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Chemical laboratory safety awareness, attitudes and practices of tertiary students

Ayana U.C. Walters, Wendy Lawrence, Nigel K. Jalsa *

Department of Chemistry, University of the West Indies, St. Augustine Campus, Trinidad and Tobago

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ABSTRACT

This study investigated the current state of chemical laboratory safety awareness, attitudes and practices among tertiary students in Trinidad. It also sought to determine if there was any correlation between awareness and practice and if there were any useful predictors for the likelihood of accidents in the laboratory. The cross-sectional survey was conducted at three institutions with a sample size of 226 students. A self-administered questionnaire was used to collect data which were analysed using descriptive statistics, the Pearson correlation coefficient, and binary logistic regression. Additionally, a semi-structured interview was conducted with a member of the supervisory staff at each institution to gain insight into the established safety procedures. The results show that though awareness was high there were deficiencies in the areas of hazard identification and emergency response. Attitudes and practices were acceptable but needed improvement, with a weak correlation existing between these two variables. The characteristics of the particular institution were found to be the only predictor of the likelihood of accidents. It was concluded that more education and training need to be implemented for improvement.

1. Introduction

1.1. Background

Students pursuing science as part of their formal education are of necessity, to take part in laboratory sessions. These practical classes help students to examine the theory learned in greater detail; and can improve interest in the subject area (Adane and Abeje, 2012). Laboratory classes are therefore considered to be an important part of the curriculum. Chemistry is one of these subject areas in which often hazardous chemicals are used extensively during lab sessions. In these classes, students are introduced to, and use, chemicals of differing types and properties.

While chemicals used daily have many benefits they can also be hazardous and present health, physical and environmental hazards (Ryder, 2014). Hazardous properties include those that are corrosive, explosive, easily oxidising, flammable, harmful, irritating, radioactive or toxic to human beings and also may pollute the environment (Adane and Abeje, 2012). Exposure to such chemicals can lead to chemical burns, skin and eye irritations, headaches, organ disorders, cancer and even death. Depending on the severity, these effects can significantly affect a person's ability to continue work and may decrease the quality of life. Not to be overlooked are the potential negative impacts caused by accidental releases and incorrect disposal practices, on the environment, and by extension, the human population. The release of methylmercury into Minamata Bay, Japan, by the Chisso Corporation in the 1950s, which led to an outbreak of mercury poisoning, is an example of an environmental disaster caused by a chemical (Government of Japan. MoE, 2002, Report of the first patient and The government's announcement). While safety considerations are an issue for everyone exposed to potentially hazardous substances, persons who routinely work with chemicals, for example: students and persons working in laboratories, are particularly at risk.

Though there are hazards associated with chemical laboratory work, the potential danger may be mitigated once systems are in place to ensure safe handling and management. The use of improper techniques can lead to accidents in the lab environment (Draman et al., 2010). This premise is verified by a report which showed that for three years, 49% of accidents on university campuses in Taiwan were related to the improper use of chemicals in otherwise standard laboratory exercises (Su and Hsu, 2008). Adane and Abeje (2012) also concluded that accidents involving chemicals can be expected to occur in cases of inexperience, and lack of awareness about the risks associated with different

* Corresponding author.
E-mail address: nigel.jalsa@sta.uwi.edu (N.K. Jalsa).

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substances and techniques in the lab. One major incident reported was the death of Sheharbano Sangji while working with the pyrophoric chemical, tertiary Butyllithium, at the University of California Los Angeles campus (UCLA) (Allen, 2014). This case led to a greatly improved safety management system at the UCLA and had implications for other personnel involved. Other reported cases include: fires in three laboratories in Malaysian universities (Draman et al., 2010); the death of a chemistry professor from Dartmouth College, New Hampshire, due to mercury poisoning after working with dimethylmercury (USCSB, 2011); and a second degree burn sustained by a post-doctoral Fellow from concentrated sulphuric acid due to use of the wrong gloves (AIHA, 2015).

1.2. Chemical safety

To minimise the occurrence of accidents in lab environments, it is important that all individuals working therein are educated about chemical safety. Hill and Finster (2010) note that for many years the topic of chemical safety was included at the margins of lab courses or as a note in lab experiments. Since the late 20th century however, the approach has improved, with greater focus on safety due to a number of legal, ethical and educational reasons. Chemical safety is the result of a combination of attitude and safe practices in addition to a strict observance of procedures (Karapantsios et al., 2008). As illustrated in the examples in Section 1.1, chemical safety does not come naturally to individuals, and needs to be taught and inculcated through continuous training (National Research Council, 2011). Key aspects of chemical safety include: hazard identification and risk assessment, emergency response, waste management, and accident reporting and investigation. These aspects of chemical safety and their importance should be communicated to students and encouraged throughout their education to help avoid accidents in laboratories.

1.3. Regional and local perspective

In the Caribbean, safety legislation is based on the Factories Act from the 1940s (Kjaer, 1997) which was based on an agricultural work environment and previously, there had been no emphasis on safety culture. However, due to the diversity of economies, a model Occupational Safety and Health (OSH) legislative framework was developed by the International Labour Organisation (ILO) for the region, which has been passed in Guyana and Trinidad and Tobago, but exists as draft legislation in other Caribbean countries. Even though there have been efforts to improve safety at work through an OSH legislative framework, no specific legislation/standard exists to govern the operation of laboratories.

In 2014, the Laboratory Safety Institute (LSI) conducted a Laboratory Safety Management course at the University of the West Indies (UWI) St. Augustine Campus in Trinidad which targeted laboratory technicians and managers, students, and secondary school teachers, among others. Hosting this course allowed the topic of laboratory and chemical safety to be discussed locally and provided incentive for programs to be developed to strengthen safety performance and allow for continuous improvement in this area. Due to reports of laboratory incidents at the tertiary level in other parts of the world, this study focused on tertiary students on the island of Trinidad in the Republic of Trinidad and Tobago.

In the Caribbean, typical entry requirements into tertiary institutions are completion of Caribbean Secondary Examination Certificate (CSEC) examinations at the end of secondary education and/or Caribbean Advanced Proficiency Examinations (CAPE). The findings of the literature search conducted indicated that this is the first study of its kind in Trinidad and by extension the rest of the Caribbean, the majority of which are classified as "developing countries". This research sought to obtain information about the chemical safety awareness among tertiary students pursuing chemistry laboratory classes. The three major tertiary institutes in the country participated in the study: the College of Science, Technology and Applied Arts of Trinidad and Tobago (COSTAATT), the University of the Southern Caribbean (USC) and the University of the West Indies (UWI), St. Augustine Campus. Undergraduate students from all levels pursuing Bachelor degrees in Chemistry or Biology were targeted. Specifically the study aimed to achieve the following:

1. To evaluate the awareness of tertiary students regarding issues of chemical laboratory safety.
2. To determine the attitudes of tertiary students pursing chemistry lab courses towards the safe use of chemicals.
3. To investigate practices being used in the lab while working with chemicals.
4. To determine if there is any correlation between awareness and employment of safe practices.
5. To identify useful predictors for the likelihood of accidents in the laboratory.

2. Methodology

2.1. Scope

A cross-sectional survey was conducted among tertiary level students in Trinidad, during the second teaching semester of 2015. The population targeted in the study consisted of undergraduate students registered for courses with chemistry laboratory components. After consultation with the list of accredited institutions on the Ministry of Tertiary Education and Skills Training's website (Ministry of Tertiary Education and Skills Training, 2010) a total of four institutions offering relevant programs were shortlisted. A summary proposal was emailed to a senior member of staff in the Science Departments of each institution, and this was followed up with a phone call to confirm receipt and to determine if the study would be facilitated. Three of the four institutions confirmed their ability to facilitate the study after which the necessary verbal and written approvals were sought before data collection commenced.

At each institution students were randomly selected to participate in the survey. Data was collected from 226 students from a population of 934 students across the three institutions. Additionally, an interview was conducted at each institution with at least one member of the supervisory staff. The supplementary information includes the survey instrument used to conduct the interviews.

2.2. Instrumentation

A self-administered questionnaire was prepared by reviewing past Knowledge, Attitude and Practices (KAP), and safety awareness studies done in the area of chemical safety (Akintayo, 2013; Adane and Abeje, 2012; Goswami et al., 2011; Yu et al., 2005). Questions were also derived from questionnaires found in two previous studies (Hedberg and Bussell, 1978; Joyce Fox Productions, 1996). A pilot study was then undertaken among recent science graduates. The critiques received were reviewed and incorporated into the final instrument before being distributed for data collection.

The final questionnaire comprised of a total of 29 questions which included both open and close-ended questions spread across six sections. The open-ended questions were included in the awareness section to better determine what students were aware of, instead of simply using close-ended questions with multiple options. The first section consisted of six demographic questions including variables such as: age, year of study, highest level of chemistry completed in secondary school; and the second section