laboratories, only 30% were equipped with acid cabinets, while no laboratory had an eye wash station, fire blankets, fireproof cupboards, gas masks, hand gloves, lab coats, or safety goggles. Similarly, only 20% had functional fire extinguishers and 17% had first aid kits. These findings revealed a significant gap between the required and actual safety provisions, indicating poor compliance with basic laboratory safety. Such conditions might exposed students and teachers to potential chemical, fire, and biological hazards, highlighting an urgent need for policy-level intervention and improved school safety management practices.

Discussion

The results of this study were very alarming. There were some international and national research studies highlighting worrying safety status in science laboratories. Limboo et al. (2022) examined chemistry laboratories in Bhutan. He revealed that while safety practices and awareness were relatively good in terms of emergency planning and chemical storage, serious shortages of safety gloves and goggles were observed. These findings directly comparable to this study observation of total absence of personal protective equipment like gas masks, hand gloves, lab coats and safety goggles. Meanwhile, Rafique, Dayan &Asma (2024) found inadequate safety measures in laboratories of secondary schools in Peshawar. Similarly, Muzammal and Hashmi (2024) in Lahore found a strong positive relationship between the quality of laboratory resources and student performance, but noted that few laboratories lacked basic safety measures. These studies collectively revealed that safety provision was a challenge in science laboratories of some developing countries including Pakistan. It necessitated and demanded immediate reforms in policy, training, and monitoring.

Conclusion

The overall status of safety provision in science laboratories of government high schools for boys was unsatisfactory. Majority of safety equipment was either unavailable or non-functional, indicating very poor and alarming safety provision. a safe and secure environment in science laboratories is not only crucial for protecting students and teachers but also for promoting effective hands-on science learning. Immediate attention from policy makers and education authorities was required to address these safety deficiencies.

Recommendations

It was recommended that a comprehensive safety provision framework should be included in policy documents and integrated into the curriculum to promote a sustainable culture of safety in science laboratories at secondary level. Specific budgets should be allocated for the purchase and maintenance of laboratory safety equipment. Regular safety audits and inspections were suggested to ensure compliance with safety provision in schools at secondary level. It was also recommended to provide professional development and training on laboratory safety and emergency procedures to science teachers at secondary level. Furthermore, schools were advised to develop a laboratory safety manual for both students and staff.

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