Correlation of Safe Benzene Duration (Hours/Day) and Blood Profile (Leukocytes, Hematocrit, Hemoglobin) in the Osowilangun Shoe Home Industry

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Abstract

Introduction: Benzene is a volatile organic solvent that easily enters the body when inhaled. Continuous exposure to benzene can cause interference with blood profiles such as leukocytes, hematocrit and hemoglobin. The Threshold Limit Value for benzene exposure is 8 hours /day, but the safe duration in each person is different in hours / day. One industry that uses benzene solvent is the home shoe industry in Osowilangun, Surabaya. The purpose of this study was to determine the relationship between the safe duration of benzene (t_E) in hours / day with blood profiles (leukocytes, hematocrit and hemoglobin).

Methods: This research was conducted at the Osowilangun shoe industry in Surabaya. This research is observational using bivariate analysis using Pearson correlation test. The population in this study amounted to 38 people and used accidental sampling method with 12 samples. The variables studied included the safe duration of toluene (hours/day) and blood profile (leukocytes, hematocrit and hemoglobin).

Result: The average safe duration (t_E) of workers in the Osiwilangun shoe industry in hours / days is 0.0418. The majority of blood profiles (leukocytes, hematocrit and hemoglobin) are normal. Through Pearson correlation, the safe duration (hours/day) of benzene are leukocyte levels (p = 0.933), hematocrit levels (p = 0.119) and hemoglobin levels (p = 0,000).

Conclusion : There was no significant relationship between safe duration (hours/day) of benzene with leukocyte and hematocrit levels. However, there was a significant relationship between safe duration (hours/day) of benzene and hemoglobin levels.

Key words: *Hemoglobin, Leukocyte, Hematocrit, Safe Duration, Benzene*

Introduction

One of the fast growing informal shoe industries in Surabaya is located in the Osowilangun area. A total of 40% of Indonesian shoe exports are sent to the United States market, while 33% are sent to Europe and the rest are exported to African countries, the Middle East and South America. Despite a decline in exports due to the economic crisis, shoe production remains one of the main industries in Indonesia[1]. Every year there are more than 250 million accidents at work and more than 160 million workers become sick because of hazards at

work. In addition, 1.2 million workers died as a result of accidents and illness at work[2]. In the process of making shoes, there are several stages in the shoe production process. One of the steps in the shoe making process is the process of installing the upper part of the shoe and the bottom of the shoe using glue. The glue used contains hazardous chemicals that can affect health. One of the dangerous chemicals in glue is benzene.

Benzene is an organic solvent that is very volatile and is toxic. The impact of chronic benzene exposure is damage to the hematopoiesis system in the bone marrow. The impact of this bone marrow damage is a progressive decrease in the number of blood cell elements[3]. The results of research that states that there is a decrease in hematological parameters (total white blood cells, red blood cells, platelets, and hematocrit) during workers exposed to benzene that exceeds normal limits[4]. China, the largest shoe manufacturer in the world, reported that there were health problems due to benzene exposure. This study shows that workers exposed to benzene were more at risk of death from leukemia with a relative risk of 2.3 compared to those who are not exposed to benzene[5].

The chemicals that are in the glue during the shoe-making process are a risk hazard. In the process there is exposure to organic solvent vapor contained in the glue and is very likely to have an impact on health if inhaled (Lu, 2006). The path of exposure can show differences in the way to enter the body. The benzene exposure pathway can be through the respiratory tract, digestive tract and through the skin. Benzene entering through the respiratory tract and skin is a major concern with several exposure scenarios[6]. Exposure to benzene with low concentrations and in a long time continuously can cause interference with the formation of blood cells such as decreased red blood cells, white blood, platelets which can cause blood cancer (leukemia). Organic solvent vapors that enter the human body can cause a variety of reactions, such as mild irritation, addiction, kidney disorders, pulmonary odema reactions to disorders of the central nervous system[7]. Exposure to benzene in the body can result in damage to the bone marrow so as to make the production of blood cells disrupted, including disrupting the function of hemoglobin in the body, thus hemoglobin level in the blood will decrease[8].

To see the high content of organic solvents in the form of benzene contained in the glue used, an analysis of benzene exposure to blood profiles is needed. Benzene levels in the blood can be used to assess low exposure to benzene as a sensitive method. However, this method also has technical constraints i.e reduced levels due to volatile benzene and contamination in sampling. A trial conducted by Brugnone et al (1992) the half-life of benzene in the blood is estimated to be 8 hours[9]. The amount of exposure allowed by the NIOSH (National Institute for Occupational Health and Safety) for 8 working hours is only 0.1 ppm for benzene. In Indonesia the Minister of Health Regulation No. 70 of 2016 concerning the Standards for Industrial Health Environmental Requirements stipulates that the threshold value of benzene in the air is 0.5 ppm[10].

Materials and Methods

This is an observational study with no special treatment given to respondents. This research was conducted at the shoe home industry in Osowilangun, Surabaya, which uses benzene as a solvent in its production process. The population in this study were all 38 workers exposed to benzene in the home shoe industry in Osowilangun, Surabaya. The research sample was taken using the accidental sampling method for 12 respondents. The variables studied in this study were safe duration (t_E) and blood profile (hemoglobin, hematocrit, leukocytes). Analysis of the data used is bivariate analysis using Pearson correlation test. To find out the safe duration in hours per day of benzene exposure in certain concentrations, the following formula is used[1].

$$t_E\ (jam/hari) = \frac{W_b \times t_{avg} \times \mathrm{RfC}}{\mathrm{C} \times \mathrm{R} \times f_E \times D_t}$$

t_E = safe daily exposure time (safe duration (hours / day))

W_b = weight (kg)

T_{avg} = average time period (30 years × 365 day/year)

RfC= benzene reference concentration = 0,03 mg/ m^3

C = concentration of risk agent (mg/m3)

R = concentration of risk agent (mg / m3)

f_E = annual exposure frequency (day/year)

D_t = duration of exposure (years)

The safe duration of benzene is obtained through calculations proposed by Tualeka (2015). Data on the characteristics of respondents such as age, sex and education level were taken through 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 Work Safety and Health Technical Implementation Unit (UPTK3) Surabaya. Blood samples are taken by doctors who are experts in their fields and then analyzed in the Nutrition Laboratory of Airlangga University.

Result

Distribution of Characteristics of Respondents to Workers Exposed to Benzene

Respondent characteristics include age, sex, level of education, and work area. The following is a distribution table of the characteristics of workers exposed to Benzene in shoe home industry.

Table 1. Distribution of Characteristics of Workers Exposed to Benzene

Characteristics of Workers	Frequency	Percentage
Age		
16-25	1	0,083%
26-35	0	0%
36-45	4	0,33%
46-55	3	0,25%
56-65	4	0,33%
Gender		
Male	6	50%
Female	6	50%
Level of Education		
Primary	1	0,083%
Junior High	5	0,42%
Senior High	6	50%

Source: primary data

Based on table 1, most industrial workers are aged 36-45 years (0.33%) with male and female sexes having the same percentage and level of education and most are high school (50%).

Safe Duration (t_E)

Table 2. Distribution of Safe Duration of Benzene Exposed Workers

No. Res	Wb (kg)	Tavg	RfC (mg/kg/hari)	C (ppm)	C (mg/m3)	R (m3/hour)	fE (day/year)	Dt (year)	tE safe (hour/day)
1.	60	10950	0.0003	0.4	0.000308	0.62	364	25	0.0283
2.	100	10950	0.0002	0.2	0.000219	0.73	364	15	0.0943
3.	55	10950	0.0003	19.40	0.000326	0.60	312	10	0.0017
4.	69	10950	0.0002	19.40	0.000282	0.65	312	25	0.0007
5.	41	10950	0.0003	8.50	0.000390	0.53	312	22	0.0017
6.	46	10950	0.0003	0.06	0.000364	0.56	364	30	0.1572
7.	84	10950	0.0002	53.80	0.000247	0.69	364	20	0.0002
8.	53	10950	0.0003	0.40	0.000334	0.59	312	25	0.033
9.	70	10950	0.0002	8.50	0.000279	0.65	364	7	0.0047
10.	65	10950	0.0002	0.20	0.000308	0.62	364	30	0.0471
11.	75	10950	0.0003	0.20	0.000293	0.63	360	17	0.1165
12.	55	10950	0.0003	0.20	0.000326	0.60	364	40	0.0177

Based on table the highest concentration of benzene in the air is 53.8 ppm and the lowest is 0.06 ppm with an average value of 9.2 ppm.

$t_E\ (jam/hari) = \frac{W_b \times t_{avg} \times \text{RfC}}{\text{C} \times \text{R} \times f_E \times D_t}$ the safe duration in hours / day using the following formula.

Based on the calculation of safe duration in hours/day the highest is 0.1572 hours and the lowest is 0.0002 hours. The average safe duration in hours/day is 0.0418.

Blood Profile

Table 3. Blood Profile of Workers Exposed to Benzene

Blood Profile	Frequency	Percent	Average
Leukocytes (103/ µL)			
Abnormal	1	0,083%	8425
Normal	11	0,92%	
Hematocrit (%)			
Abnormal	2	0,17%	41.76
Normal	10	0,83%	
Hemoglobin (gr/dL)			
Abnormal	1	0,083%	15.81
Normal	11	0,92%	

The blood profile examined in this study included the number of leukocytes, hemoglobin and hematocrit. This is then compared with the existing TLV and is categorized into 2 types ie not normal and normal. Normal leukocyte counts generally range from 3200 - 10,000 / mm3 or 3.2 - 10.0 x 109 / L. The normal amount of hemoglobin in women is 12-16 gr/dL and in men 13-18 gr / dL. For the normal amount of hematocrit ranges from 32-36 gr/ dL[12]. Based on the table, the majority of workers have leukocyte, hemoglobin and hematocrit levels under normal conditions. In sum, the average value of workers blood profiles is in normal category.

Correlation of Safe Benzene Duration and Blood Profile

Table 4. Statistical Test Results of Safe Benzene Duration and Blood Profile

Variables	P-Value	Correlation coefficient	N
t_E Benzene	0,933	-0,027	12
Leukocytes			
t_E Benzene	0,119	-0,474	12
Hematocrit			
t_E Benzene	0,000	-0,975	12
Hemoglobin			

Based on the statistical test results in table 6, there is no significant relationship between the safe duration (t_E) of benzene and leukocytes, hematocrit in workers in the home shoe industry with a p value> 0.05. Whereas in the benzene safe duration (t_E) statistical test with hemoglobin there was a significant relationship in workers in the home shoe industry with a p value <0.05.

Discussion

Based on the results of the study, the highest concentration of benzene in the air was 53.8 ppm and the lowest was 0.06 ppm with an average value of 9.2 ppm. Regulation of the Minister of Health of the Republic of Indonesia Number 70 Year 2016 regarding the Standards for Health Standards for the Industry Work Environment states that benzene has a TLV TWA of 0.5 ppm[16]. Based on the measurement results there are 5 measurement points that have benzene levels above TLV that exceed 0.5 ppm. The results of the average measurement of the concentration of benzene are higher when compared to other studies which state that the average concentration of benzene in the breathing zone of respondents (sol workers) within the safe limit below TLV is 0.238 ppm[13]. Other research also shows that the measurement results of benzene concentration in the Semarang City X Printing Industry are below the quality standard with the average concentration of inhaled benzene being 0.422 mg / m3 or 0.13 ppm[14]. This is still below average as compared to research conducted in the Home Shoe Industry.

Based on the results of the study there was no significant relationship between the safe duration (t_E) of benzene, the number of erythrocytes and hematocrit in workers with a p value> 0.05. However, there was a significant relationship between safe duration (t_E) of benzene and hemoglobin levels in workers with a p value <0.05. The results also showed that there was no dose effect on response to most of the hematologic parameters examined. Another study in the printing industry X in Semarang city concluded that there was no significant relationship between benzene exposure and levels of erythrocytes, leukocytes, platelets, hematocrit, MCH and MCHC among workers with a value of p> 0.05. This is possible because the level of benzene exposure experienced by workers is in a mild level, with an average benzene level of 0.132 ppm (SD ± 0.1742) and an average duration of exposure for 7.5 years (SD ± 6.642)[15]. Other related research is the level of benzene with acute exposure in humans with a duration of 1 day with a time of 5-10 minutes with exposure up to 20,000 ppm can cause death, for a duration of 1-21 days with a time of 2.5–8 hours / day with exposure to 60 ppm can cause respiratory system disorders such as mucus, membrane irritation and dyspnea), haematological system disorders such as leukopenia, anemia, thrombocytopenia, increased MCV, and disorders of the skin system[16]. When an increase in the safe duration of benzene (hours / day) there is also an increase in blood profile levels. However, there are several aspects that can influence the increase in blood profile when there is an increase in exposure to safe duration of benzene such as equipping workers with PPE (Personal Protective Equipment), nutritious supplementary feeding, adequate ventilation, smoking habits, and personal hygiene[17]. This is also in line with other studies which state that there are other factors such as length of work, nutritional status and others that cause no relationship with blood profile[18]. According to Minister of Health Regulation R1 No. 1077/ MENKES/PER/ 2011 concerning guidelines for indoor air sanitation, good ventilation is to meet the criteria for ventilation area> 10% of workplace floor area[19].

Conclusion

There are 5 measurement points with benzene content above TLV (0.5 ppm) and there are 7 measurement points with benzene content below TLV. The results of the mean benzene levels are above the TLV that has been set by ACGIH. A total of 41.67% of workers are in locations with Benzene concentrations above the threshold value. The majority of workers had leukocyte, hematocrit and hemoglobin levels in the normal category. There was no significant relationship between benzene safe duration (t_E) with leukocyte and hematocrit levels in workers with a p value> 0.05. There was a significant relationship between safe duration (t_E) of benzene and hemoglobin levels in workers with a p value <0.05.

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