



Chemical Exposure, Self-Reported Haematological Symptoms, and Laboratory Safety Practices Among Undergraduate and Postgraduate Science and Medical Students

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ABSTRACT

Exposure to laboratory chemicals with potential haematotoxic effects is a growing concern among science and medical students who routinely engage in practical laboratory activities. This study assessed chemical exposure, self-reported haematological symptoms, and laboratory safety practices among 412 undergraduate and postgraduate science and medical students using a structured questionnaire. Overall, 55.8% of respondents demonstrated good knowledge of haematotoxic chemicals, while 78.4% reported regular exposure to laboratory agents such as solvents, acids, and disinfectants. Common self-reported haematological symptoms included fatigue (48.5%), pallor (27.2%), recurrent infections (21.6%), and easy bruising (16.3%). A significant association was observed between chemical exposure and the presence of symptoms ($\chi^2 = 18.97$; $df = 1$; $p < 0.0001$). Preventive practices were suboptimal, with only 44.2% of participants demonstrating good laboratory safety behavior. Knowledge level was significantly associated with preventive practices ($\chi^2 = 27.56$; $df = 2$; $p < 0.0001$), indicating that higher awareness improves compliance with safety measures. In spite of moderate-to-good knowledge levels, gaps in practice and exposure control persist. These findings highlight the need for strengthened safety training, improved access to protective equipment, and integration of haematological risk awareness into academic laboratory programs to minimize chemical-related health risks among students.

Keywords: Chemical exposure, haematological symptoms, laboratory safety, science and medical students, occupational health.

INTRODUCTION

Laboratory chemical exposure is an occupational and academic health concern, particularly in settings where undergraduate and postgraduate students, as well as medical trainees, routinely handle solvents, reagents, and other potentially haematotoxic chemicals [1]. These chemicals, including organic solvents, acids, and disinfectants, can adversely affect haematopoiesis, leading to conditions such as anaemia, leukopenia, and thrombocytopenia [2,3]. In spite of the well-documented risks, studies suggest that awareness and adherence to safety protocols among students remain suboptimal, increasing vulnerability to chemical-induced haematological disorders [4,5]. The knowledge, attitudes, and practices (KAP) of students regarding laboratory chemical hazards are critical determinants of their risk profile.

Previous studies in occupational and academic laboratory settings have shown that insufficient training, inadequate use of personal protective equipment (PPE), and poor reporting practices contribute to preventable chemical exposure and adverse health outcomes [6–8]. Furthermore, the integration of haematology-specific risk awareness in chemistry and biomedical curricula is often limited, creating a gap between theoretical knowledge and practical safety behavior [9,10]. In spite of existing studies on laboratory safety and chemical exposure, most have focused primarily on occupational settings such as healthcare workers and industrial environments, with limited attention to students in academic laboratories, particularly within developing country contexts [6–8]. Furthermore, while previous research has examined general chemical safety awareness, there is a paucity of studies explicitly linking chemical exposure to haematological health outcomes among students. In addition, existing studies rarely integrate knowledge, exposure patterns, self-reported haematological symptoms, and preventive practices within a single analytical framework. This creates a critical gap in understanding how laboratory chemical exposure may translate into early haematological risks in academic environments.

Therefore, this study was conducted to bridge this gap by providing an assessment of chemical exposure, haematological symptoms, and safety practices among undergraduate and postgraduate science and medical students.

METHODOLOGY

Study Design

A descriptive cross-sectional survey was conducted to evaluate chemical exposure, self-reported haematological symptoms, and laboratory safety practices among undergraduate and postgraduate science and medical students. The design enabled assessment of relationships between knowledge, exposure, symptoms, and preventive behaviors within an academic laboratory setting.

Study Area and Population

The study was conducted among students enrolled in chemistry, biochemistry, microbiology, medical laboratory science, and related medical programs at two universities in Ekiti State, Nigeria. Participants included undergraduate students (100–500 level) and postgraduate students with routine laboratory exposure. Students not actively involved in laboratory work were excluded.

Sampling Technique and Sample Size

A stratified random sampling method was used to ensure representation across academic programs and levels of study. The sample size was determined using Cochran's formula for cross-sectional studies, assuming a 50% prevalence, 95% confidence level, and 5% margin of error, resulting in a minimum of 384 participants. A total of 420 students were approached, and 412 completed the questionnaire.

Data Collection Instrument

Data were collected using a structured, self-administered questionnaire adapted from validated KAP instruments on chemical exposure and laboratory safety [1–4]. The questionnaire (see appendix) comprised six sections:

- **Section A:** Demographic information (age, gender, program, level of study)
- **Section B:** Knowledge of haematotoxic chemicals and their effects on blood
- **Section C:** Exposure to laboratory chemicals (types, frequency, duration)
- **Section D:** Preventive practices (PPE use, fume hood utilization, spill management)
- **Section E:** Self-reported haematological symptoms (fatigue, pallor, bruising, infections, epistaxis)
- **Section F:** Incident reporting practices and barriers

Responses were scored as correct = 1, and incorrect = 0, and categorized into poor (<50%), moderate (50–74%), and good ($\geq 75\%$) levels.

Experimental Procedure

The questionnaire was administered physically during laboratory sessions and lecture periods. Participants were informed about the study objectives, and written informed consent was obtained prior to participation. Each questionnaire required approximately 15–20 minutes to complete. Completed responses were collected anonymously and checked for completeness before data entry.

Ethical Considerations

Participation was voluntary, and confidentiality of all respondents was strictly maintained.

Statistical Analysis

Data were entered into Microsoft Excel and analyzed using SPSS version 26.0 (IBM, USA).

- Descriptive statistics: frequencies, percentages, mean \pm standard deviation
- Inferential statistics:
 - Chi-square (χ^2) test to assess associations between knowledge, exposure, symptoms, and preventive practices
 - Logistic regression to determine predictors of good safety practices

Statistical significance was set at $p < 0.05$.

RESULTS AND DISCUSSION

Socio-Demographic Characteristics

A total of 412 respondents participated in the study (response rate: 98.1%). The majority were within the 18–25 years age group (59.2%), with a mean age of 24.3 ± 5.8 years. Females constituted 53.4%, while males accounted for 46.6%. Undergraduate students represented 68.2%, while 31.8% were postgraduate students. The distribution across science and medical programs is presented in Table 1.

Table 1: Socio-Demographic Characteristics of Respondents (n = 412)

Variable	Category	Frequency (n)	Percentage (%)
Age (years)	18–25	244	59.2
	26–35	122	29.6
	>35	46	11.2
Gender	Male	192	46.6
	Female	220	53.4
Level of Study	Undergraduate	281	68.2
	Postgraduate	131	31.8
Program	Science	229	55.6
	Medical	183	44.4

Knowledge of Haematotoxic Chemicals

Overall, 55.8% of respondents demonstrated good knowledge, 29.1% had moderate knowledge, and 15.1% had poor knowledge. Postgraduate students showed significantly higher knowledge levels compared to undergraduates ($\chi^2 = 14.82$; $df = 2$; $p = 0.0006$). Detailed distribution is shown in Table 2.

Table 2: Knowledge of Haematotoxic Chemicals by Level of Study

Level	Good n (%)	Moderate n (%)	Poor n (%)	Total	χ^2	df	p-value
Undergraduate	140 (49.8)	88 (31.3)	53 (18.9)	281	14.82	2	0.0006
Postgraduate	90 (68.7)	32 (24.4)	9 (6.9)	131			
Total	230 (55.8)	120 (29.1)	62 (15.1)	412			

Chemical Exposure and Self-Reported Haematological Symptoms

A total of 78.4% of respondents reported regular exposure to laboratory chemicals. The most common exposures included organic solvents (64.3%), acids (71.1%), and disinfectants (58.5%).

Self-reported haematological symptoms included:

- Fatigue: 48.5%
- Pallor: 27.2%
- Frequent infections: 21.6%
- Easy bruising: 16.3%

There was a significant association between chemical exposure and presence of symptoms ($\chi^2 = 18.97$; $df = 1$; $p < 0.0001$), as shown in Table 3.

Table 3: Association Between Chemical Exposure and Haematological Symptoms

Exposure Status	Symptoms Present n (%)	No Symptoms n (%)	Total	χ^2	df	p-value
Exposed	198 (61.3)	125 (38.7)	323			
Not Exposed	29 (32.6)	60 (67.4)	89	18.97	1	<0.0001

Preventive Practices and Their Association with Knowledge

Only 44.2% of respondents demonstrated good laboratory safety practices, while 36.4% had moderate and 19.4% had poor practices.

A strong association was observed between knowledge level and preventive practices ($\chi^2 = 27.56$; $df = 2$; $p < 0.0001$). Respondents with good knowledge were more likely to adopt appropriate safety measures. Details are presented in Table 4.

Table 4: Association Between Knowledge and Preventive Practices

Knowledge Level	Good Practice n (%)	Poor/Moderate n (%)	Total	χ^2	df	p-value
Good	136 (59.1)	94 (40.9)	230			
Moderate	34 (28.3)	86 (71.7)	120			
Poor	12 (19.4)	50 (80.6)	62	27.56	2	<0.0001

This study evaluated chemical exposure, self-reported haematological symptoms, and laboratory safety practices among science and medical students, revealing important insights into occupational risk within academic laboratory settings. The findings demonstrated moderate-to-good knowledge of haematotoxic chemicals among participants, with postgraduate students exhibiting significantly higher knowledge levels than undergraduates (Table 2). This trend is consistent with recent studies indicating that advanced academic training enhances awareness of chemical hazards and associated health risks [11,12]. However, the presence of knowledge gaps among undergraduates suggests insufficient integration of haematotoxic risk education into early-stage curricula.

Chemical exposure was high (78.4%), with organic solvents and acids being the most commonly encountered agents. This aligns with recent occupational and academic laboratory studies reporting widespread exposure to chemical hazards among students and early-career professionals [13,14]. The high exposure rate observed underscores the routine nature of chemical handling in laboratory environments and highlights the need for stricter safety enforcement.

Importantly, a significant association was observed between chemical exposure and self-reported haematological symptoms ($\chi^2 = 18.97$; $p < 0.0001$) (Table 3). Symptoms such as fatigue, pallor, and recurrent infections may reflect early manifestations of haematological disturbances associated with chronic low-level chemical exposure. Similar associations have been reported in recent toxicological and public health studies linking chemical exposure to subclinical haematological alterations [15,16].

Preventive practices were suboptimal, with less than half of respondents demonstrating good safety behavior. The strong association between knowledge and preventive practices ($\chi^2 = 27.56$; $p < 0.0001$) (Table 4) indicates that improved awareness significantly enhances safety compliance. However, consistent with recent literature, knowledge alone does not guarantee safe practices, as behavioral and institutional factors also play critical roles [17,18].

Furthermore, poor reporting of exposure incidents observed in this study reflects findings from recent research highlighting underreporting of laboratory and occupational hazards due to fear, lack of awareness, or absence of formal reporting systems [19]. This suggests the need for structured reporting frameworks and supportive institutional policies.

Recent advances in occupational toxicology emphasize the importance of integrating exposure assessment with behavioral and educational interventions to reduce long-term health risks [20]. The findings of this study support this approach, demonstrating that improving both knowledge and institutional safety culture is essential for minimizing haematotoxic risk.

Overall, the study highlights significant exposure to laboratory chemicals, associated self-reported haematological symptoms, and gaps in preventive practices among students. Addressing these challenges through targeted education, improved safety infrastructure, and enforcement of laboratory protocols is critical for safeguarding student health.

CONCLUSION AND RECOMMENDATIONS

This study demonstrated that undergraduate and postgraduate science and medical students are frequently exposed to laboratory chemicals with potential haematotoxic effects, with a high proportion reporting regular contact with solvents, acids, and disinfectants. Although more than half of the respondents exhibited moderate-to-good knowledge of chemical hazards, significant gaps remain, particularly among undergraduate students.

Importantly, the study identified a significant association between chemical exposure and self-reported haematological symptoms ($\chi^2 = 18.97$; $p < 0.0001$), suggesting that routine laboratory exposure may contribute to early manifestations of haematological disturbances. Additionally, preventive practices were suboptimal, with less than half of participants adhering consistently to recommended safety measures.

The strong relationship between knowledge and preventive practices ($\chi^2 = 27.56$; $p < 0.0001$) indicates that improved awareness enhances safety behavior; however, knowledge alone is insufficient without adequate institutional support and enforcement. Overall, the findings highlight a critical need to strengthen laboratory safety culture and integrate haematological risk awareness into student training.

Recommendations

1. Curriculum Integration: Incorporate haematotoxic risk and chemical safety into science and medical curricula.
2. Safety Training: Conduct regular laboratory safety training on chemical handling and exposure risks.
3. PPE Compliance: Ensure availability and consistent use of personal protective equipment.

4. Laboratory Policies: Enforce standard procedures for chemical handling, spills, and waste disposal.
5. Reporting Systems: Establish effective incident reporting mechanisms and encourage timely reporting.
6. Health Monitoring: Implement periodic medical screening, including basic haematological tests.
7. Further Research: Promote biomonitoring and longitudinal studies on chemical exposure effects.

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Author contributions

KSO conceptualized the study, drafted the manuscript, and supervised; OEF contributed to literature review and editing; AOD provided clinical insights and data support; all authors approved the final manuscript.

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Appendix A: Sample Questionnaire

Title: *Chemical Exposure, Haematological Symptoms, and Laboratory Safety Practices Among Science and Medical Students*

Section A: Demographic Information

1. Age:
 18–25 26–35 >35
2. Gender:
 Male Female
3. Level of Study:
 Undergraduate Postgraduate
4. Field of Study:
 Chemistry Biochemistry Microbiology Medical Laboratory Science
Medicine Others (specify): _____

Section B: Knowledge of Haematotoxic Chemicals

5. Are some laboratory chemicals capable of affecting blood cells?
 Yes No
6. Prolonged exposure to organic solvents can cause anaemia.
 True False
7. Benzene exposure is associated with blood disorders.
 True False
8. Personal protective equipment (PPE) reduces exposure to harmful chemicals.
 Yes No
9. Chemical exposure can affect white blood cell function.
 Yes No

Section C: Chemical Exposure

10. How often do you handle laboratory chemicals?
 Daily Weekly Occasionally Rarely
11. Which of the following chemicals do you frequently handle? (Select all that apply)
 Organic solvents Acids Bases Disinfectants Others: _____
12. Have you ever experienced accidental chemical exposure (spill, inhalation, skin contact)?
 Yes No

Section D: Preventive Practices

13. Do you regularly wear gloves during laboratory work?
 Always Sometimes Never
14. Do you use a lab coat during practical sessions?
 Always Sometimes Never
15. Do you use a fume hood when handling volatile chemicals?
 Yes No
16. Are you trained on chemical spill management?
 Yes No

Section E: Self-Reported Haematological Symptoms

17. Have you experienced any of the following symptoms? (Select all that apply)
- Fatigue
 - Pallor
 - Easy bruising
 - Frequent infections
 - Nosebleeds
 - None

Section F: Incident Reporting

18. Have you ever reported a chemical exposure incident?

Yes No

19. If no, what are the reasons?

Not aware of reporting system

Fear of consequences

Considered it unimportant

Others: _____