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Safety and security in a higher education establishment laboratories using a checklist from the University of Illinois at Chicago

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ABSTRACT: In laboratories, teaching and research can be performed. To avoid accidents in laboratories and to ensure safety, there is a need and responsibility for periodic inspection as well as an assessment of user's risk perception, which can be achieved by the use of checklists. In this work, the Chemical Hygiene Officer Laboratory Self-Audit Checklist from University of Illinois at Chicago was the elected template to apply in higher education establishment laboratories. This checklist was distributed to a sample of 128 users (59% women and 41% men). The objective of this work was to analyze the answers given by these users to investigate to assess risk perception coupled with risk assessment. Based on these results, women seem to be more aware of the risks than men. The themes with more positive risk awareness are Access and Personal Protective Equipment and the themes that require more attention are chemical hygiene officer and chemical hygiene plan.

1 INTRODUCTION

Laboratories are facilities in which scientific training and research activities are developed. Laboratories can have various aspects and risk according to scientific disciplines: chemistry, biology, physics and others. Classifying these laboratories is therefore, a difficult task, particularly in terms of risk assessment. Different risk groups with different knowledge and risk perception can be found in these spaces: students, teachers, researchers, maintenance and cleaning teams. New laboratory workers and students are particularly relevant groups as they are not fully aware of the risks related to the use of dangerous products. But also, experienced users are not free from dangers (Watch, 2008; Fruchtnicht et al., 2013; Van Noorden, 2013). As a result, accidents do happen. The evaluation of risks is made through the following steps: Identifying hazards and corresponding risks; evaluating and prioritizing risks; deciding on preventive action; taking action; monitoring and reviewing (OSHA 2011; Wargniez et al., 2012; Phifer, 2014; Theis, 2014). Safety is a priority in chemical and biological laboratories. To ensure that all users are familiar with rules and regulations and understand how to operate laboratory equipments various laboratory safety manuals are available. Usually, these manuals are elaborated by someone with proper safety training, namely a chemical hygiene officer (Ashbrook, 2014). The different laboratory manuals include instructions to safety, identification of hazards (physical, biological, toxic, radiation,…), good laboratory practices, laboratory safety checklists (Agilent Technologies, 2000; British Colombia, 2003; WHO, 2008; CDC, 2009; WHO, 2009; ACS 2013). Some publications related to laboratories are specifically published for students including safety guides and short laboratory courses where they should have satisfactory scores. With these tools, an increase in safety awareness is expected (ACS, 2003a; ACS, 2003b, Crockett, 2011). With the advance of technologies, it is increasingly common to manage the laboratory risks with appropriate software. New laboratories are designed according to the specific research themes and respective risks. The disposal of materials, reagents and equipments should comply with local and regional safety and environmental regulations that may vary with country (Cagiltay et al., 2010; Maiti, 2010; Marendaz, 2013). For this work, the checklist from University of Illinois at Chicago was distributed to survey the risk perception from laboratories of a higher education establishment. The findings will support the design of a short safety course for laboratories in order to provide risk awareness to the users.

2 METHODS

In this work, out of 36 checklists found from different laboratories, the Chemical Hygiene Officer's Laboratory Self-Audit Checklist from University of Illinois at Chicago[1] was selected as the most appropriate and used as a template to apply in the

[1] http://www.uic.edu/depts/envh/HSS/Documents/CHOChecklist.pdf

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laboratories in a higher education establishment. The checklist was composed of 12 general categories, ranging from chemical storage and compressed gases to fume hoods and PPE. This checklist was distributed in paper format to 128 respondents (59% women and 41% men) of which: 66% were students, 9% researchers and 25% were part of cleaning and maintenance teams. The completed checklists were analyzed for age, gender, profession and qualifications. In addition, the laboratories of the higher education establishment were also evaluated for aspects such as principal investigator, number of scientists, and the type of laboratory (teaching or research). The results obtained from 128 answered checklists were organized in a matrix and two new possible answers were included in data management: "not valid" and "not answered". Results were divided according to gender to survey if this variable might play a role in risk perception. After this analysis, all the original answers "yes", "no", "not applicable/not available" were converted into logical values of "zero" or "one", depending if the risk perception is negative (0), or positive (1), respectively. The average values for each topic was calculated. Bar graphs and histograms were constructed for each set of questions. Line charts were constructed to evaluate the percentage of positive risk perception.

3 RESULTS

Figure 1 shows the variation of score with cumulative percentage of respondents representing the total of positive perception that each respondent expressed. The maximum score (87%) of positive perception was obtained by two women. Another reading that can be made is that 60% of respondents show score below 50%.

Seventy-eight questions were arranged in descending order, according to the score relative to positive perception. Figure 2 shows the top 8 questions with more positive perception, i.e., with value "one". It can be seen that the major theme questions are "access" and "general work environment". The average value of these top 8 questions with positive perception is 81%.

Figure 3 shows the top 6 questions with the least positive perception. The themes "chemical hygiene plan" and "emergency training" are the most representative and therefore the most serious. The average value of these top 6 questions is 10%.

The average values were calculated for each theme and represented in Table 1. The results showed that the most critical themes were "chemical hygiene plan", "chemical hygiene officer" and "emergency training". The theme where users demonstrate more positive perception were: "access", "personal protective equipment" and "general work environment".

4 DISCUSSION

The results showed that some respondents left some answers blank (i.e. without a response). This behaviour is possibly due to the lack of

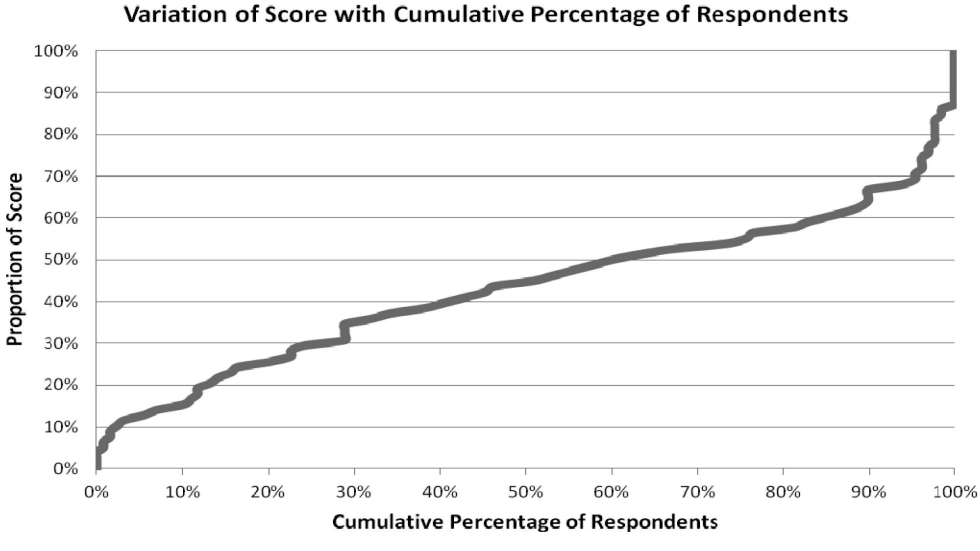


Figure 1. Representation of variation of score with cumulative percentage of respondents.

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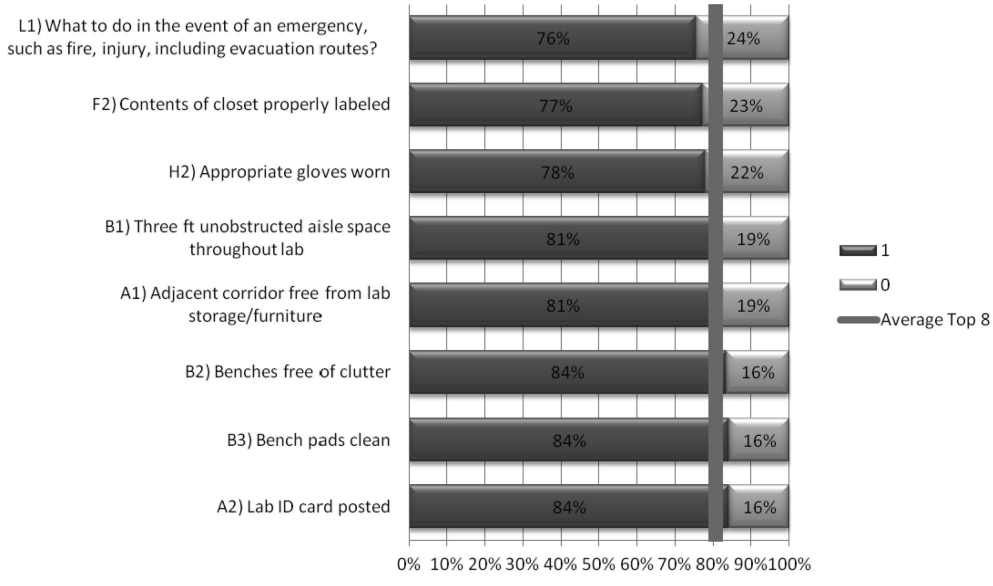


Figure 2. Top 8 questions for the most positive perception.

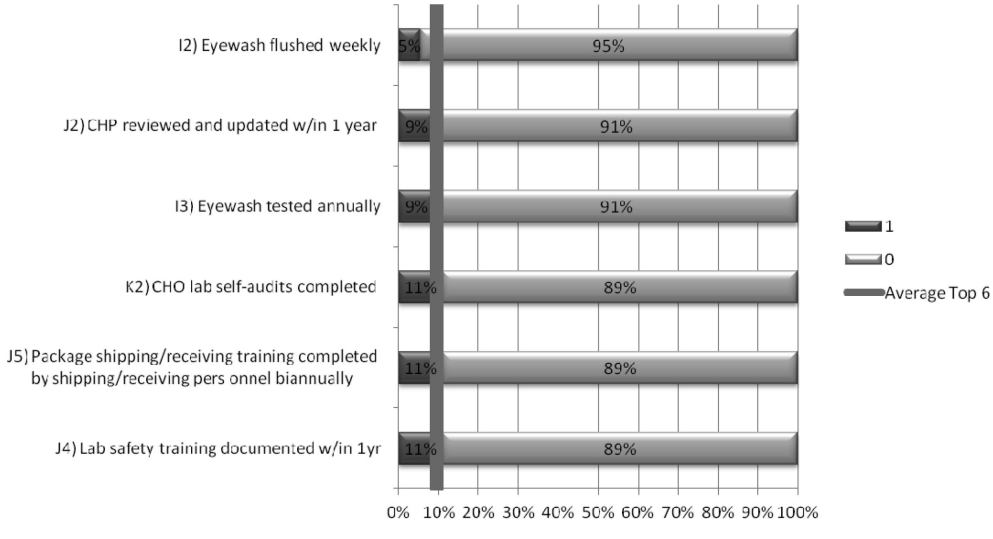


Figure 3. Top 6 questions for the less positive perception.

information or the user did not want to collaborate in the questionnaire. Therefore, it is an urgent aspect to address from a prevention standpoint. If checklists were to be available on-line, more users could be reached for answers. It addition, completing the questionaire could be made a requirement (not unlike other mandatory online questionnaires adopted by Universities) in order for students to better assess their knowledge.

The transformation of the original results, i.e., the answers "yes", "no", "not applicable/not available", "not valid" and "not answered" into scores allowed for added information about prevention in laboratories. All the original results are relevant, but concerning risk prevention, the absence of information should be penalized. The 78 questions of checklist were constructed in such a way that a "yes" to all the questions translates

Table 1. Summary of positive perception averages obtained for the different themes.

Theme		Average
A	Access	71%
B	General work environment	64%
C	Chemical storage	39%
D	Chemical hazardous waste	48%
E	Compressed gases	29%
F	Closets	58%
G	Fume hoods	48%
H	Personal protective equipment	68%
I	Emergency training	27%
J	Chemical hygiene plan	14%
K	Chemical hygiene officer	19%
L	Awareness—do laboratory workers know	51%

into a "perfect laboratory" while conversely, all "no" answers score the lowest.

Concerning the laboratories that checklist were applied, some showers and eye wash stations contained obstacles that prevents their use. Eye wash stations should have appropriate access and should be flushed weekly to prevent bacterial build up and to check for water quality. Some storage cabinets had heavy bottles on the upper selves and not all laboratories contained extinguishers. It is important to maintain heavy glass bottles (which may contain hazardous liquids) below eye level to avoid spills.

5 CONCLUSIONS

In this work, many conclusions can be resumed. Safety in laboratories is a very important area that should be taken seriously and comply with its rules. Still, many users are unaware or ignore the importance of safety in laboratories, and as a result, the accidents occur. There are laboratory safety manuals and chemical hygiene plans that several universities and foreign institutions use. In laboratories, the location or placement of equipment, materials and reagents should be done taking into account the size of these items and safety of the user and worker. The checklist distributed via paper served to study attitudes, values and beliefs from the 128 participants. One limitation of the questionnaire was the need to input the responses from checklist to checklist on a digital platform (excel), which took time to organize of the information. It was observed that laboratories of a higher education establishment still have safety opportunities and there are improvements to be made, for example, in training and communication of safety in laboratories. The checklist used within this study did not have questions related to ergonomic safety or seismic safety, issues that should be taken into account in the future.

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