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FULL PAPER

Impact of xylene exposure on blood profiles and neurotoxic symptoms among printing workers in Surabaya

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Xylene exposure is influenced by worker characteristics and the quality of the work environment. This study aimed to investigate the relationship between xylene exposure, blood profiles, and neurotoxic complaints among printing workers in Surabaya. An observational, cross-sectional design was employed, involving 30 workers who met the inclusion criteria. Data collection methods included questionnaires, documentation, interviews, and measurements. The independent variables were the concentration of xylene in the work environment (used to assess the intake dose) and worker characteristics such as age, years of service, working hours, nutritional status, use of personal protective equipment (PPE), smoking habits, and exercise habits. The dependent variables included blood profiles (erythrocytes, platelets, leukocytes, LDL, and cholesterol) and neurotoxic complaints. The results revealed that xylene concentrations were still below the threshold limit value. A total of 16 workers (53.3%) reported experiencing neurotoxic complaints. Blood profiles (erythrocytes, platelets, leukocytes, LDL, and cholesterol) remained within the normal range. Statistically significant relationships were found between xylene intake dose and neurotoxic complaints, between xylene intake dose and blood profiles, and between worker characteristics and neurotoxic complaints. To mitigate risks, it is recommended that printing companies improve ventilation systems, ensure safe working environments, promote a culture of health and safety, conduct regular health checks, and provide appropriate PPE for workers.

KEYWORDS

Xylene exposure; blood parameters; neurotoxic symptoms; printing industry workers; workplace safety.

Introduction

Printing businesses use several chemicals that can cause harm in terms of equipment, the environment, and the workers themselves. Based on an initial survey that has been conducted in several printing in Surabaya City, it was found that the printing industry uses chemical solvents for its production process, especially solvent chemicals for its production process, cleaning agents, inks, glues, and other solutions for wetting printing plates [1,2]. The use of organic compounds in the printing production process can increase health and safety risks, particularly through air pollution, with xylene exposure being one of the main concerns [3,4]. Solvents with low boiling points like xylene are examples of liquids that release vapor. Paint solvent vapor is generated from the spray painting process [5,6]. Therefore, solvent (solvent) is the most important component in paint [7,9].

Organic solvents are generally volatile liquids. The vapor of organic solvents is known to be fat-soluble, which is why the vapor of organic solvents is easily absorbed through the capillary membrane, making inhalation the main route of exposure to vapors generated in the work environment [10,12]. Workers who use chemicals, namely xylene as a solvent result in health complaints such as dizziness, nausea, eye irritation, respiratory, liver, kidney, skin irritation, and nervous system disorders [13,15].

Poisoning due to exposure to hazardous solvents such as toluene and xylene has similar symptoms to benzene acute poisoning. Exposure to both solvents can cause skin abnormalities, impaired kidney function, liver and muscle disorders [16,17] Fatal damage can affect the nervous system, immunity and reproductive function [11]. The following are some xylene exposure cases recorded in the US EPA (2002), including Goldie reported the case of eight painters exposed to paint materials containing 80% xylene and 20% methyl glycol acetate solvent. The workers

complained of dizziness, severe headaches, gastric distress, dry throat and intoxication-like symptoms after thirty minutes of exposure to xylene [18,19].

The study by Klaucke *et al.* (as cited in EPA, 2002) documents an incident where fifteen workers were exposed to xylene at an estimated concentration of 700 ppm through inhalation. Following this exposure, all individuals were hospitalized with at least two of the following symptoms: dizziness, nausea, vomiting, severe headache (vertigo), and irritation of the eyes, nose, and esophagus. Fourteen of the fifteen workers reported experiencing an unusual odor for approximately 15-30 minutes prior to the onset of these symptoms [20,21].

The workers operate in an enclosed, air-conditioned environment that continuously recirculates air, causing xylene concentrations to accumulate. A strong, pungent odor permeates from the production room to outside, as mentioned in prior studies [22,23]. Although there is ventilation within the production area, it is inadequate relative to the workplace size, limiting effective air exchange. This deficiency leads workers to inhale xylene continuously, exacerbated by the lack of Personal Protective Equipment (PPE) [24,25].

In addition, the workforce typically has an average tenure of about two years. Unfortunately, workers lack awareness of the hazardous effects associated with the chemicals used in production. This combination of inadequate ventilation, continuous xylene exposure, insufficient PPE usage, and lack of hazard awareness poses significant health risks, reinforcing the need for improved safety measures, effective ventilation, PPE, and education on chemical hazards in the workplace.

This study begins with a preliminary site survey, which includes data collection and interviews about health complaints experienced by workers at the printing factory. The data include the total number of

workers in the production process, working hours, and the layout of the workplace. Health complaints reported by workers include headaches, eye pain, short breath, nausea, and coughing.

Based on the description above and the results of the initial survey that has been conducted the author in several printing industries, the author would like to analyze the relationship between xylene exposure and blood profile in printing industry workers in the city of Surabaya.

Methods

This study used an analytical observational design to analyze the association between neurotoxic complaints, blood profile, and xylene exposure in printing workers in Surabaya, using the Q18 questionnaire and blood profile measurements. It was conducted with a cross-sectional research design and also it was conducted in printing facilities in Surabaya City in December 2019. The population of this study was 30 workers consisting of 11 workers in location one and 19 workers in location two.

TABLE 1 Measurement results of xylene levels in the body of workers

Intake dose xylene	Total number of workers	Percentages %
< 1.05 mg/kg days	22	73%
> 1.05 mg/kg days	8	27%
Total	30	100%

Identifying the characteristics of printing workers in Surabaya City

Table 2 shows the age variable of respondents in printing most dominated by the age range under the age of <38 years, namely as many as 18 workers (60%). All respondents in printing workers are included in the productive age group according to Law No. 13 of 2003 concerning Labor with an age range of 15-64 years, labor with an age range of 15-64 years. Related to the working period of printing workers in printing workers in Surabaya City,

Results

Distribution of measurement results of xylene levels in the body of printing workers in Surabaya City

Table 1 indicates that the intake dose of xylene received by workers is different. These variations are due to several factors, including age, working period, working hours, respiration rate, and work environment. The average intake dose received by workers in the Surabaya city printing press is below the average of 22 workers (age, working period, working hours, respiration rate, and work environment). Surabaya is lower than the average of 22 workers (73%) and above the average of 8 workers (27%). workers (27%). If the calculation is carried out in the risk assessment process, then the condition of the 30 workers is included in the risk category because the RQ value is higher than 1. The value of the printing workers is higher than 1.

it was found that most of the 19 workers (63%) had a working period of less than 10 years. 17 respondents (57%) have working hours of 8 hours/day while 13 respondents (43%) have working hours of more than 8 hours/day. more than 8 hours/day. Most of the workers at the printing press in Surabaya City have a normal nutritional status as many as 23 workers (76%), category overweight in printing workers as many as 5 workers (16%), and obese category 1 as many as 2 workers (8%), obese category 1 as many as 2 workers (8%).

TABLE 2 Characteristics of printing workers in Surabaya City

Variable	Category	Quantity	Percentages
Age (years)	< 38	18	60%
	≥ 38	12	40%
Period of Employment	< 10 years	19	63%
	> 10 years	11	37%
Duration of work	<8 hours	17	57%
	> 8 years	13	43%
Nutritional status	Normal	23	76 %
	Obese	5	16 %
	Obese 1	2	8 %
Use of PPE	Always (6 working days)	6	20%
	sometimes (1-3 working days)	6	20%
Smoking habit	Not use	18	60%
	Yes	13	47%
	Sometimes	7	23%
	No	10	30%
Exercise habits	Yes (4 times a month)	13	47%
	Sometimes (1-2 times a month)	7	23%
	No	10	30%

The use of PPE can be seen in workers who always use PPE as many as 6 workers (20%), and workers who sometimes use PPE as many as 2 workers (8%). 6 workers (20%), workers sometimes use PPE 6 workers (20%), and those who do not use PPE were 18 workers (60%). The variable of smoking habits can be known to workers who smoked were 13 workers (47%), workers who sometimes smoked were 7 people (23%) and those who did not use PPE were 18 workers (60%). 7 workers (23%) who sometimes smoked and those who do not smoke were 10 workers (30%). The variable of exercise habits can be known to workers who exercise as many as 8 workers (27%), those who sometimes exercise were 6 workers (20%), and workers who do not smoke were 10 workers (30%). 6 workers sometimes do exercise (20%) and those who do not exercise as many as 16 workers (53%).

Blood profile examination results (erythrocytes, platelets, leucocytes, LDL, and cholesterol) of printing workers in Surabaya City

Distribution of blood profile examination results (erythrocytes, platelets, leucocytes, LDL, and cholesterol) of 30 printing workers/respondents in Surabaya City

Table 3 indicates that blood tests on workers in the printing workers in Surabaya city showed the average was in the normal category related to erythrocyte levels of 70% with a standard range (4.0 - 5.5 x 10⁶ /μL), platelets by 80% with a standard range (140-440 x 10³/μL), and leucocytes by 76.6% with the standard range (5 - 10 x 10³/μL).

Table 4 shows that the examination of LDL number of categories was normal for as many as 27 workers 90% with a standard of less than 100 mg/dL and associated examination of total cholesterol showed a normal category of 20 workers (66.7%) with a standard value of less than 200 mg/dL.

TABLE 3 Blood profile examination results of printing workers in Surabaya City

Variable / Category	Blood Testing					
	Erythrocytes		Platelets		Leukocytes	
	n	%	n	%	n	%
Low	0	0%	6	20%	4	13,3%
Normal	21	70%	24	80%	23	76,6 %
High	9	30%	0	0%	3	10%
Total	30	100%	30	100%	30	100%

TABLE 4 LDL and total cholesterol test results of printing workers in Surabaya City

Variable / Category	LDL		Total Cholesterol	
	n	%	n	%
Normal	27	90%	20	66.7%
Close to normal limits	2	6.7%	8	26.7%
High	1	3.3%	2	6.7%
Total	30	100%	30	100%

The results of the identification of neurotoxic complaints in printing workers in the city of Surabaya

workers are in the form of headaches by 72%, weakness in the arms/legs by 78%, and numbness in the hands/legs 83%.

The distribution of the results of the Q18 questionnaire to see the neurotoxic risk in printing workers in Surabaya city is presented in Table 5.

Based on Table 5, it can be seen that out of a total of 30 workers in the two locations with different xylene exposures, the workers who experienced neurotoxic complaints using the German Q18 questionnaire had category as many as 16 workers (53.3%), workers with moderate complaints of 9 workers (29.9%), and 5 workers (16.6%) with mild complaints. workers (16.6%). The results of the data recapitulation obtained from the German Q18 questionnaire show that the most common complaints experienced by workers are that complaints that are often experienced by

Discussion

Blood profile examination of printing workers in Surabaya City

Erythrocytes

Erythrocytes or erythrocytes are one of the cell components contained in the blood. The results of blood tests that have been carried out on erythrocyte levels in printing workers that 9 workers (30%) have high erythrocyte levels, 30 workers (70%) have high erythrocyte levels, while 30 workers (70%) have normal erythrocyte levels. The standard number of erythrocytes in adults ranges from 4.0 - 5.5 x 10⁶ /μL.

TABLE 5 Identification of neurotoxic complaints in printing workers in Surabaya City

Neurotoxic complaints in printing workers	Workers who experience neurotoxic complaints (Q18)	Percentages (%)
Severe complaints	16 workers	53.3 %
Moderate complaints	9 workers	29.9%
Mild complaints	5 workers	16.6%
Total	30 workers	100%

Platelets

The normal level of platelets in the human body is about $150 - 450 \times 10^3 / \mu\text{L}$. The results of blood tests that have been carried out show platelet levels in printing workers 6 workers (20%) have abnormal leucocyte levels, while 24 workers (80%) have normal platelet levels. Standard platelet levels in adults range from $140-440 \times 10^3 / \mu\text{L}$.

Leukocytes

Leukocytes or white blood cells are blood cells that have a nucleus. In normal human blood, the number of leucocytes is found to range from 4500-10,000 cells/mm³. In general, leukocytes play a role in the cellular and humoral defense of humans. The results of blood tests that have been carried out show leukocyte levels in the printing workers 4 workers (13%) have leucocyte levels in the abnormal category, while 26 workers (87%) have normal leucocyte levels, while 26 workers (87%) had normal leukocyte levels. Standard levels of Leukocytes in adults range from $3.6 - 11 \times 10^3 / \mu\text{L}$.

LDL

LDL is a lipoprotein that plays a role in the transport of cholesterol to the liver and peripheral tissues that need it. If there is an excess of LDL particles in the blood, the LDL will enter the sub-endothelial layer of blood vessels and trigger the formation of the vascular sub-endothelial layer and the formation of foam cells which can then develop into fatty streaks [26]. The results of blood tests that have been carried out on LDL levels in printing workers showed that 3 workers (10%) had abnormal LDL levels, LDL levels in the abnormal category, while 27 workers (90%) had a normal category. Standard LDL levels in adults are less than 100.

Cholesterol

Blood contains 80% cholesterol which is produced by the body itself and 20% comes

from food [27,28]. Cholesterol in the body binds to proteins and is transported throughout the body. Cholesterol is very important for the body, but if the cholesterol level in the blood is excessive, it is also harmful to health. Normal cholesterol levels are around 140-200 mg/dL. Levels of high cholesterol levels are 200-400 mg/dL[29]. The results of blood tests that have been done show cholesterol levels in printing workers 10 workers (33%) have cholesterol levels in the abnormal category, while 20 workers (67%) have cholesterol levels in the normal category. Standard cholesterol levels in adults are less than 200.

Identification of neurotoxic complaints among printing workers in Surabaya City

The results of the recapitulation of the answers to the German Q18 questionnaire, workers who experienced neurotoxic complaints in the severe category were 16 workers (53.3%). Exposure to xylene exposure to the central nervous system will affect both short-term exposure and long-term exposure to xylene. At concentrations of 100-200 ppm will cause nausea and headache, 200-500 ppm with dizziness, irritability, weakness, and headache. with dizziness, irritability, weakness, vomiting, and slowing of reaction time; 800-10,000 ppm with dizziness, irritability, weakness, vomiting, and slowing of reaction time; 800-10,000 ppm with lack of muscle coordination, dizziness, confusion, ringing in the ears, and changes in balance; and >10,000 ppm with loss of consciousness. Other neurological effects include impaired short-term memory short-term memory, impaired reaction time, and impaired balance [30,32].

The xylene measurements in this work environment revealed exposure levels below the Threshold Limit Value (TLV, or NAB), yet workers still reported significant neurotoxic symptoms, with 16 workers experiencing symptoms in the severe category. Common

complaints included headaches (reported by 72% of workers), feelings of weakness in the arms or legs (78%), and numbness in the hands or legs (83%).

These findings highlight that even low-level xylene exposure, if sustained over time and occurring frequently, it can lead to chemical accumulation in the body, potentially triggering neurotoxic effects. According to the Agency for Toxic Substances and Disease Registry [32], prolonged low-dose exposure to neurotoxic chemicals can indeed result in neurological issues. Environmental and occupational conditions, such as air quality, workplace safety, labor conditions, lifestyle factors, personal habits, and prior chemical exposures, can further amplify neurotoxic responses [33].

The situation underscores the need to consider not only exposure concentrations, but also cumulative exposure duration and environmental factors that might increase the neurotoxic risk for workers. Improving ventilation, reducing exposure times, and ensuring adequate protective measures are crucial steps to mitigate these health risks effectively.

The results of this study on neurotoxic complaints due to xylene exposure are only preliminary information are only preliminary information, which can be taken into consideration by the company to ensure a preliminary diagnosis that workers are not being exposed to xylene consideration for the company to confirm the initial diagnosis that workers in the workers in Surabaya city are suffering from occupational diseases (PAK) due to xylene exposure that is acute.

Conclusion

The study of printing workers in Surabaya reveals that although xylene exposure levels remain within the National Air Quality Standards (NAB), a significant number of workers report neurotoxic symptoms. Most of these workers are under 38 years old, have a

long employment history (over nine years), and work approximately eight hours per day. While many maintain normal nutritional status, a number do not use Personal Protective Equipment (PPE), some are smokers, and few engage in regular exercise. Blood profile examinations (including erythrocytes, thrombocytes, leukocytes, LDL, and total cholesterol) generally fall within normal ranges for these workers. However, the prevalence of neurotoxic symptoms is high, with more workers experiencing symptoms than not. Common health complaints include frequent headaches, weakness in the arms and legs, and numbness in hands and feet. This situation highlights the complex health impact of xylene exposure, which may not always be evident in standard blood profiles or immediate health markers but can manifest as neurotoxic symptoms, particularly with long-term exposure. Further measures, such as reinforcing PPE usage, improving workplace ventilation, encouraging healthy habits, and providing education on xylene risks, are recommended to enhance worker safety and minimize neurotoxic health impacts in this population.

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Authors' Contributions

All authors contributed to data analysis, article preparation, and revision and collectively assumed reasonability for all aspects of this work.

Conflict of Interest

The authors declare that there is no conflict of interest in this study.

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