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HAZARDOUS CHEMICALS' SAFETY MEASURES AND AWARENESS IN PUBLIC AND PRIVATE HOSPITAL LABORATORIES IN BURAYDAH, AL QASSIM

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Abstract

Medical laboratories in general operate with various hazardous chemicals. The storage, usage and knowledge about the hazardous chemicals are important aspects of safety measures employed in Medical Laboratories. This comparative study explores the differences in safety measures and knowledge of chemical safety among laboratory employees in Public (PBL) and Private (PRL) Hospital medical laboratories. This cross-sectional study was conducted in randomly selected Public and Private Hospital laboratories in Buraydah, Al Qassim, in 2013. The study was designed to: estimate the proportion and types of the hazardous chemicals used in the laboratories with a chemicals list; to assess safety measures currently being practiced with a standard chemical safety measures checklist; and to assess laboratory employee awareness on chemical safety with an interview schedule. Public Laboratories showed better results as

compared to the Private Laboratories, in that their employees were more disciplined in wearing Personal Protection Equipment, and the laboratory was active in managing chemical accidents and its consequences. Whereas the Private Laboratories had better results on four aspects, namely: better storage and handling of hazardous chemicals; neutralizing hazardous chemicals; better precautions established for hazardous chemical use; and better assessment of chemical toxicity, as compared to the Public Laboratories. There were subtle differences between the Public and Private medical laboratories on chemical safety measures. The differences recorded were mainly in storage and handling of hazardous chemicals; the proportion and types of hazardous chemicals used; employee discipline on chemical safety measures; assessment of chemical toxicity; and in managing chemical accidents in the laboratories.

Keywords

Hazardous, Corrosive, Toxic, Flammable, Carcinogenic, Chemicals, Safety, Public, Private, Medical Laboratories

1. Introduction

Medical laboratories contain various types of hazards; an important type is the chemical hazard. Potentially toxic chemicals used in medical laboratories on a daily basis could pose hazardous conditions for laboratory personnel (Vonesch N, et al, 2006). Chemical Safety Levels defined by the levels of hazard (1 through 4), based on a risk assessment in laboratories and conducted by qualified individuals (ACS, 2015) may ensure the safety and productivity of medical laboratories.

The chemicals used in medical laboratories may be carcinogenic, corrosive, toxic, oxidizing and highly flammable. These chemicals need to be used with caution as they have the potential for adverse events and accidents not only for the employees but for the whole community. This in is a valid reason to emphasize the importance of precautionary measures in laboratories and the imperative awareness and necessary training in the use of hazardous chemicals among laboratory employees. It has been reported that overall safety is improving and increasing in laboratory science, however, new safety hazards, such as repetitive stress injuries and potential toxicities from nanoparticles are under closer scrutiny (Perkel JM, 2010).

It is important to provide employers and employees in clinical laboratories with a flexible, viable alternative to traditional substance-specific regulation in order to create a safe

working environment. (Ejilemele AA, et al, 2004). There is a need for more emphasis and study on compliance regulations, including implementing a chemical hygiene plan, provide workers with the necessary safety information and training necessary to improve workplace safety and health and to reduce the number of chemical-related injuries and illnesses in clinical laboratories. The purpose of this study was to explore the differences in safety measures employed in clinical laboratories and knowledge of chemical safety among laboratory employees in Public (PBL) and Private (PRL) Hospital medical laboratories.

2. Background

Chemists and other scientists working in laboratories handle collectively thousands of chemicals in relatively small quantities in their experiments; perform procedures, and other laboratory operations that have the potential for injury and disasters. Recognition of chemical hazards, an essential component of laboratory safety (WHO, 2004), depends upon the availability of clear and accurate information about specific chemical hazards on labels and other sources, such as Material Safety Data Sheets (Hill R, 2010).

Chemical exposure hazard is defined as a chemical for which there is evidence that acute (immediate) or chronic (delayed) health effects may occur in an exposed population. Exposure is related to the dose (how much), the duration and frequency of exposure (how long and how often), and the route of exposure (how and where a material gets in or on the body), whether through the respiratory tract (inhalation), the skin (absorption), the digestive tract (ingestion), or percutaneous injection through the skin (accidental needle stick). The resulting health effects can be transient, persistent, or cumulative; local (at the site of initial contact with a substance), or systemic (after absorption, distribution, and possible biotransformation, at a site distant from initial contact with a substance) (ACS, Task Force, 2015). Thus, it is imperative for medical laboratories to emphasize on hazardous chemical identification and impart training in chemical hazard management for laboratory employees.

The United States (U.S.) Department of Energy (DOE) has a policy of Integrated Safety Management System (ISMS) that requires a hazard analysis and implementation of controls to protect the workers and public in an authorized hazard facility. The ISMS apply to all DOE facilities through DOE P 450.4, *Safety Management System Policy*, and DOE Acquisition Regulation (DEAR) clause 48 CFR 970.5223-1, *Integration of Environment, Safety, and Health*

into Work Planning and Execution. To provide a common understanding of non-nuclear SB for chemical facilities, this report identifies various steps involved in developing a safety document that includes essential features of the five core steps of the ISMS. The SB development is an iterative process, but in general order of process completion, the listed steps for chemical, non-nuclear facility safety documents are: Facility and work description; Hazard identification;

Facility hazard classification – industry Process Safety Management (PSM) based versus DOE traditional based high/moderate/low classification; Hazard analysis – qualitative and/or semi quantitative; Identification of controls; Commitments to safety management programs (SMP); Document and approval process (Laul JC, et al, 2006).

Flammable chemicals pose life-threatening situations for laboratory personnel and others in the near vicinity, thus prompting pre-emptive action to avoid injury and death. Awareness of chemical hazards and recall of chemical hazard information (Sathar F, et al 2016) is vital in order for label warnings and precautionary information to promote effective safety behaviors among laboratory personnel.

At Yale University, Environmental Health and Safety director Peter Reinhardt and his staff undertook a census of campus labs to determine who was using flammable chemicals, how much they had on hand, and what they were using them for. Of the 536 principal investigators that work with chemicals on campus, Reinhardt says, “we identified maybe 10 or 15 labs that have this type of flammable chemical, of which maybe five use it on a regular basis.” For the most part, the census uncovered no problems; in those labs, researchers were using and storing the chemicals correctly, in accordance with the university’s existing safety plan for pyrophoric chemicals. Yet members of his office also realized that the plan could use something of a makeover. Yale University’s previous plan, for instance, merely suggested a flame-resistant lab coat and chemical-resistant gloves; the new policy requires them. “Before this incident, there were maybe a few people using flame-resistant lab coats, but not all,” Reinhardt says. Under the new plan, “we made sure everyone had them,” even purchasing protective equipment for researchers if needed. Reinhardt and his colleague, Tom Ouimet, also developed a 14-minute online video demonstrating the proper techniques for working with these materials. (<http://www.yale.edu/ehs/onlinetraining/OrganoLithium/OrganoLithium.htm>). As old techniques fall by the wayside, new technologies with new safety concerns arise to take their place. For the

safety officers charged with protecting lab workers, the work environment is an ever-evolving challenge (Perkel JM, 2010).

Many chemical accidents occur in the laboratories including fire, toxic chemical spills, hazardous materials leakage, fatalities and adverse health effects involving the use of hazardous materials. A research conducted at Universitas Indonesia (Lestari, F et al, 2015) investigated the implementation of Chemical Health, Safety and Security Program within the health faculties laboratories. The method used in this study employed a Chemical Health, Safety and Security Checklist developed from several references including the: American Chemical Society Safety Audit/Inspection Manual, American Chemical Society Security Vulnerability Checklist for Academic and Small Chemical Laboratory Facilities, and Universitas Indonesia (UI) procedures for laboratory safety, health and security inspections. Inspections and observations were conducted in fifty-one laboratories which use chemicals within the health faculties at UI. Their results suggested that several laboratories have implemented a good University standard for a laboratory chemical safety, health and security programs, while others need improvement in particular parameters.

The prevalence of fire safety deficiencies was measured in the College of American Pathologists Laboratory Accreditation Program. Of the 1732 inspected laboratories, 5.5% lacked records of electrical receptacle polarity and ground checks in the preceding year. Of these inspected laboratories, 4.7% had no or incomplete documentation of electrical safety checks on laboratory instruments. There was no evidence of quarterly fire exit drills in 9% of the laboratories. Deficiencies were also found in precautionary labeling (6.8%), in periodic review of safe work practices (4.2%), in the use of safety cans (3.7%), and in venting of flammable liquid storage areas (2.8%). Fire preparedness would be improved if all clinical laboratories had smoke detectors and automatic fire-extinguishing systems. In-service training courses in fire safety should be targeted to the needs of specific service areas (Hoeltge et al 1993). In a survey of safety practices among hospital laboratories in Ethiopia, (Sewunet T, et al, 2014) found that laboratory workers were at high risk of combined physical, chemical and microbial hazards. Their research recommends prompt recognition of the problem and immediate action being mandatory to ensure safe working environment for hospital laboratory employees.

Thus, the aim of our study was to estimate the proportion and types of the hazardous chemicals used in hospital (Public and Private) laboratories with a chemicals list; to assess safety measures currently being practiced with a standard chemical safety measures checklist; and to assess laboratory employee awareness on chemical safety with an interview schedule.

3. Methodology

3.1 Study Design

This was a cross-sectional study conducted in a randomly selected Public and Private Hospital laboratories in Buraydah, Al Qassim, during January to June 2013. The study was designed to: estimate the proportion and types of the hazardous chemicals used in the laboratories with a chemicals list; to assess safety measures currently being practiced with a standard chemical safety measures checklist; and to assess laboratory employee awareness on chemical safety with an interview schedule.

Inclusion Criteria: Public and Private Hospital laboratories in Buraydah, Al Qassim, involved with hazardous chemicals, and willing to participate in the study.

Exclusion Criteria: Public and Private Hospital laboratories in Buraydah, Al Qassim, not involved with hazardous chemicals and not willing to participate in the study.

One public hospital medical laboratory and one private hospital medical laboratory that satisfied the inclusion criteria were randomly selected by lottery method.

3.2 Data Collection

Data was collected from the randomly selected laboratories after obtaining informed consent from the participating institutions and their employees. The following survey instruments were used to collect data from the two medical laboratories:

- A chemicals list was obtained to identify the Hazardous chemicals used in the sampled hospital laboratories.
- A Safety Measures Checklist was used to gather information on the current practices of chemical safety measures in the sample laboratories. This check list included assessment of: Written Laboratory Safety, Policies/Procedures/Programs, Employee and Visitor Training, Signs that meet OSHA standards used to warn of potential hazards or unsafe practices, Chemical storage segregation, Safety Equipment and Personal Protective Equipment.

- The laboratory employee awareness on chemical safety measured through an interview by the researcher using a structured questionnaire. The structured awareness questionnaire included Demographic characteristics of the lab employee; Job details (no. of years of service, job title, job description, names of chemicals handled by employee, etc...); Knowledge questions about hazardous chemicals; awareness questions on chemical safety; questions on adverse events and management of chemical accidents.

3.3 Data Analysis

Qualitative variables were analyzed with descriptive statistics using mean and standard deviations for continuous variables; and frequency and percent for categorical variables.

4. Results

In the study we compared one public and one private hospital laboratory. The two laboratories were comparable with the 200-bed public hospital, having 63,159 In-Patients per year and running about 238,263 laboratory tests per year, and the 156-bed private hospital having 50,000 In-Patients per year and running about 246,000 laboratory tests per year.

The two hospital laboratories have four sections namely, chemistry, microbiology, hematology and serology sections which was the only section that does not contain any hazardous chemicals in both hospital laboratories (Figure 1). In the public Hospital laboratory 59% of hazardous chemicals were used in microbiology section, as compared to 60% of hazardous chemicals used in the chemistry section at the Private hospital laboratory.

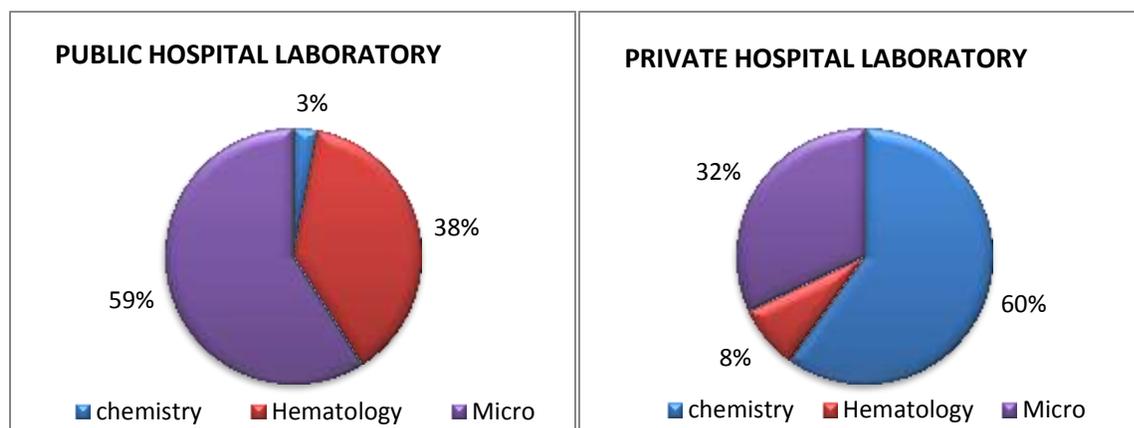


Figure 1: *Proportion of Hazardous Chemicals Used by Public and Private Hospital Laboratories*

The most hazardous chemical type used in the public laboratory (Figure 2) was the toxic type 72% then the irritant type 9% and then the corrosive and the toxic, irritant types 6%, with 3% use of flammable and toxic, corrosive chemicals. In the private hospital laboratory (Figure 2) the most hazardous type that was frequently used in the laboratory was the flammable type 32%, then toxic, corrosive and corrosive types 24%, with 20% toxic only.

Public hospital laboratory has all the six types of the hazardous chemicals with different proportions while the private hospital laboratory has no irritant type and no toxic, irritant type of the hazardous chemicals but it uses more flammable, corrosive and toxic, corrosive chemicals with less toxic chemicals than the proportion used in the public hospital laboratory.

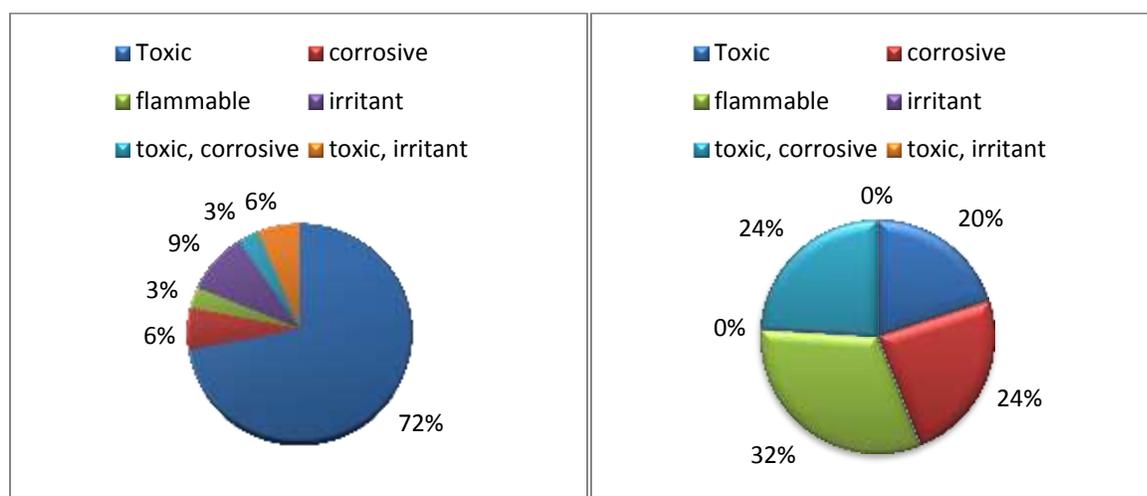


Figure 2: Types of Hazardous Chemicals used in Public (left) and Private (right) Hospital Laboratories

4.1 Hazardous Chemical Safety Measures Checklist

The data on chemical safety measures check list related to hazardous materials, chemical storage, safety equipment, personal protective equipment, hazardous chemical waste and laboratory safety (policies, procedures, programs, training and occupational health) were analyzed. The storage and segregation of chemicals in the public hospital laboratory was unsatisfactory, as the chemicals were stored all together under the sink and there was neither appropriate segregation nor any appropriate chemical storage cabinet. Whereas, in the private hospital laboratory the chemical storage system was found to be satisfactory with appropriate labelling and designated chemical storage cabinets (Figure 3).



Figure 3: Chemical storage system in Public (left) and Private (right) Hospital Laboratories

The PRL showed more appropriate handling of chemicals and their storage system than the PBL. The area for toxic compounds was well designed in PRL 100% while in PBL the percentage was 64%. The labeling system was better in the PRL with 100% and in the PBL little less 96%. The segregation of toxic chemical was appropriate in the PRL 100% and in the PBL it was 52%. In PRL use of approved flammable containers for the flammable chemicals was 100% while in PBL it was only 48% but it needs to be noted that they use much fewer flammable chemicals than the PRL (32%PRL vs. 3%PBL).

4.2 Hazardous Chemical Safety Awareness among Public and Private Hospital Laboratory Employees

The demographic characteristics of the survey participants from the Public and Private Hospital laboratories respectively, are given in Table 1.

Table 1: Characteristics of the Laboratory Employees that participated in the Chemical Safety Awareness Survey

Characteristics	Total Sample (n=50) Number (%)	Public Hospital Laboratory (n=25) Number (%)	Private Hospital Laboratory (n=25) Number (%)
Age in Years (Mean ± SD)	30 ± 4.5	31.4 ± 4.4	28.8 ± 4.2
Education:			
Diploma	28 (56)	14 (56)	14 (56)
B.Sc.	20 (40)	11 (44)	9 (36)
M.Sc.	2 (4)	--	2 (8)
PhD	--	--	--
Job Description:			
LAB Technician	34 (68)	17 (68)	17 (68)
LAB Specialist	12 (24)	5 (20)	7 (28)
Hazardous Material Officer	1 (2)	--	1 (4)
Lab tech-Supervisor	1 (2)	1 (4)	--
Microbiology Supervisor	1 (2)	1 (4)	--
Safety Officer	1 (2)	1 (4)	--
Number of Years of Experience on the job (Mean ± SD)	6.5 ± 4.6	8.2 ± 4.9	4.8 ± 3.5

The results show little difference in age of the employees in that the public hospital laboratory employees are older with more years of experience than in the private hospital. Educational attainments of employees of both laboratories were comparable except for the 8% employees in the Private laboratory that had a Master's degree. The proportion of lab technicians in both laboratories were equal (68%) however, there were more lab specialists in the private laboratory (28%) as compared to the public laboratory (20%). A Hazardous material officer was employed only in the private hospital laboratory. Whereas, a few additional personnel employed in the public hospital laboratory were Lab tech-supervisor, a Microbiology supervisor and a general Safety officer.

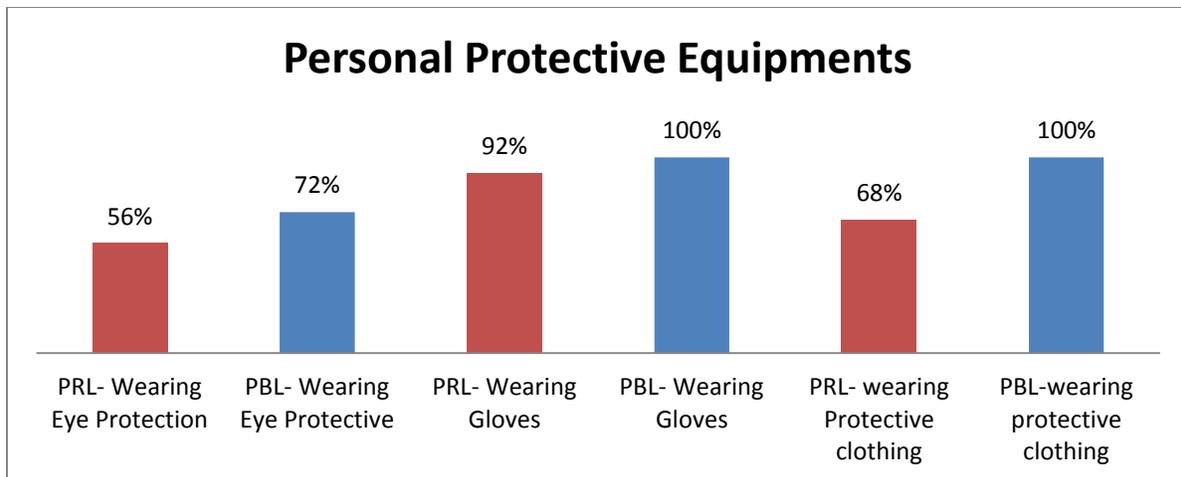


Figure 4: Use of Personal Protective Equipment among the Employees in Public and Private Laboratories

The employees of the public sector laboratory were found to adhere to the norms of wearing personal protective equipment as compared to their private sector counterparts.

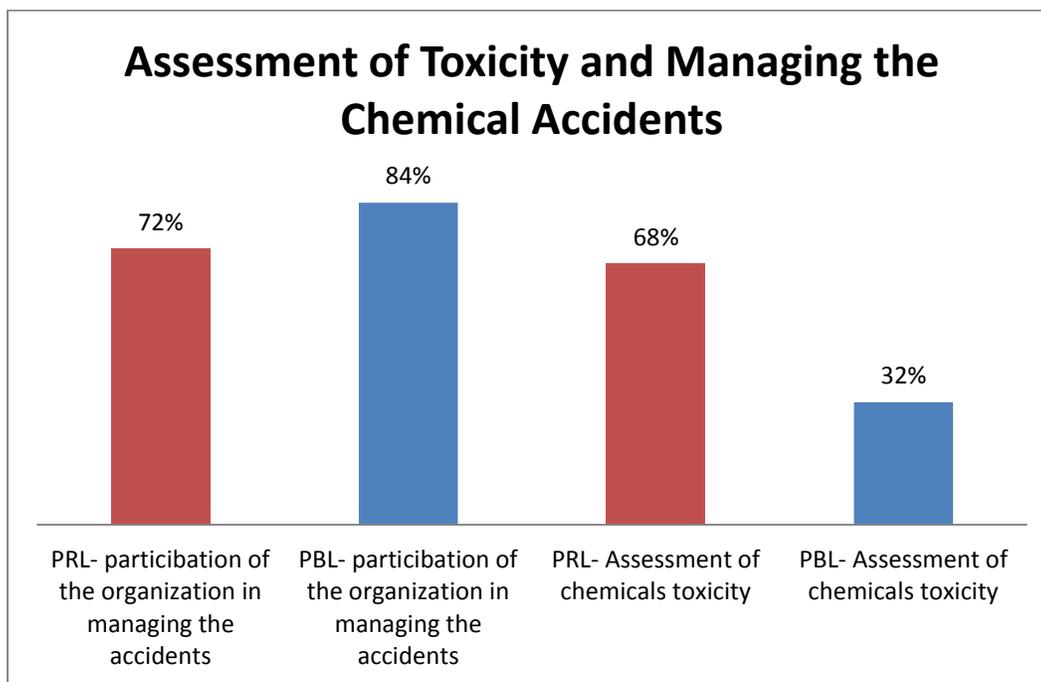


Figure 5: Toxicity Assessment and Management of Chemical Accidents in PBL and PRL

The assessment of chemical toxicity was higher in the private hospital laboratory than the public hospital laboratory (68%PRL vs. 32%PBL). However, the public hospital laboratory participated more in managing the chemical accidents (84%PBL vs.72%PRL).

4.3 Chemical Accidents in the Past Year

In the public hospital laboratory (56%) of the employees answered that it was not very serious accidents like managed chemical spills and splash of Hcl on the floor. (24%) of the employees answered that most of the accidents were burns from corrosive chemicals and increased sensitivity reaction due to irritant chemical exposures. While In the private Hospital laboratory (56%) of the employees answered that they haven't seen serious accidents rather, it was only managed chemical spills. (44%) of the employees answered that they haven't seen any accidents during their tenure.

4.4 Role of the Organization in Managing Chemical Accidents

In the public Hospital laboratory (84%) said that the managing of the accidents according to the type and nature of the chemical, each one has specific policy. They report the accident and inform the employees in the section and the safety supervisor. They provide training programs, safety measures, first aid kits and spills kits.

In the private Hospital laboratory (64%) said that they provide the lab with safety measures, first aid and chemical spill kits, safety shower, eye wash and they make it accessible to everyone in the lab. They give training programs on managing the chemical accidents. They report and inform, they put signs around the area until it managed and train the responsible on how to handle the chemicals and manage the accidents. The answers in this part match our results of the questionnaire when we found that PBL participate more in managing the chemical accidents with 84%.

5. Discussion

In the study we compared two randomly selected hospitals public and private sector hospital laboratories with similarities in bed capacity; number of In-Patients and laboratory tests per year. Earlier studies had reported on the awareness of the employees and on the safety measures in regarding to chemical safety. This study examined the precautions taken for hazardous chemicals used in laboratories; the awareness of lab employees and the responsibility of the hospital laboratory employer toward the employee with regards to training programs, providing them with the safety materials and equipment; instructions about use of hazardous chemicals and its effect on health. In the checklist we found differences in the chemical storage

section we found a lack in the storage system in the public hospital laboratory and we found that both labs do not have storage refrigerator for the flammable materials.

The proportion of the hazardous chemicals was mostly (72%) toxic chemicals in the public hospital and flammable chemicals in the private hospital. In reviewing the checklist, chemical list and employee awareness; it is apparent that there is an increased need for the public hospital laboratory to reduce the use of toxic chemicals and choose chemicals with less toxicity (72% vs. 20%). Public hospital laboratory employees when asked if they get an assessment of the toxicity of the chemicals; 68% responded they did not receive this information, and 72% of the chemicals they use were reported as toxic. Thus, there is a great need to get better assessment as suggested by ACS (2015). The private hospital had fewer toxic chemicals 20% with better assessment of the toxicity, however 32% of their employees reported they do not get chemical assessment. The private hospital laboratory use a higher proportion of flammable chemicals than the public hospital laboratory (32% PRL vs. 3%PBL). But, they have better storage system for the flammable chemicals they need to use storage refrigerator with flammable proof system. These results compare well with the results of the study by Lestari F, et al (2015) that indicated that there was room for improvement in the laboratory standards for chemical safety precautions that needs regular monitoring, assessments and review by laboratory personnel.

Laboratory employee awareness results revealed variations in use of personal protective equipment, toxic chemicals handling and storage, assessment of toxicity and management of the chemical accidents between public and private hospital laboratories. In the first part personal protective equipment, PBL employees showed more discipline in wearing PPE more than the PRL employees. Another view of chemical handling and storage system it showed that the private hospital laboratory has more appropriate storage system than the public hospital. Appropriate chemical storage and segregation of the chemicals is important to minimize chemical-related accidents. Similar findings were reported by another study which showed inappropriate chemical storage and ventilation system, Balkhiour (2011). We found another differences in assessment of the chemical toxicity it's higher in the private hospital laboratory than the public hospital laboratory and here we have to say that there is an increased need for the PBL to increase the assessment of the toxicity of the chemicals because they use much higher proportion of toxic chemicals than the PRL. Finally, the public hospital laboratory participates

more than the private hospital laboratory in managing the chemical accidents. The importance of developing an action plan was emphasized by Foster (2004), in which it should include procedures for fires ,chemical spills, evacuation, ventilation failure, and incident reporting.

6. Conclusion

In comparing the public and private hospital laboratory in Buraydah, Qassim, it was found that the public hospital had more bed capacity and number of In-Patients with a smaller number of laboratory tests performed per year than the private hospital. There was lack of storage sections in the public hospital laboratory for hazardous chemicals whereas the private hospital laboratories had proper storage cabinets. Hazardous waste disposal system was in place at the private hospital laboratory and not in the public hospital laboratory.

The private hospital laboratory used more toxic chemicals than the public hospital laboratory. The employees of both public and private hospital laboratories were aware of the chemical safety issues and had knowledge about the personal protective equipment. However, the public hospital laboratory employees were more disciplined in using personal protective equipment than their private counterparts. The public hospital laboratories participate more than the private hospital laboratory in managing the chemical accidents.

Based on the study results it seems imperative that Public Hospital Laboratory needs to improve the storage and handling of hazardous chemicals; make regular assessments of chemical toxicity and improve the employee's knowledge about these chemicals and its effect on their health and well-being. The Private Hospital Laboratory needs to address issues related to employee compliance to wearing personal protective equipment and to monitor and improve the flammable chemical storage system since they use more flammable chemicals.

There are very limited studies conducted in Saudi Arabia that explore the safety in the laboratories, and the appropriate handling of hazardous chemicals. This study would reveal more data and suggest more recommendations if it could be done on a larger scale and more hospitals are included.

We also recommend conducting a prospective study to assess the health status of hospital laboratory employees exposed to toxic chemicals in their work environment.

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