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Review Article

Recent case studies on handling of chemicals and their safety measures in the chemistry laboratory: A significant in drug discovery.

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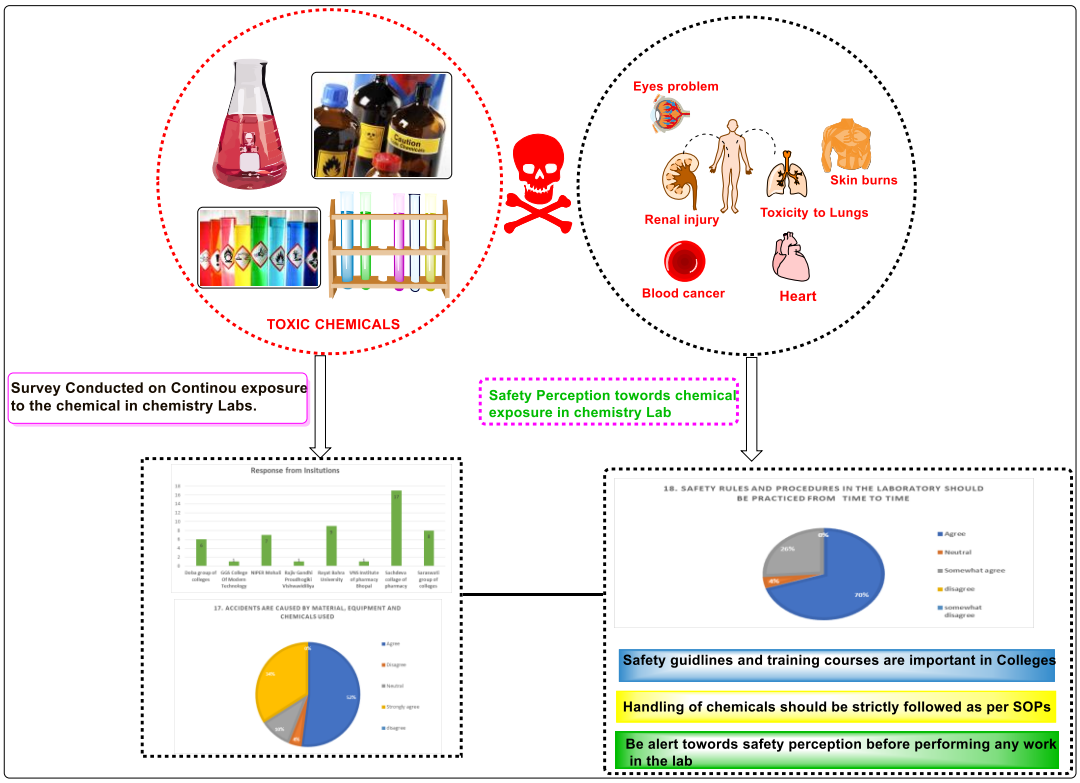
Abstract

Chemical compounds exposure (carcinogenic, mutagenic, flammable) occurs in a variety of work settings, including research and chemistry laboratories, which have not been thoroughly researched. There were several incidents happened during working in the chemistry research laboratory which are more injurious to the health discussed by the several research scholars. The study's primary goals were to investigate occupational exposure to hazardous chemical substances among research Chemistry laboratory workers, to assess their awareness and perceptions of chemical hazards, to investigate adherence to guidelines for safe handling of chemical compounds while working in the chemistry research lab. We discussed several accidents happened in the chemistry research laboratory and their safety measures to prevent from this kind of hazardous chemicals.

Methods: *A survey was conducted among research lab professionals who had been exposed to chemicals during their work. Participants completed a questionnaire about their expertise, perspectives, and practices about chemical hazards in research activities.*

Secondly, we studied several case studies based on hazardous chemical causes incidents in chemistry lab and their safety measures.

Results*: Our research revealed serious knowledge deficits and a lack of readiness for following safety procedures to reduce and eliminate dangers associated with the use of hazardous substances in research labs. To guarantee that researchers are fully aware of the risks and the precautions that may be taken to prevent or minimize chemical exposures, it is important to implement occupational training. This will also help to strengthen the commitment to and oversight of safety procedures among research supervisors and principal investigators.*



1. Introduction

Almost every product manufactured by humans is made of chemicals, which are also widely used in daily life worldwide. Chemical synthesis, manufacture, processing, transportation, and their effects on the environment and human health all constitute chemical dangers. One kind of occupational hazard brought on by chemical exposure at work is a chemical hazard.

Workplace chemical exposure can have negative short-or long-term health impacts. Hazardous chemicals come in many forms, such as carcinogens, immunological agents, neurotoxins, dermatologic agents, asthma genes, reproductive toxins, systemic toxins, pneumoconiosis agents, and sensitizers.[1]

It is widely accepted that chemistry is an area that uses chemicals in its practical laboratory knowledge and experiments on a large and frequent basis. These substances might be gasses, liquids, or solids, and they can be either organic or inorganic in nature. They could also poison the environment and be hazardous, annoying, radioactive, combustible, corrosive, explosive, and easily oxidizing.

It is also seen that the employees and students who are unaware of the risks connected with most of the chemicals in their laboratories are more likely to have accidents caused by laboratory chemicals. When handling dangerous compounds, even highly skilled laboratory personnel run the risk of injury if they don't take the necessary safety precautions. [2]

To avoid these chemical hazards in laboratories, there are three main steps involved in evaluating the risk associated with a chemical process or procedure: risk identification, risk evaluation, and risk minimization. [2]

1.1 Chemical Hazards

Exposure to chemicals at work may give rise to a range of occupational dangers, including chemical hazards. Working with chemicals at work can harm short- and long-term health.

Chemical dangers might emerge during scientific investigations or laboratory activity. These operations may involve pouring chemicals, producing reagents and solutions, labelling, boiling, heating, pipetting, and storing, transporting, and disposing of chemicals. Workers may receive toxic and corrosive injuries as a result of chemical spills and spurting hazards while preparing and pouring acids or other hazardous materials in a laboratory. Misidentification concerns develop when chemical bottles are improperly labelled, occasionally due to frequent destruction by corrosive fumes and pests.[3]

Students in chemistry and biology labs who work with compounds that could be irritating, explosive, combustible, radioactive, or pose a health risk have received special care and consideration. There have been numerous reports of mishaps in chemical laboratories around the world for a variety of reasons, including

insufficient expertise, erroneously chemical handling, and a lack of understanding on what to do in an emergency.

Combustible gases

- Explosion hazard
- Must maintain below lower explosive limit.

Toxic gases

- Hazardous to human health.
- Employee exposure must be limited.

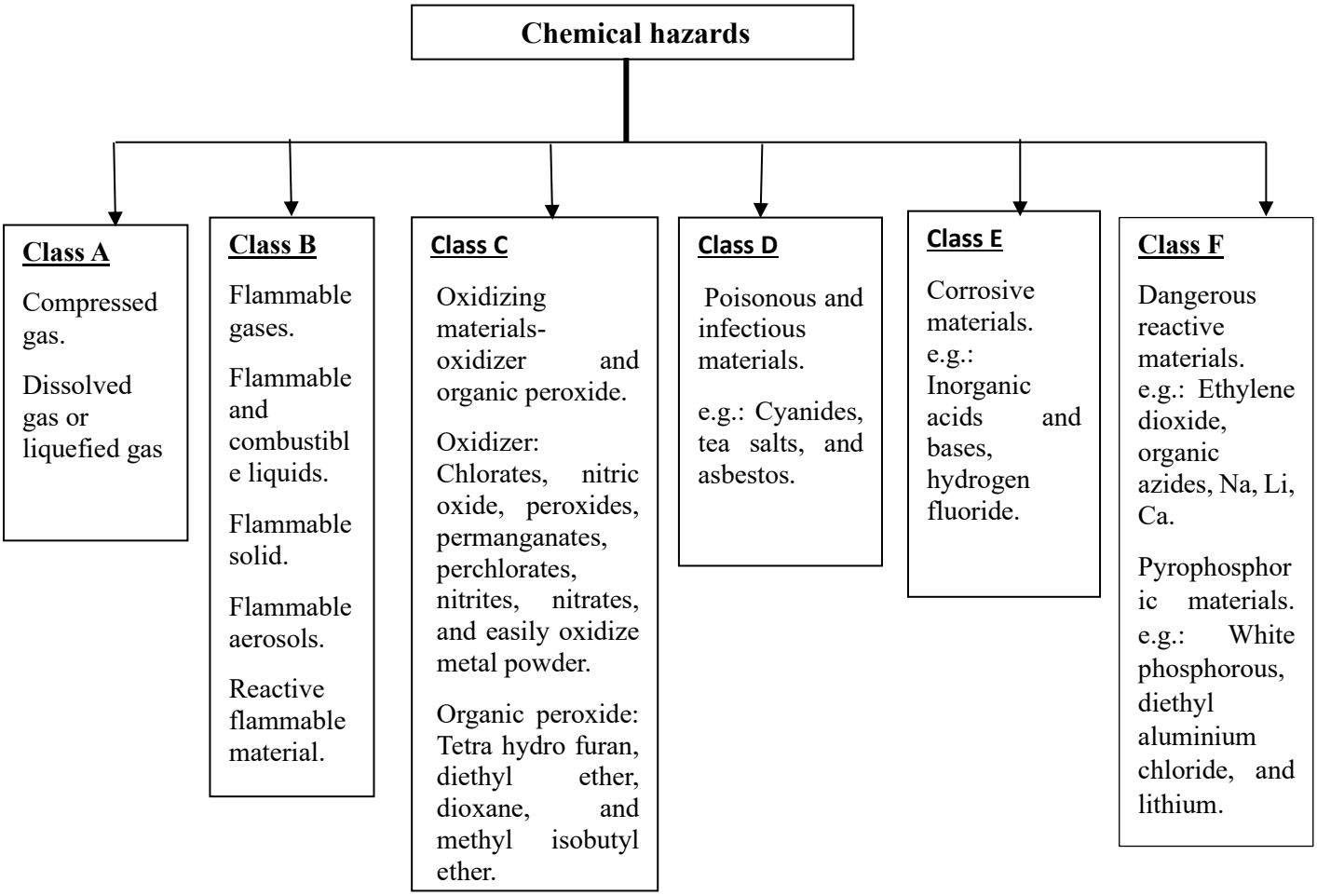
Oxygen displacing gases

- Indirect human health hazard.
- Deficiency of breathing oxygen.

It is still difficult to distinguish between laboratory safety and industrial production plant safety. Due to a lack of finance, institutions in low-income countries have placed a lower priority on chemical risk evaluation and mitigation.[4]

1.2 Table 1: Types of chemical hazards:

There are following chemical hazards given below.[1]



1.3 Routes of exposure to chemicals

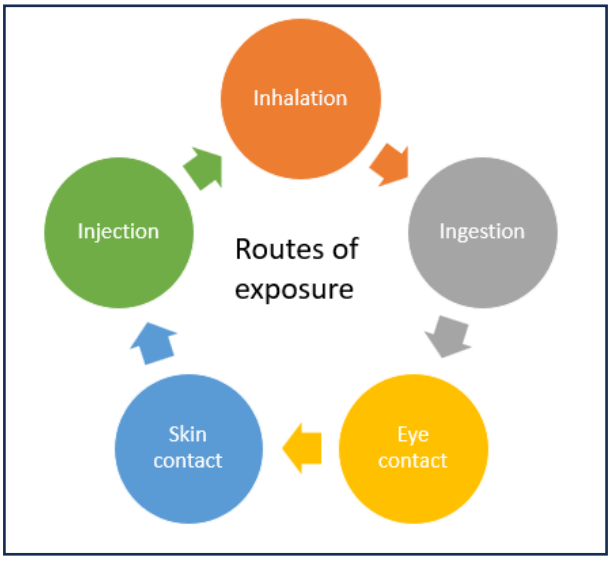


Figure -1 Routes of exposure to the hazard chemicals

ISO standards for protection in chemistry lab-

• ISO 6530 Protective clothing - Protection against liquid chemicals -- Method for

testing materials' resistance to liquid penetration.

• ISO 16602, Protective Clothing against Chemicals Classification, labelling, and performance The requirements follow a 6-tier framework similar to those described in the CEN standards.

• ISO 17491 Protective gear protects against gaseous and liquid chemicals. Determine the resistance of protective gear to liquid and gas penetration.[5]

Methodology:

Descriptive survey research design came was put in for this study. Nwodu (2006) opined that survey research is a research method that focuses on a representative sample derived from the entire population of study. The study population from which the sample was drawn for the study consists of laboratory staffs, technologist, students and lecturers in the selected tertiary Institution in Mohali Punjab. This research work was carried out in various institutions of learning, which includes Institution **A, B, C, D, E , F ,G , H.**

The various cases reported in chemical laboratories are mentioned here:

Case 1: One of the assistant professors in **institution A** witnessed **Blast in ampoule** while performing the experiment ‘’**Bromination of acetanilide** ‘’ in lab -201 along with b. Pharmacy 2nd semester students. The assistant professor said that while hitting the grove of ampoule, instead it hit the base of ampoule and resulted into blast with noise of breaking glass, on account of the blast the fuming hood became red due to bromine spill out of glass wall and shelf of fuming hood, this whole incident led to bromine spillage over the belly of assistant Professor while handling bromine ampoule and lead to first- degree burn of stomach as upper body was protected by glass of fuming hood.

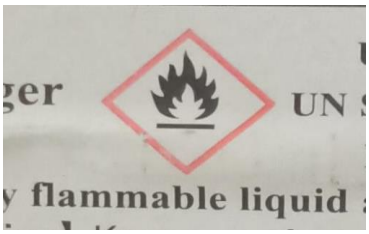
Caution: Bromine is very harmful and toxic so should be handled with Carefulness and under safe supervision

Case 2 : In this case study we studied one more incident that happened in chemistry **lab no. 201** while verification of chemicals by one of the faculty member of **Institution A** due to **mishandling and Lack of consciousness** of person , while picking bottle by holding its cap the bottle fell down from hand due to loose cap and eventually the **chlorosulfonic acid spilled** over the feet of faculty member due to bare feet this lead to three degree burn and faculty member was referred to hospital immediately , it took over one month to recover from injury .

Caution: 1. Always read the bottle label and try to hold it by firm group from sides.

2. Always cover your shoes while working in chemistry lab.

3. Chlorosulfonic acid is highly corrosive, should be handled with Carefulness.

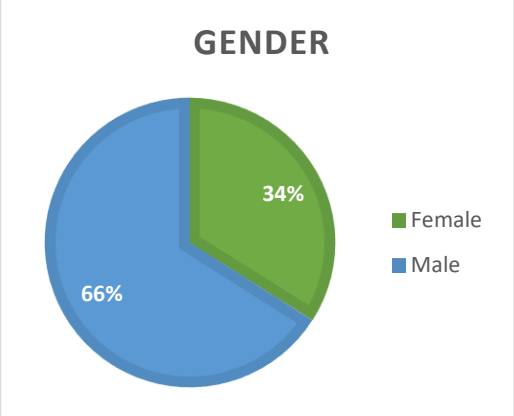
Name of chemical	Laboratory precautions	Hazardous sign or symbol
1.Formic acid (HCOOH) **M.W 46.03** **Orthophosphoric acid** **H_3PO_4** **M.W: 98**	. Additional eye/face protection should be worn in the form of goggles or a face shield .Gloves should be worn while handling	
2.Dinitrophenyhydrazine **$C_6H_6N_4O_4$** **M.W: 198.14**	Avoid contact (never smell, inhale, or taste them) wear protective equipment wash your hands after removing gloves use fume hoods store chemicals safely	
3. 4- Aminophenol **C_6H_7NO** **M.W: 109.13**	. Avoid exposure .Have a chemical hygiene plan .Use safety data sheets	
4.Benzoin **C_{14} $H_{12}O_2$** **M.W: 211.25**	. Wear personal protective .Avoid handling alone .close containers immediately .Use fume cupboard .Avoid touching , tasting or smelling	
5.phenolphthalein Indicator **$C_{20}H_{14}O_4$** **M.W: 318.32g**	.Avoid ignition sources .Don't heat with open flame .Wear personal protective equipment .Use safety glasses .wear flame resistant clothing	
6.Sulphamic Acid **$NH_2.SO_3H$** **M.W: 97.09**	. Never touch, taste or smell any reagents . Use chemical laboratory hood . wash your hands after handling chemicals . wear protective equipment	

Survey results

Data were collected through a well-structured questionnaire. Survey research method was used for the study through distribution of copies of questionnaire to collect necessary information from respondents Thirty three (33) questionnaire was developed and used as research instrument for the study, the questionnaire contained four inter- related sections, section A elicited information on the bio-data of the respondents, section B elicited information on the level of awareness on safety consciousness among laboratory technologists, section C provided information on the effectiveness of safety procedures and regulations in the laboratory, while section D elicited on the impact of safety procedure and regulations on laboratory users.

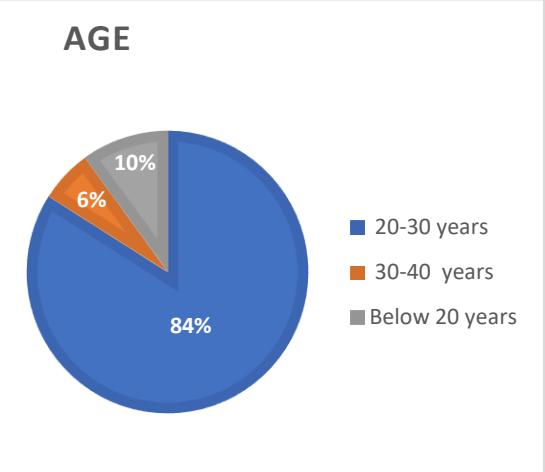
The data was analyzed using descriptive statistical analysis

1.Gender	Count of Responses
Female	17
Male	33



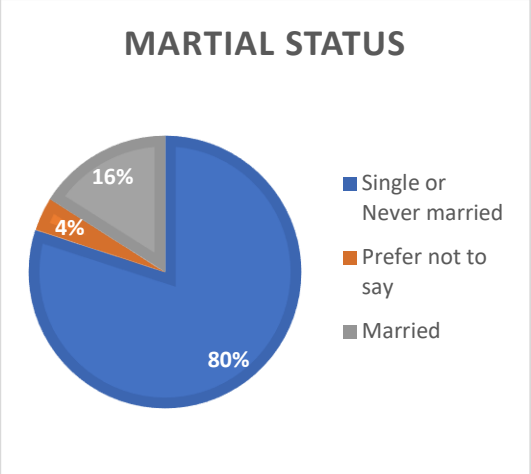
- 66% of respondents were Male and and 34% of respondents were female .

2.Age	Count of responses
20-30 years	42
30-40 years	3
Below 20 years	5



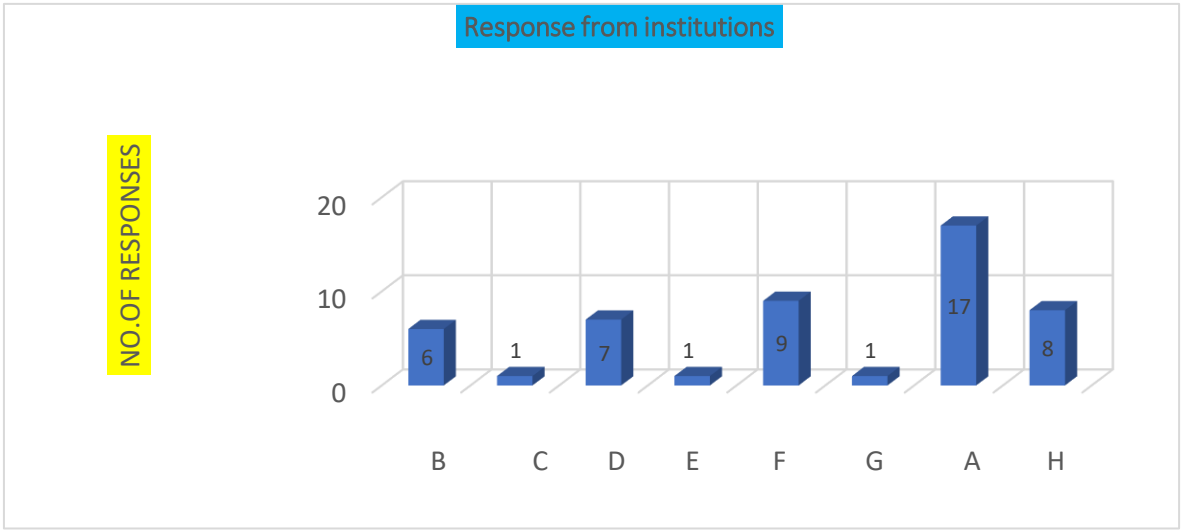
- The Age group of 84% respondents were 20-30 years, 10% were Below 20 years and 6% of respondents were of age group 30-40 years.

3.Marital status	Count of responses
Married	8
Prefer not to say	2
Single or never married	40

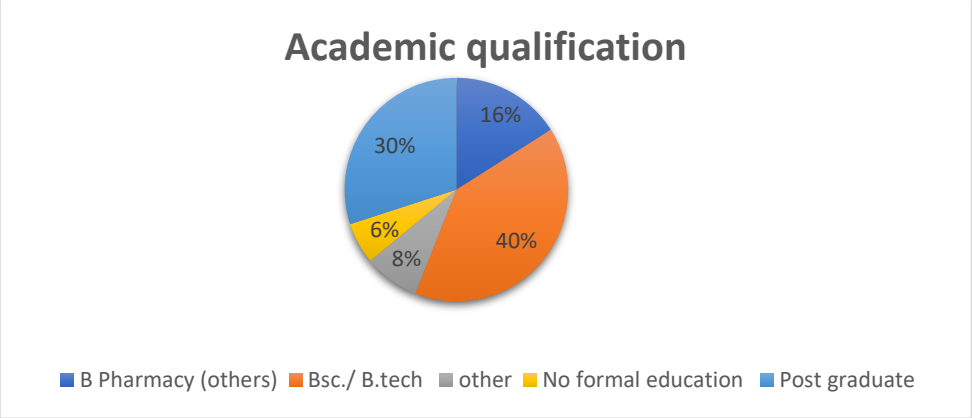


- 80% of respondents were Single ,16 % of respondents were married and 4% of respondents preferred not to reveal their gender.

4.Institution	NO. Of Responses
A	17
B	6
C	1
D	7
E	1
F	9
G	1
H	8



- 17 respondents were from institution A ,9 respondents from institution F, respondents 8 from institution H, 7 from institution D , 6 from institution B, and few respondents from other institutions.

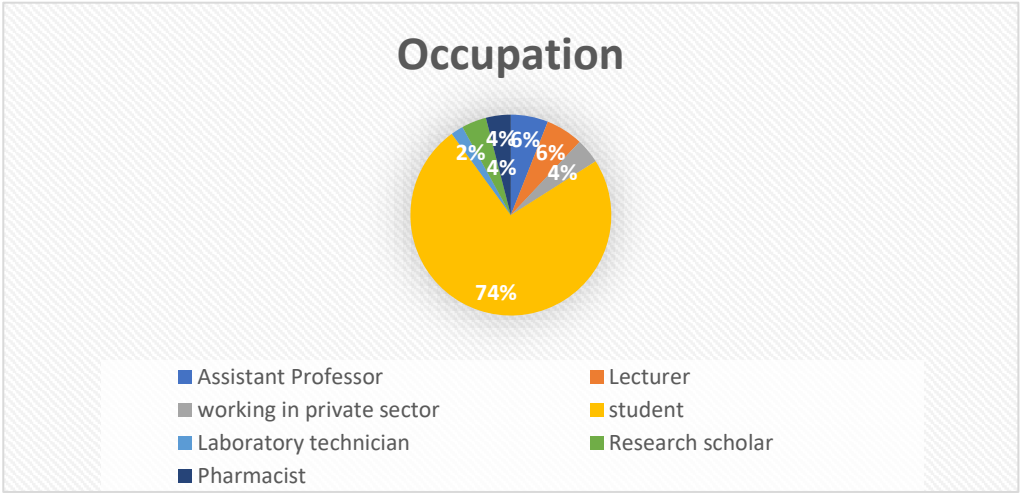


The academic qualification of 40% students was B.Sc/B.tech, 30% respondents were post graduate ,16% respondents were B. pharmacy ,8% of respondents were of different academics and rest 6% of respondents had no formal education.

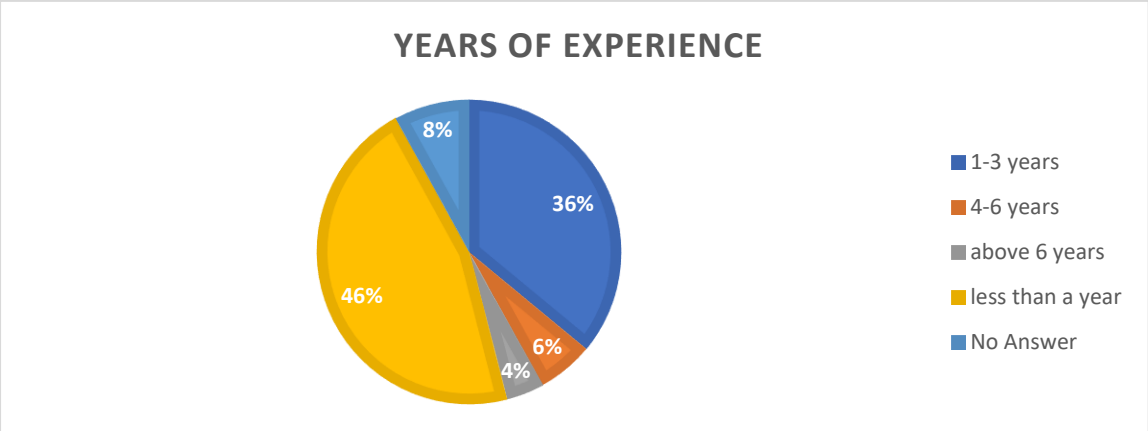
6.Occupation	count no of responses
Assistant Professor	3
Lecturer	3
working in private sector	2
student	37
Laboratory technician	1
Research scholar	2
Pharmacist	2

74% of respondents were students, 6% were lecturers, 6% were lecturers ,4% each were pharmicist, Research scholar, and working, rest 1% were laboratory technician.

5.Academic qualification	count of responses
B Pharmacy (others)	8
B.Sc./ B. tech	20
other	4
No formal education	3
Post graduate	15



9. Years of experience	Count of responses
1-3 years	18
4-6 years	3
above 6 years	2
less than a year	23
No	4



46**%** of respondents had experience less than a year, 36% had 1–3-year experience, 8% had no experience, 6% had 4–6-year experience and rest 4% have above 6-year experience

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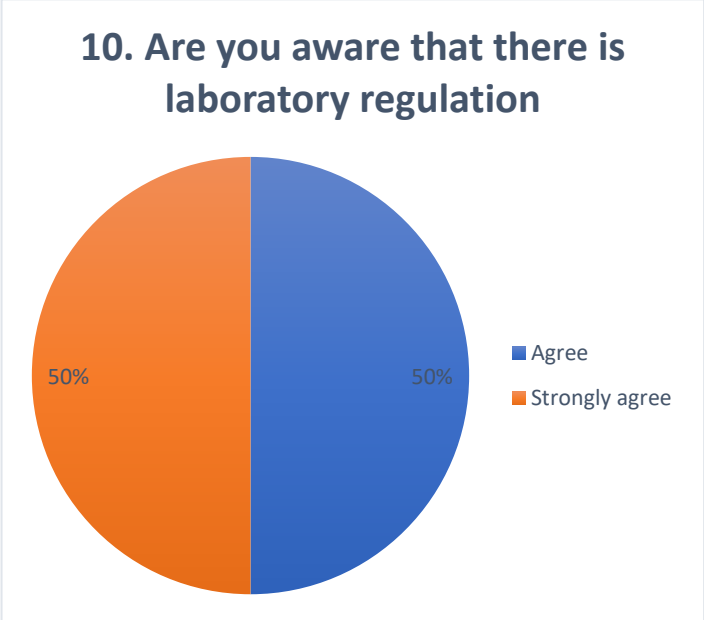
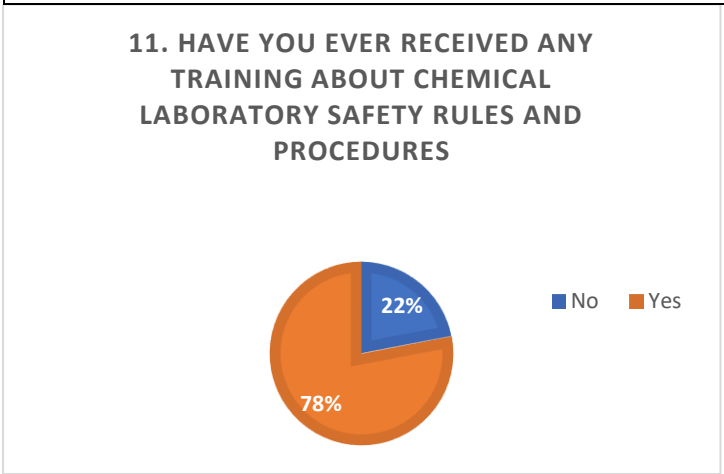
10. Are you aware that there is laboratory regulation	Count
Agree	**25**
Strongly agree	**25**

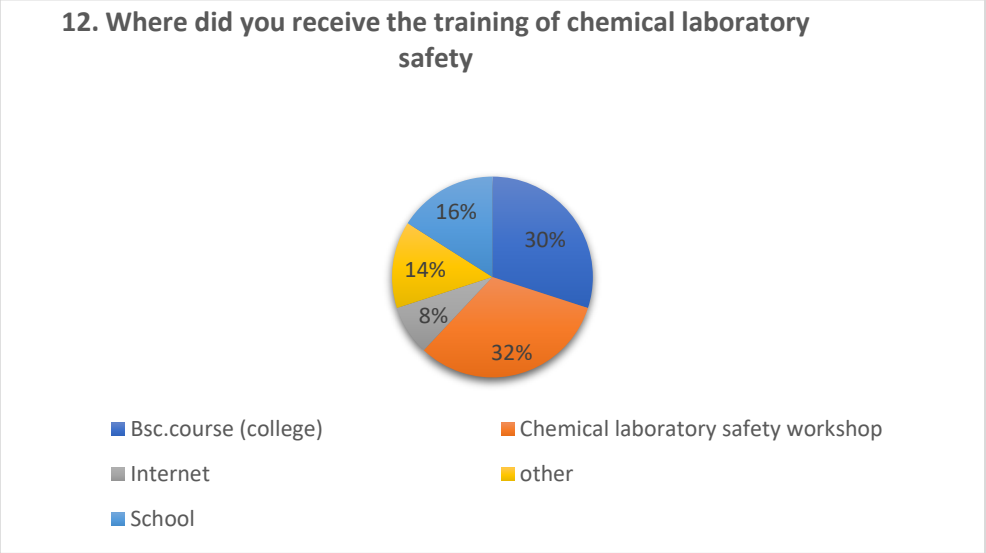


- 50% of the respondents agreed Strongly while other 50% also agreed about awareness of laboratory regulation.

11. Have you ever received any training about chemical laboratory safety rules and procedures	No. Of Responses
No	11
Yes	39

12. Where did you receive the training of chemical laboratory safety	No of response
BSc. Course (college)	15
Chemical laboratory safety workshop	16
Internet	4
other	7
School	8





32% of respondents said they received training of chemical laboratory safety through chemical laboratory safety workshop, 30% respondents received training through B. Sc course, 16% of respondents received training in school, while 14% of respondents received training through other means, and rest 8% received training through internet

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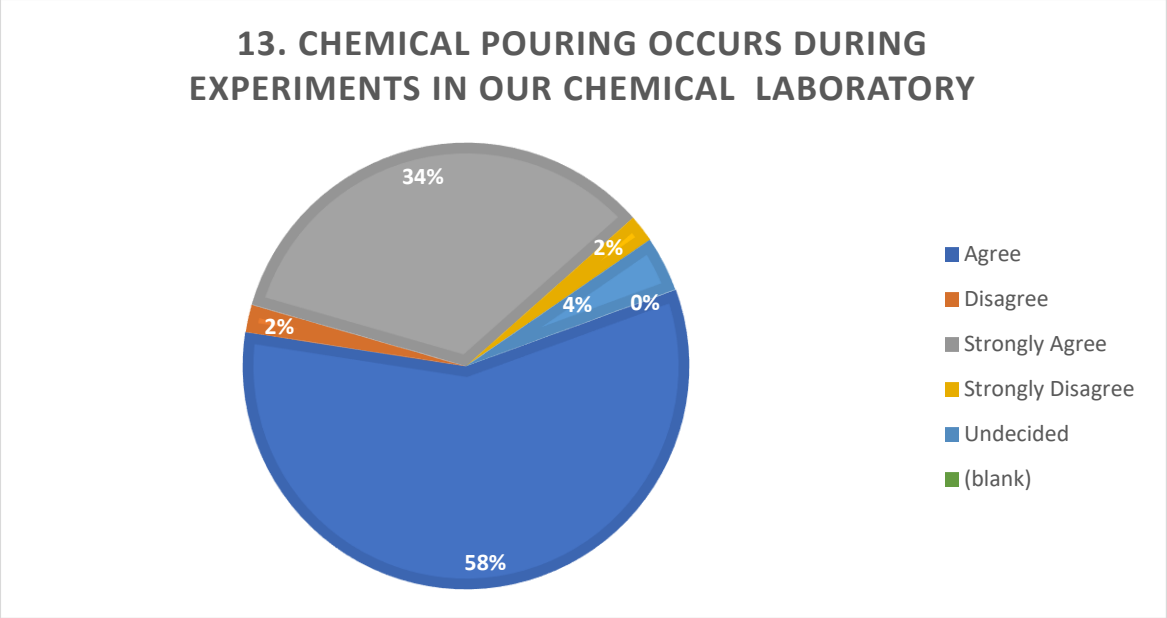
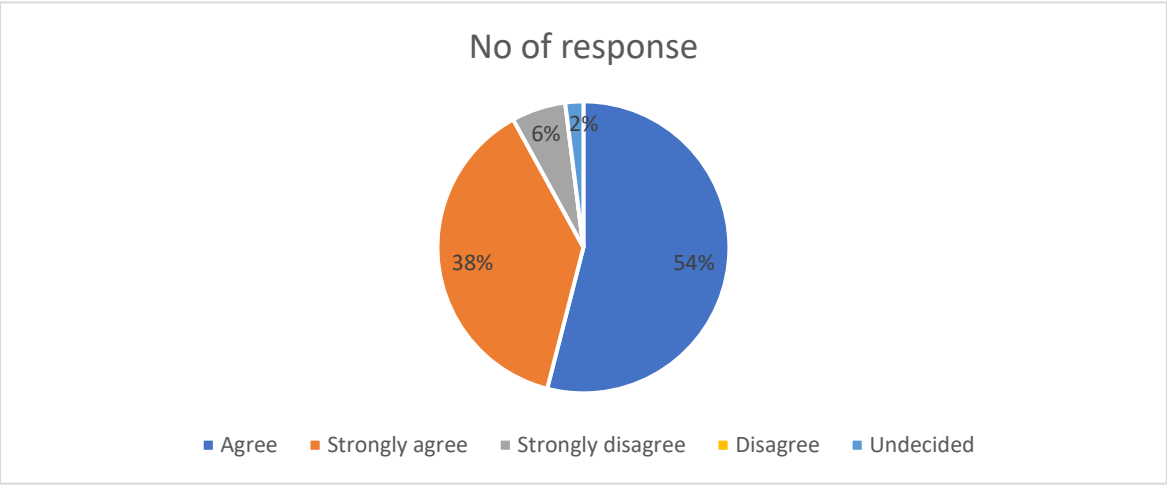
13. Chemical pouring occurs during experiments in our chemical Laboratory	**Count of responses**
Agree	29
Disagree	1
Strongly Agree	17
Strongly Disagree	1
Undecided	2



58% of respondents agreed and 34% strongly agreed about occurrence of chemical pouring during experiments in laboratory ,4% of respondents had no idea about chemical pouring, while 2% disagreed and rest 2% strongly disagree.

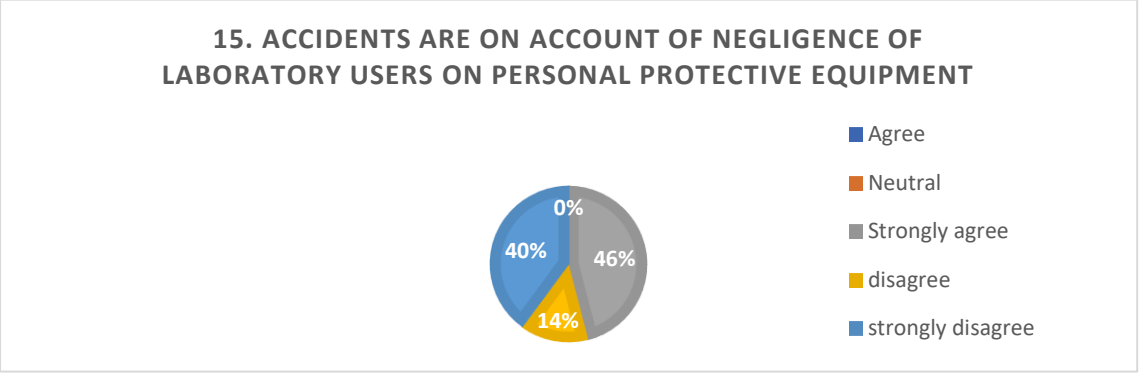
14. Are there any Safety procedures and regulations physically present in laboratory	**No of response**
Agree	27
Strongly agree	19
Strongly disagree	3
Disagree	0
Undecided	1



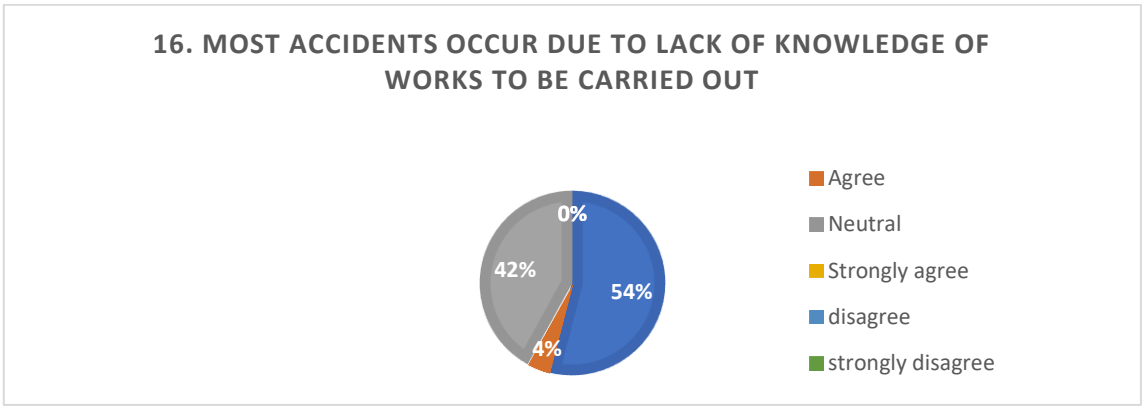
16. Most accidents occur due to lack of knowledge of works to be carried out	Count of responses
Agree	27
Neutral	2
Strongly agree	21
disagree	0
strongly disagree	0

The survey was conducted about physical presence of safety procedures and regulations and we came to know 54% of respondents agreed ,38% of respondents strongly agreed, 6% of respondents strongly disagreed and rest 2% had no idea.

15. Accidents are on account of negligence of laboratory users on personal protective equipment	Count of responses
Agree	23
Neutral	7
Strongly agree	20
disagree	0
strongly disagree	0

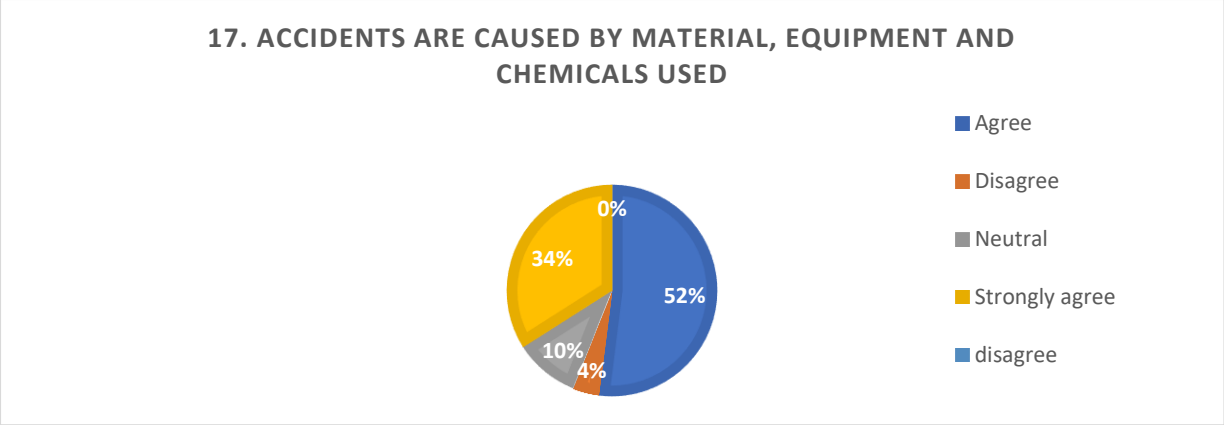


Survey results showed 46% of respondents strongly agreed, 40% also agreed and rest 14% of respondents were neutral about the occurrence of accidents due to negligence of laboratory users on personal protective equipment.



Survey conducted depicted that 54% of respondents agreed, while 42% strongly agreed and rest 4% were neutral about occurrence of most accidents due to lack of knowledge of work to be carried out.

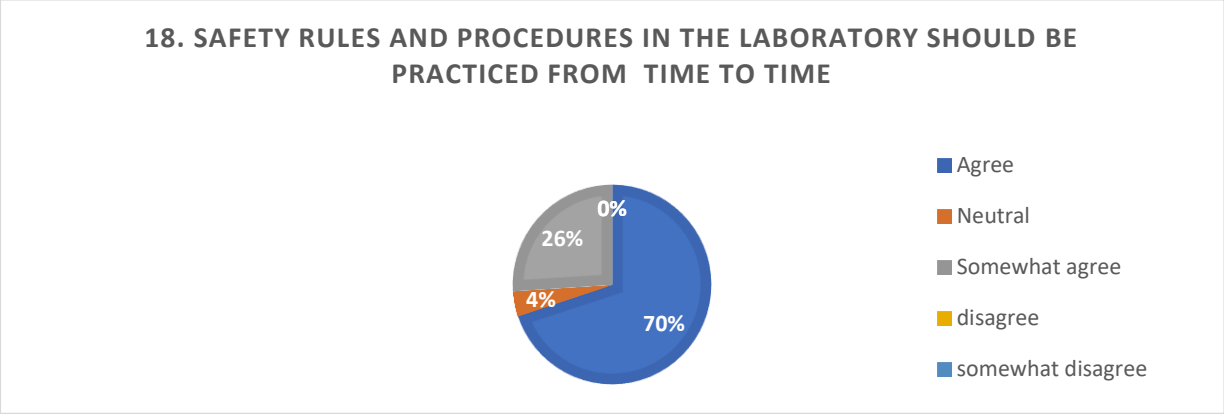
17. Accidents are caused by material, equipment and chemicals used	**No. Of response**
Agree	26
Disagree	2
Neutral	5
Strongly agree	17
disagree	0



The survey showed 52% of respondents agree and 34% strongly agree, 10% of respondents were found neutral and rest 4% of respondents disagree about accidents are caused by material, equipment and chemicals used.

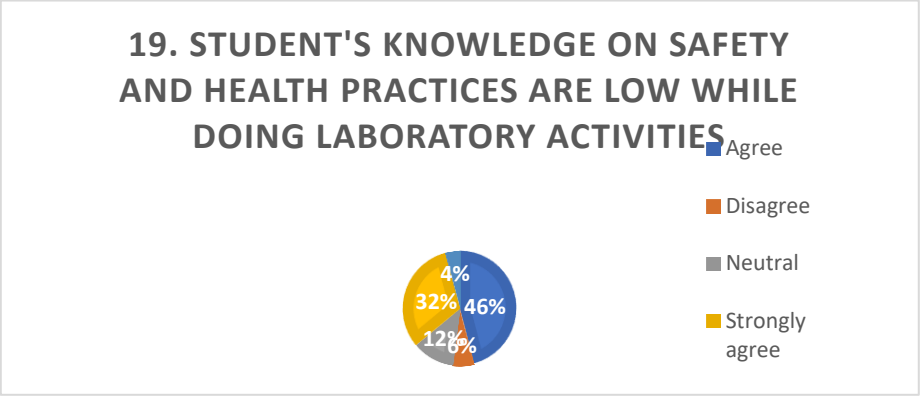
18. Safety rules and procedures in the laboratory should be practiced from time to time	**No of responses**
Agree	35
Neutral	2
Somewhat agree	13
disagree	0

somewhat disagree	0



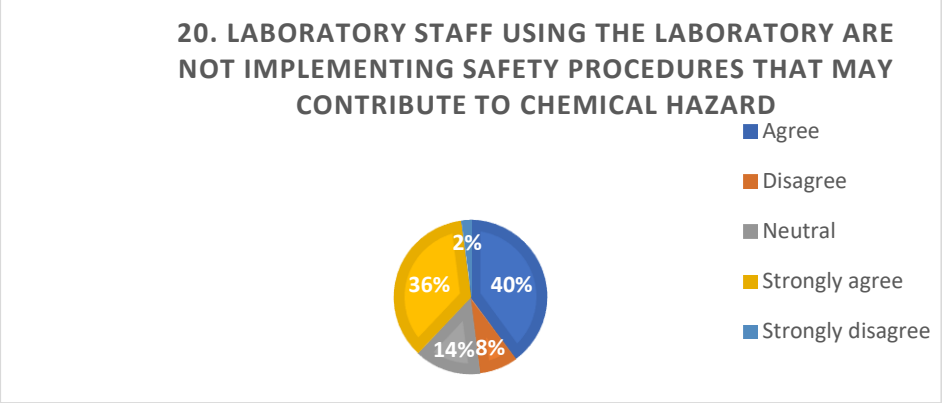
The survey was conducted about practice of safety rules and procedures in the laboratory from time to time and it was found 70% of respondents agreed, 26% of respondents somewhat agreed and 2% of responds were found neutral

19. Student's knowledge on safety and health practices are low while doing laboratory activities	No. of responses
Agree	23
Disagree	3
Neutral	6
Strongly agree	16
Strongly disagree	2



- The survey was conducted about students' knowledge on safety and health practices are low while doing laboratory activities and it was found 46%of respondents agreed, 32% of respondents strongly agreed, 12% of respondents were neutral while 6%of respondents disagree and rest 4%strongly disagreed.

20. Laboratory staff using the laboratory are not implementing safety procedures that may contribute to chemical hazard	No. of responses
Agree	20
Disagree	4
Neutral	7
Strongly agree	18
Strongly disagree	1



- The survey conducted showed that 40% of the respondents agreed, 36% of respondents strongly agreed, 14% of respondents were neutral ,8% of respondents disagreed and 2% of respondents strongly disagreed about implementation of safety procedures that may contribute to chemical hazard by laboratory staff.

21. How do you keep flammable solvents like hexane in chemical laboratory	responses
All of above	30
Avoid skin contact	5
Don't know	2
Keep all containers of Flammable solvents tightly closed when not in use	4
Keep the source of ignition away while handling flammable liquids	7
None of the above	2

22. How special sites for strong acids in chemical laboratories are selected	No. Of response
Acids should be segregated from bases and active metals viz Na, Mg, K	3
All of the above	32
Don't know	3
Large bottles containing acids should be stored on lower shelves or in acid cabinet	9
None of the above	1
Oxidizing acids should be segregated from organic acids and flammable materials	2

- The research was conducted about how do you keep flammable solvents like hexane in chemical laboratory 60% of respondents were fully aware about the safety procedures, while 30% of respondents were partially aware about safety procedures and rest 8% were not aware about safety procedures

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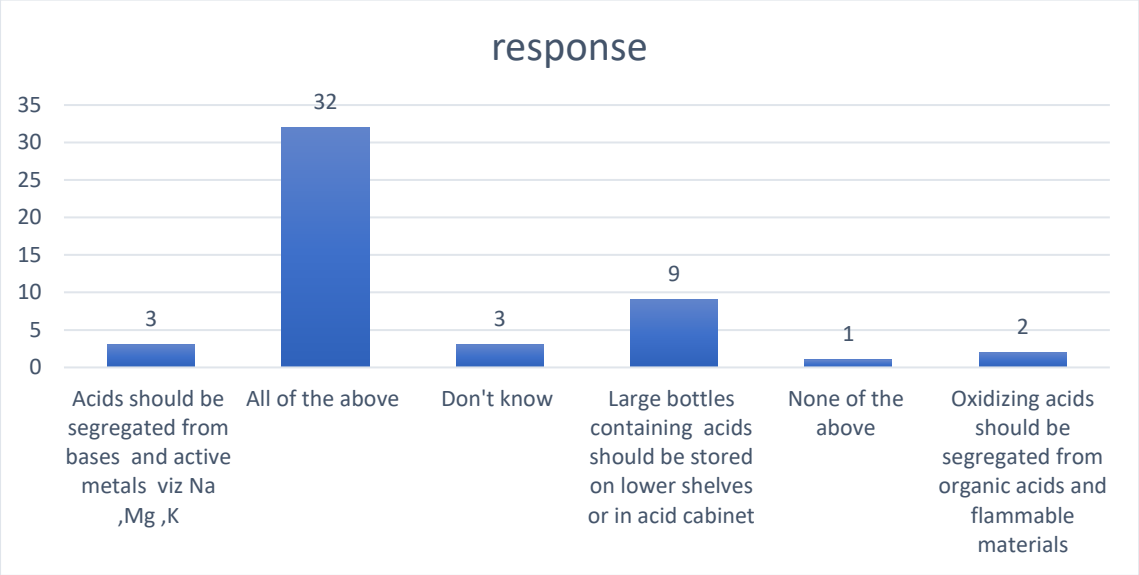

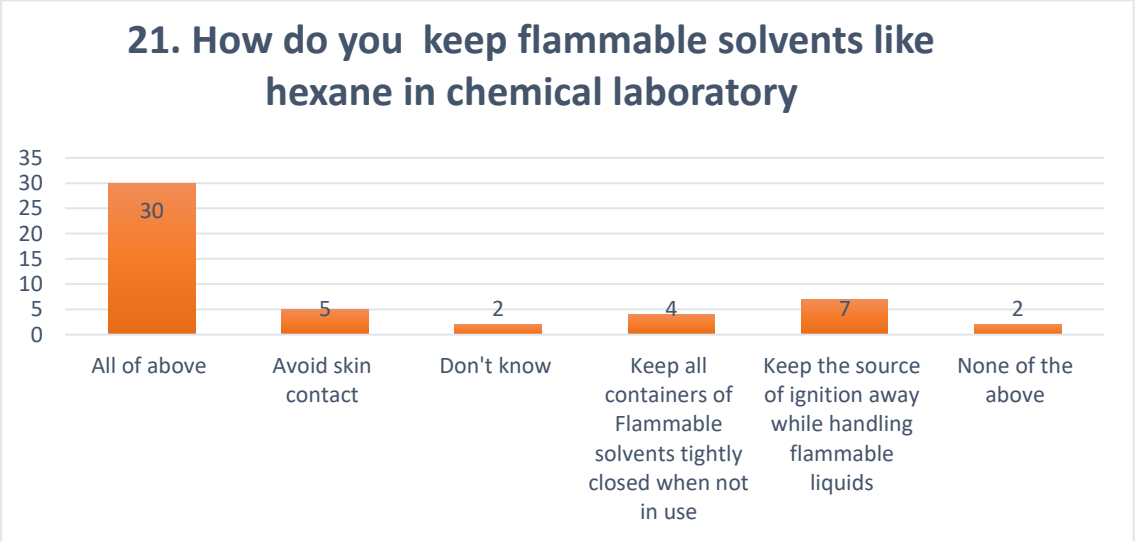

RESULTS: Our research revealed serious knowledge deficits and a lack of readiness for following safety procedures to reduce and eliminate dangers associated with the use of hazardous substances in research labs. To guarantee that researchers are fully aware of the risks and the precautions that may be taken to prevent or minimize chemical exposures, it is important to implement occupational training. This will also help to strengthen the commitment to and oversight of safety procedures among research supervisors and principal investigators.

CONCLUSION:

In this research, a descriptive survey design was employed and concluded chemical laboratory hazards that occurred accidently are on account of lack of exact knowledge of laboratory safety guidelines this has led to an evolving concern on safety culture in laboratory. This survey reflected the need for regular and improved education in chemical laboratory, the literacy skills of chemical laboratory safety rules and procedures should be incorporated into curriculum and should be practiced from time to time. we have to literate the researchers about the risk identification and assessment as a core foundation for safety culture.

Researchers should be taught about the awareness of the critical laboratory skills along with excellent decision evolving capacity as part of lab safety culture along with continuous improvement of lab safety practice to meet the safety challenges and concerns

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