Relationship between Benzene Concentrations with Erythrocyte, Hemoglobin, and Health Complaints of Workers in Surabaya Printing Industry

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Abstract

Printing industry uses a lot of raw materials that contain benzene in the production process. Exposure to benzene can cause haematological effects that affect the production of blood cells. The purpose of this study was to determine the relationship between benzene concentrations with erythrocytes, hemoglobin, and health complaints among workers in Surabaya Printing Industry. This research was conducted in Printing X Surabaya. This research is observational, quantitative approach, and cross-sectional. The respondents in this study were 19 people. The variables studied were the concentration of benzene in the air, erythrocytes, hemoglobin, and health complaints among workers at Printing X Surabaya. Data analysis using Spearman rank correlation test. Measurement of the concentration of benzene in the air exceeds the Threshold Limit Value. There were 5 respondents had erythrocyte level above the normal and 1 respondent had hemoglobin level below the normal. There was a quite significant and positive relationship between the concentration of benzene in the air and erythrocytes (p=0.033). But there was no significant relationship between the concentration of benzene in the air and hemoglobin (p=0.158). Health complaints experienced by workers in Printing X Surabaya included coughing, headaches, and shortness of breath. There is a fairly strong relationship between benzene concentrations and erythrocytes but there is no relationship between benzene concentration and hemoglobin.

Keywords: *Benzene, erythrocytes, hemoglobin, health complaints, printing*

Introduction

Printing industry is one of the industries that in the production process uses many raw materials such as ink, solvents, and cleaning agents. These raw materials contain substances that can interfere with the health of workers, one of which is benzene. Benzene is a colorless liquid with a sweet aroma. It can evaporate very quickly, is slightly soluble in water, and flammable. In addition, it has lipophilic property that it is a good solvent in ink, paint, glue, and thinner. Steam or gas from benzene-containing materials such as paint, glue, furniture wax can be a source of exposure for workers in the workplace. Workers who have the possibility of

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being exposed to benzene include printing workers, rubber workers, shoe makers, laboratory technicians, firefighters, and gas station workers[2]. According to the Regulation of the Minister of Manpower of the Republic of Indonesia Number 5 of 2018, benzene is categorized as A-1 category, which is proven to be a carcinogen for humans[15]. The Environmental Protection Agency (EPA) classifies benzene as a known human carcinogen for all routes of exposure namely inhalation, ingestion, and skin[2].

In Indonesia, the benzene TLV in the environment is 0.5 ppm and the permitted short exposure (PSD) of benzene is 2.5 ppm[15]. ACGIH regulates the benzene TLV in the air to be 0.5 ppm[1]. NIOSH stipulates that benzene exposure at work for 8 working hours per day and 40 hours per week is 0.1 ppm[12]. A research conducted by Nikmah in the Semarang X printing industry shows that the results of the measurement of benzene level in the environment exceeded the exposure limit set by NIOSH by 0.132 ppm[11].

Benzene can enter the body through the respiratory tract, digestive tract, and skin. At high concentrations, approximately half of the benzene that is inhaled enters the lungs, then enters the bloodstream and spreads throughout the body[2]. Benzene can cause cells to not work properly. The severity caused by benzene exposure depends on the amount/concentration, route of exposure, length of time of exposure, age, and preexisting medical conditions of the person exposed. Long-term exposure to benzene has a major effect on blood. Benzene causes harmful effects on the bone marrow and can cause a decrease in erythrocytes which can lead to anemia. Benzene can also cause excessive bleeding, affect the immune system, increase the chance of infection and cause leukemia[4].

Workers exposed to high levels of benzene vapor in the printing industry exhibit severe haematological system effects[2]. Research conducted by Parinduri in the printing industry in Medan, North Sumatra found that the reduction in hemoglobin levels was affected by the length of exposure and length of service among printing industry workers[14].

Setiowati in his research got the result that the most common health complaints experienced by workers exposed to benzene were the nervous system and haematological complaints. Complaints of the nervous system that are often experienced include pain in the feet, hands, shoulders and dizziness. Haematological complaints that are often felt by workers are easily tired and sleepy[16]. Research by Yuniati showed that most workers who were exposed to benzene complained of dermatitis[20].

The purpose of this study was to determine the relationship between benzene concentrations with erythrocytes, hemoglobin, and health complaints among workers in Surabaya Printing Industry.

Materials and Methods

This research is observational, quantitative approach, and cross-sectional. The research was conducted in December 2019 at Printing X Surabaya. Respondents in this study used a population of workers in Printing X Surabaya with a total 19 people. The variables to be examined are the concentration of benzene in the air, erythrocytes, hemoglobin, and worker health complaints. Respondent characteristic data including age, sex, and years of service were taken using a questionnaire. The concentration of benzene in the air was measured using the NIOSH 1501 method with the gas chromatography technique carried out by the Technical Implementation Unit for Occupational Safety and Health (UPTK3) Surabaya. Erythrocytes and hemoglobin measurements were carried out by taking a sample of the respondent's blood and then analyzing it at the Nutrition Laboratory of Airlangga University. Data analysis using the Spearman rank correlation test.

Result

Characteristics of Respondents

Table 1. Frequency Distribution of Worker's Characteristics

Respondents Characteristics	Frequency	Percentage
Age (year)		
16-25	2	10,5%
26-35	4	21,1%
36-45	8	42,1%
46-55	3	15,8%
56-65	2	10,5%
Gender		
Male	15	78,9%
Female	4	21,1%
Years of Service		
< 10 years	10	52,6%
≥ 10 years	9	47,4%

Table 1 shows that the majority of workers in Printing X Surabaya were 36-45 years old (42.1%), were male (78.9%) and had a working period of <10 years (52.6%).

Benzene concentration

Table 2. Distribution of Benzene Concentrations in Printing X Surabaya

Respondent	Benzene Concentration (ppm)	Benzene TLV (Permenaker RI No. 5 / 2018)
1	15,6418	0,5 ppm
2	1,9267	
3	15,6418	
4	15,6418	
5	1,9267	
6	15,6418	
7	0,9695	
8	0,9695	
9	15,6418	
10	15,6418	
11	1,9267	
12	1,9267	
13	15,6418	
14	15,6418	
15	1,9267	
16	1,9267	
17	1,9267	
18	1,9267	
19	15,6418	

Table 2 shows the measurement of benzene concentration in the air at Printing X Surabaya was carried out at three points with the highest concentration of benzene being 15.6418 ppm. The results of measurements of the concentration of benzene in the air show that the concentration of benzene in the air at work has exceeded the TLV set by Permenakertrans No. 5 of 2018 at 0.5 ppm.

Erythrocyte and Hemoglobin Levels

Table 3. Erythrocyte and Hemoglobin Levels of Printing Workers X Surabaya

Respondent	Erythrocytes (106/mL)	Haemoglobin (g/dL)
1	6,09	16,3
2	5,31	15,3
3	5,52	15,0
4	5,60	16,2
5	4,57	12,4
6	5,65	16,2
7	5,37	15,1
8	5,16	16,7
9	5,64	16,9
10	5,02	15,4
11	4,20	12,0
12	5,28	15,8
13	4,91	15,0
14	5,40	15,2
15	5,57	16,0
16	5,50	13,6
17	4,98	14,0
18	4,92	13,6
19	5,84	16,4

Table 3 shows that the majority of erythrocyte levels and hemoglobin level of Printing X Surabaya workers are normal. But there are five respondents with erythrocyte levels above normal and one respondent with a hemoglobin level below normal. There is one respondent with a minimum level of normal hemoglobin. Normal erythrocyte level in men is $4.4x10^6$ - $5.6x10^6$ cells/mm^3 and in women is $3.8x10^6$ - $5.0x10^6$ cells/mm^3. Normal hemoglobin levels in men are 13-18 gr/dL and in women is 12-16 gr/dL[7].

Relationship between Benzene Concentration, Erythrocyte and Hemoglobin

Table 4. Test Results for Benzene Concentration, Erythrocyte and Hemoglobin

Independent Variable	Dependent Variable	P value	Correlation coefficient	N
The concentration of benzene in the air	Erythrocytes	0,033	0,490	19
	Hemoglobin	0,158	0,338	19

The relationship between benzene concentration, erythrocyte and hemoglobin was obtained through the Spearman rank test. Table 4 shows that there is a significant relationship between the concentration of benzene in the air and erythrocytes ($p=0.033$; $p<0.05$) with a correlation coefficient of 0.490, which means the relationship between the two variables is quite strong and has a positive direction. There was no significant relationship between the concentration of benzene in the air and hemoglobin ($p=0.158$; $p>0.05$).

Health Complaints

Table 5. Health Complaints Experienced by Printing X Workers in Surabaya

Health Complaints	Total	Percentage
Headache	12	63,2%
Tottering	1	5,3%
Out of breath	5	26,3%
Cough	14	73,7%
Low Appetite	1	5,3%
Sore eyes	2	10,5%
High tempered	1	5,3%
Nausea	2	10,5%
Itchy skin	1	5,3%

Table 5 shows that the most common health complaints experienced by workers were coughing (73.7%), headache (63.2%), and shortness of breath (26.3%).

Discussion

Measurement of the concentration of benzene in the air at Surabaya Printing X was carried out at three points with the highest benzene concentration was 15.6418 ppm and the lowest concentration was 0.9695 ppm. The benzene threshold value (TLV) in the environment determined by Permenaker Number 5 of 2018 is 0.5 ppm[15]. Thus the concentration of benzene in the air at Surabaya X Printing has exceeded the specified TLV. Another research conducted by Setiowati shows that the production room for making sandals has levels of benzene in the air that exceeds TLV that is equal to 2.97 ppm[16]. Other studies have found that there are 2 measurement points where the concentration of benzene in the air exceeds TLV that is equal to 0.9129 ppm and 2.333 ppm[18]. The results of measurements of benzene

concentrations in the air at Printing X Surabaya have a higher average than the two studies.

Exposure to benzene can result cells in the body not working normally. The severity of the effects of benzene exposure depends on several factors including the amount of exposure, the route of exposure, duration of exposure, age, and pre-existing health conditions in exposed people[4]. As many as 52.6% of workers had ten years of service <10 years and 47.4% of workers had ≥ 10 years of service. The longest working period is 24 years while the shortest working period is 1 year. Prolonged work period can be a risk factor for health effects due to benzene exposure. According to the results of research by Triyadi, the duration of work (years) can increase the level of risk due to benzene exposure. The longer the duration of work, the greater the health risk due to benzene exposure[17]. Other studies have also found that there is a significant relationship between the length of work experience (years) and the effect of benzene on the peripheral blood of exposed workers. The longer the duration of work, the higher the effect of benzene exposure on the blood[10].

The majority of the effects of long-term benzene exposure (exposure to benzene for a year or more) occur in the blood[4]. Some more recent epidemiological studies have shown haematological effects (including significant reductions in the number of erythrocytes, leukocytes, and platelets) in workers who are chronically exposed to benzene with concentrations below 10 ppm and even as low as 1 ppm or less[2]. The results of blood tests showed that there were 5 out of 19 respondents in Printing X Surabaya who had erythrocyte level above the normal. The results of the examination of erythrocyte levels differed in studies conducted by Lazarevic that there was a decrease in erythrocyte levels in workers exposed to benzene[3]. This difference in results can be due to different individual characteristics, different research sites, and different sources of benzene exposure. But the results of erythrocyte levels both in this study and Lazarevic's research showed abnormalities in the body's erythrocyte levels. This health condition needs to be considered in order to be able to prevent the appearance of haematological effects caused by benzene exposure.

The results of blood tests also showed that 18 workers had normal hemoglobin levels. Although the majority is normal, one respondent has a hemoglobin level below normal and 1 other respondent has a minimum hemoglobin level normal. Similar examination results for hemoglobin levels were found in Tualeka's study that 95% of respondents had normal hemoglobin levels[18]. In addition, Nikmah in her research explained that although the results of examining blood profiles (hemoglobin, erythrocytes, leukocytes, platelets, hematocrit, MCV, MCH, and MCHC) workers in the Printing X industry in Semarang City were still in the normal category, but the numbers tended to be low or close to lower limit of normal standards[11].

The test results of the relationship between the concentration of benzene and erythrocyte showed that there was a significant relationship between the concentration of benzene in the air with erythrocytes with p=0.033. This relationship is quite strong and has a positive direction, which means that the higher levels of benzene in the air, the higher the level of erythrocytes. The results of this study are in line with the results of Haen's research that there is a relationship between the concentration of benzene in the breathing zone with the number of erythrocytes[6]. Mohamed's research to assess the haematological effects on benzene exposure stated that there were significant differences in the levels of erythrocytes and leukocytes between the benzene and non-exposed groups. Erythrocyte and leukocyte levels decreased in the group exposed to benzene[10]. The direction of the relationship in Mohamed's research results is not in line with this study where a positive direction relationship was found which means that the level of erythrocytes has increased along with the higher levels of benzene in the air. Benzene can interfere with the system in the bone marrow so that the process of blood formation cannot work normally[4]. Hemoglobin is a protein used by red blood cells to distribute oxygen to other tissues and cells in the body[9]. Low hemoglobin levels cause anemia while high hemoglobin levels will cause erythrocytosis as a result of too many red blood cells[19].

There was no significant relationship between the concentration of benzene in the air and hemoglobin with p=0.158. The results of this relationship test are in line with a research in Printing X, Semarang that there was no significant correlation between benzene exposure and hemoglobin[11]. Mohamed in his research explained that

there was no difference in hemoglobin levels between the benzene exposed group and the unexposed group[10].

Printing X Surabaya workers experienced several health complaints including cough (73.7%), headache (63.2%) and shortness of breath (26.3%). Similar health complaints were also found in a study at Printing X in Semarang City in 2017, that one of the health complaints experienced by workers is a headache[5]. Other studies have found that there are a number of workers who experience health complaints such as headaches, nausea, and shortness of breath[13]. According to the CDC, individuals who inhale benzene in high levels can experience signs and symptoms such as drowsiness, dizziness, rapid and irregular heartbeat, headaches, tremors, confusion, unconsciousness, and even death (at very high levels). The exposure of benzene that occurs directly to the eyes, skin, or lungs can cause injury to the tissues and irritation[4]. According to the Leukemia & Lymphoma Society, symptoms of Polycythemia or erythrocytosis include headaches, dizziness or vertigo, excessive sweating, impaired vision, fatigue, and prutitus or itching of the skin[8]. Worker health complaints are signs that benzene exposure is starting to have an effect on health.

Conclusion

The concentration of benzene in the air at Surabaya X Printing has exceeded the TLV set by Pemenakertrans No. 5 of 2018. The majority of Surabaya Printing X workers have erythrocyte levels and hemoglobin levels that are classified as normal. There are 5 respondents with erythrocyte levels above normal and one respondent has hemoglobin levels below normal. There is a significant relationship between benzene concentration and erythrocytes. The two variables are strongly related and in the same direction the higher the levels of benzene, the higher the level of erythrocytes. There is no significant relationship between benzene concentration and hemoglobin. Many health complaints experienced by workers in this study included coughing, headaches and shortness of breath.

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