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Original Article

Health impact of xylene exposure on laboratory workers at a selected healthcare facility in Oman

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ABSTRACT

Introduction: Xylene is a commonly used chemical in medical laboratories for various purposes such as treating tissues, dyeing and covering sliding. However, exposure to xylene can pose potential health risks for laboratory staff and healthcare professionals. The study aims to provide alternative preventive measures and safety procedures to ensure laboratory technicians' health and safety. Its primary objective is to assess the potential health impacts of xylene exposure on laboratory and healthcare staff in Oman.

Methods: The study adopted quantitative research design which is descriptive in nature to investigate the effect of xylene exposure on laboratory workers at healthcare facilities in Oman. A close-ended and open-ended questionnaire was designed to collect data from 115 histopathology workers achieving a 100% response rate. The data collected in 1st January to 3rd March time period and analyzed in Excel.

Results: The Findings show that exposure to xylene mostly affects the eyes and nose. 21% of participants reported experiencing muscular problems like weakened muscles, loss of coordination, and impaired grip strength. The results also revealed that the third health issue was related to the skin, as 16% of the respondents experienced some form of skin problem due to exposure to xylene, such as skin irritation, itching, peeling, or burns.

Conclusion: Based on the study findings, it is evident that xylene has various negative health effects. Alternative substances instead of xylene, such as d-limonene-based products, olive oil, pine oil, and rose oil, are recommended. These alternatives are environmentally friendly and cost effective, although they may not be as effective as xylene. Therefore, it is essential to implement effective measures that prioritize the well-being of histology staff while working with xylene.

Keywords: Health effects, Histology laboratory workers, Xylene exposure.

Introduction

Histology staff working in laboratories make use of different substances and solvents, including xylene. Known also as xylol in chemistry terms, xylene is any of three organic compounds with the formula $(CH_3)_2C_6H_4$.[1] It consists of an aromatic hydrocarbon that is frequently employed in manufacturing and medical technology. Xylene exists as either liquid or gas; it is colorless and naturally occurs from petroleum or wood tar. Xylene has increasingly been used for various purposes, including medical ones.[2]Nowadays, xylene is widely used for cleaning purposes and staining as well as tissue processes. Histopathology labs are identified as the chief workplaces for xylene exposure.[3] Histopathological employees working in laboratories of healthcare facilities and who routinely come in contact with xylene are most likely to be exposed to certain levels of xylene, as exposure to xylene can occur via inhalation,

ingestion, and eye or skin contact.[4] The type and severity of the health impacts caused by xylene vary according to several factors, such as the exposure mode, the length of exposure, the level of xylene being absorbed and how each person reacts to different degrees of exposure.[5] Xylene can be absorbed orally, topically, and through inhalation. Absorbed xylene can be found in the human body by measuring the level of methyl hip uric acid in the urine.[6] On absorption, xylene can penetrate the bloodstream and is then transported all over the body. According to NIOSH, the human body automatically gets rid of the Xylene 18 hours following the exposure; however, with constant exposure, xylene can be permanently found in the human body.[5]A plethora of health impacts caused by Xylene exposure on workers working with xylene exist in the literature, including laboratory technicians and histologists. For example, excessive and long exposure to xylene can result in severe damage to the liver or even liver failure, which might, in turn, lead to heart attack and, consequently, death. The authors point out that the kidney can equally be affected by high and long exposure to xylene. Some authors revealed that the substance could cause debilitating conditions upon inhalation.[7,8] Corroborating this, the effects of xylene among laboratory histology technicians who were exposed to xylene over an extended period in labs were conducted. Their study showed that the technicians experienced decreased lung function and dyspnea.[9] The same study reported that some technicians even showed cardiovascular side effects such as flushing, tachycardia, and chest pains.[10] In line with that, the Agency for Toxic Substances and Diseases Registry contended that inhaled xylene might trigger breathing difficulties as it has the potential to cause intra-alveolar hemorrhage, pulmonary edema, and serious lung occlusion when inhaled. Along similar lines, other studies have attempted to examine the effect of xylene on the Nervous coordination as well as sensory impairment of workers; for instance, Fuente et al. studied how memory and hearing abilities might be affected by xylene.[11] This finding was emphasized by Draper and Bamiou et al., stated that fatigue, conjunctivitis, memory loss, and hand degreasing were also present in their empirical study, along with dermatitis, pharyngitis, coryza, memory loss, disturbance of the catamenia system, and loss of coordination and identified dizziness, inability to concentrate and forgetfulness as emanating from exposure to xylene.[12] The study conducted to examine the effect of xylene on the eyes, nose and throat of workers who were exposed to mixed doses of xylene at permanent and regular frequency. They found out that workers showed a significant increase in throat and nasal irritation. The study further noted that sudden splash injury to the eye interior is also possible but disappears in a few days. Muscle and adipose tissues are among the organs that can be affected by exposure to xylene.[13] The study indicated that xylene-exposed workers complained of weaker muscles in their limbs and impaired grabbing ability.[14]Many studies have described a variety of gastrointestinal issues provoked by xylene fumes on a regular basis.[15,8] The most common gastro effects include nausea, vomiting, anorexia, nausea, loss of taste and appetite, vomiting, anorexia, loss of taste and appetite, and overall gastric discomfort. Most of the studies above point out that those symptoms stopped after the contact was stopped. Tokinen et al. reported a case of a female histologist who suffered an abortion. Although the study could not prove that the abortion was solely due to xylene exposure, it can still be associated with a potential cause.[16] Based on the above literature, it is pertinent to note that xylene poses a grave health danger to healthcare workers, especially those in the histopathology unit. Therefore, identifying the potential health risks of xylene can help histopathological staff implement effective preventive measures and practices to sustain their health and safety in the workplace. Thus, this study aims to assess the potential impacts of xylene on the health of laboratory staff in Oman's healthcare facilities.

Methods

In this study adopted a quantitative research design which is descriptive in nature (describes data on characteristics of individuals or factors) to investigate the effects of Xylene exposure on histopathology workers in a selected healthcare facility in Oman. The population of the study consisted of 165 medical technologists and laboratory technicians. The logic in selection is that since all workers have a probability of being selected, then this study utilize a probability sampling approach. However, before the selection of participants for the study, it is crucial to stablish a sample size which was determined from Krijcie and Morgan (1970), similar approach has been utilized by several authors in prior studies. Since all workers in the healthcare facility cannot be administered the questionnaire.[17,18] The sample size of the study was determined using the Kriecjie and Morgan formula for determining sample size as indicated below;

$$n = \frac{X^2 NP(1-P)}{e^2(N-1)+X^2P(1-P)} \quad (1)$$

Where,

N = Population Size = 165

X^2 = Chi Square Value = 3.841

P = Population Proportion = 0.5

e = Margin of Error = 0.05

$$n = \frac{3.841 \times 165 \times 0.5(1-0.5)}{0.05^2(165-1) + 3.841 \times 0.5(1-0.5)}$$

n = 115 = sample size

After the determination of the sample size, a simple random sampling technique was adopted to select the individual respondents for the survey. This was achieved by assigning numbers to all the participants and selecting the odd numbers to take part in the study. The researchers designed the questionnaires used for data collection based on existing prior literature. The questionnaire was divided into two parts. The first part contained information on the participant's demography like gender, age and years of experience, the second part of the questionnaire contained information which solicited responses from participants about modes of exposure, duration of exposure and health problem linked with Xylene exposure. The questionnaire consisted of both close-ended questions and open-ended questions to offer the respondents more space to express their concerns freely. In a similar vein, questions were carefully chosen to ensure that respondents had the knowledge necessary to respond to them. The survey was administered by self. The study was conducted during January and February 2023, with most of the primary data being collected over one week in February 2023. Prior to distributing the questionnaire to the target audience, the researcher tested the validity of the questionnaire by having five nurses in another small hospital answer it. The study strictly adheres to ethical research norms as ethical clearance was gotten from Research and Ethics committee of the International College of Engineering and Management. The risk of harm, informed consent, anonymity, secrecy, and conflicts of interest were among the ethical issues that were taken into account in this study. Likewise, participants in the study were made aware of their right to withdraw from the survey. Also, participants were told that the data collected would be kept confidential and anonymous. Statistical tools, namely Microsoft Excel, were adopted to analyze the data collected.

Results

In this study, the total number of questionnaires distributed to the target respondents was 115. All administered questionnaires were retrieved, indicating this study's questionnaire response rate is 100%. The response rate was above the minimum expected response (more than 50%).[19] This finding is in tandem with those who distributed over 355 questionnaires to patients in a hospital setting and received a response rate of 100%. Similar findings were observed and reported a 100% response rate.[20]

The results from the first section, which includes demographic information of the participants, are presented in Table 1.0. Figures 1, 2, and 3 concern the analysis of results from section 2, which solicited responses on exposure modes, level of exposure, and health effects associated with xylene.

Table 1: Demographic data of the study respondents

Characteristics		**Frequency (%)**
Gender	Male	25 (21.73%)
	Female	90 (78.27%)
Age in years	20-30	24 (20.86%)
	30-40	43(37.39%)
	40-50	37 (32.17%)
	50-60	11 (9.56%)
Years of experience in years	Below 5	24 (20.46%)
	5-10	41 (35.65%)
	10-20	36 (31.3%)
	20 above	14 (12.17%)

According to results from Table 1.0, the majority of histology technicians in healthcare facilities are aged between 30 and 40 years old, making up 37% of the staff. The second largest group is the 40-50 age category, representing 33% of the staff. The third largest group is comprised of histology employees aged between 20 and 30, representing 21% of the staff. Those over 60 years of age make

up just 9% of the staff. Table 1.0 also presents the number of years spent by the histology staff members working in the laboratory. As can be seen in the table, those who spent 20 years or more represent a minority, standing for just 12%. For those who had less than a five-year career, they represent the second smallest group with 21% representation.

On the contrary, people with 5 to 10 careers are the majority group in the histology staff, followed by those who have 10 to 20 years; they come in the second largest group, standing for 31% of the staff. The minority group comprises individuals who have spent 20 years or more, accounting for only 12% of the total staff. Meanwhile, those who have had a career of fewer than five years represent the second smallest group, with 21% representation. The majority group in the histology staff consists of those who have spent 5 to 10 years in their career, followed by those who have worked for 10 to 20 years; they make up the second-largest group, accounting for 31% of the staff.

In Figure 1, it can be seen that about 41% of workers were affected by inhalation because it is a very common mode of exposure. Even people not in direct contact with xylene are easily affected by this mode of exposure. The second most common mode of exposure is the eye, which accounts for 32% of exposure, while skin and ingestion were the least modes of exposure to xylene.

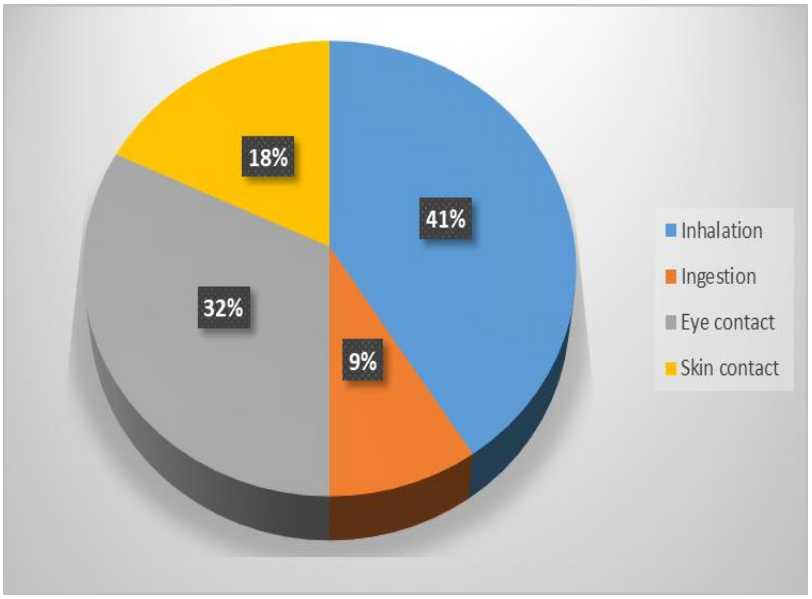

Figure 1: Modes of Exposure to Xylene

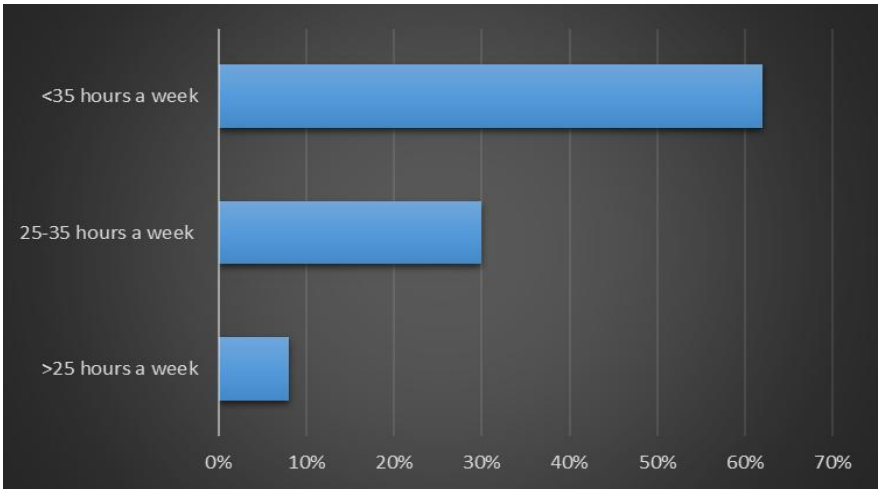

Figure 2: Duration of exposure to Xylene

According to the findings in Figure 2, more than 60% of the study population had an exposure of over 35 hours per week, while 30% of the population experienced exposure of 25-35 hours a week. The remaining 25% of the population experienced exposure of less than 25 hours a week. These results highlight the importance of the level and duration of exposure in determining the

impact of xylene on individuals.

According to the findings, the most significant health issues arising from xylene exposure are associated with the eyes, nose, and throat, accounting for 23% of the responses received. The next main effect, as seen in Figure 3.0, is on muscles, which accounted for 21% of the responses retrieved. The skin was the third most affected area at 16%, while the nervous system was next, accounting for 15% of the responses. Furthermore, the respondents reported other health effects related to the reproductive system, cancer, and gastrointestinal issues.

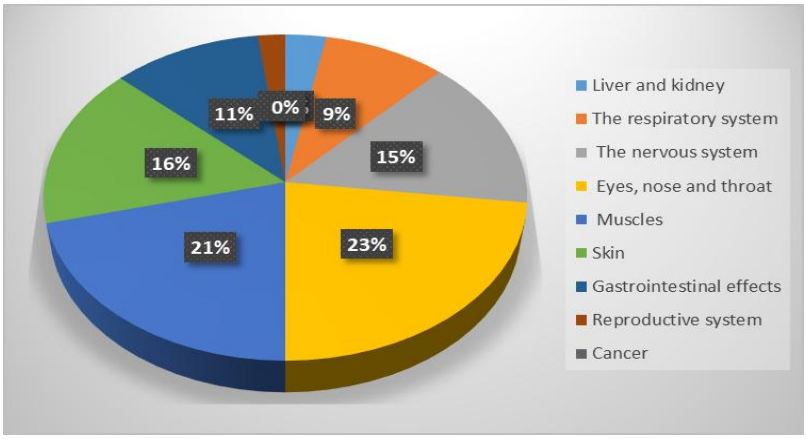

Figure 3: Common health problems experienced

Discussion

Based on the demographic analysis performed by this study, it was noted that the number of females outnumbered that of males. Based on the results, 90 out of the 115 participants were females, making up 78.27% of the histology staff. The remaining participants were males, accounting for 21.73% of the entire population. The results reveal that women were in the majority. This finding is of key importance since it adds to several studies within the Omani context, which identified Females as the leading gender in healthcare settings in Oman. To achieve the objective of the study referred to the Occupational Safety and Health (OHS) maximum allowable exposure for xylene, which is 100 ppm on average Time-weighted (TWA) of 7 hours a day/ 35 hours a week as recommended by the National Institute for Occupational Safety and Health (NIOSH) exposure limits. The study found that 62% of histology staff in the hospital are excessively exposed to xylene, while 38% of them are exposed to xylene within the allowed norms. These findings are consistent with those of previous studies.[23,24,25] When workers exceed exposure levels of Xylene-containing compounds, it results in decreased cytochrome P-450 levels, an enzyme in the human body which is responsible for drug biotransformation in the human body. These findings prove the importance of workers in these facilities taking proper care when working in the histology department, as many working activities are associated with exposure to xylene, which has ramifications for their health and safety.

Furthermore, the results also revealed that most of the respondents reported that they are exposed to xylene mostly via inhalation (41%), followed by eye contact (32%). Skin contact is the third largest mode of exposure to xylene. As for eye contact, it was identified as the least mode of exposure to xylene in the laboratories of healthcare facilities. Inhalation is commonly identified as the main mode of exposure by other previous researchers.[17,18] This finding is mostly because xylene is a substance that can spread in the air, and the only way to avoid its absorption is through using protective masks, a practice to which most lab staff are reluctant. It effects related to the eyes, nose and throat with 23% (ENT) were the most common health effects associated with histology workers in the selected healthcare facilities. These findings give credence to our earlier findings, which identified inhalation as the leading mode of entry of xylene into the body. When inhaled, xylene could result in health effects which affect the ENT.[27,28,29] Earlier studies identified side effects of xylene, including respiratory symptoms linked to the nose, as one of the leading effects tied to Xylene exposure.[30] Other studies, like, emphasized the need to observe xylene levels due to its irritating effects on the respiratory system and eye.[31] Medically, the resultant effect of the associated health problems linked to ENT following short-term exposure to xylene leads to gastrointestinal, neurological and reproductive complications.[32]Other significant health effects

disclosed by the respondents are muscle issues such as weaker muscles, loss of muscle coordination in limbs and impaired grabbing ability. Generally, the results of the current study and others reviewed in this study revealed that xylene and its related isomers are very toxic substances that possess huge health consequences for human beings, especially those in the histopathology departments.

Conclusions

This study was conducted to identify the health concerns linked with xylene exposure in workers in selected health facilities in Muscat. The study found that the leading mode of entry of xylene is inhalation, while ENT was the main part to which these effects are largely tied. Thus, there is an urgent need for the management of healthcare organizations to develop and design a robust safety management system that will effectively monitor, detect, and eradicate the effects arising from xylene exposure in healthcare settings. These include installing local exhaust ventilation in labs to reduce inhalational hazards, reducing exposure levels by requiring the histology staff to work on shifts and not to spend more than 7 hours a day in laboratories, promoting personal hygiene practices among the histology staffs, using personal protective equipment such as hand gloves, face masks and special uniforms, emphasizing health checkup sessions for histology staff and improving safety culture of the organization as several studies have identified the role of safety culture in addressing workplace exposures.[16] This study has a plethora of limitations that should be noted. First, it is worth mentioning that the effect arising from xylene exposure depends on factors concerning age, gender, personal genetic profile, immune system, and health conditions. While this study did not attempt to determine if the health concerns associated with xylene exposure are linked to these factors mentioned earlier, it is imperative that studies in the future can be done to see if demographic factors can influence the associated effects of xylene. Also, more empirical investigations are to be conducted to ascertain if the effects arising from this study are consistent across other departments in the healthcare setting and Oman in general.

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