Correlation of Toluene Safe Duration (Hours/Day) and Glutathione Concentration, Malondialdehyde and Neurotoxic Symptoms in Osowilangun Shoe Home Industry Workers

Diah Pramesthi Ningrum[1], Abdul Rohim Tualeka[2], Juliana Jalaludin[3], Syamsiar S Russeng[4], Pudji Rahmawati[5], Ahsan Ahsan[6], Indri H Susilowati[7]

[1]Research Scholar, [2]Professor, Department of Occupational Health and Safety, Public Health Faculty, Airlangga University, 60115, Surabaya, East Java, Indonesia, [3]Professor, Department of Environmental and Occupational Health, Faculty of Medicine and Health Sciences, University Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia, [4]Professor, Department of Occupational Health and Safety, Faculty of Public Health, Hassanudin University, Makassar, Indonesia,[5]Professor, Department of Development of Islamic Society, State Islamic University Sunan Ampel, Surabaya, Indonesia [6] Professor, Public Health Faculty, University of Indonesia, Depok, Indonesia, [7] Professor, Faculty of Nurse, Brawijaya University, Malang, Indonesia

Abstract

Introduction: Exposure of toluene can cause a decrease in glutathione concentration, increase in malondialdehyde and neurotoxic symptoms. The safe duration of toluene in hours/day for each person can vary. The purpose of this study is to determine the relationship between the safe duration of toluene (hours/day) with the concentration of glutathione, malondialdehyde and neurotoxic symptoms in Osowilangun shoe home industry workers.

Methods: This research was observational with quantitative approach and cross-sectional design. The sampling technique used was accidental sampling with 25 respondents. The variables studied were safe toluene duration (hours/day), glutathione concentration, malondialdehyde concentration, and neurotoxic symptoms. Data were analyzed using Pearson and Phi correlation.

Result: The average of safe duration was 1,489 hours/day, glutathione concentration was 58,349 µg/L, and malondialdehyde was 7,847 MU. As many as 11 out of 14 workers experienced neurotoxic symptoms. The relationship between safe duration (hours/day) with glutathione concentration (r=0.139) and malondialdehyde (r=-0.146) was very weak. While, the relationship between safe duration (hours/day) and neurotoxic symptoms was weak (φ=-0.223).

Conclusion: The relationship between safe duration in hours/day with glutathione concentration and malondialdehyde was very weak, while relationship with neurotoxic symptoms was weak.

***Key words**: Neurotoxic Symptoms, Glutathione, Safe Concentration, Malondialdehyde, Toluene*

Introduction

Toluene is a colorless liquid and a good solvent. Toluene can evaporate into the surrounding air and be inhaled by people who work using products containing toluene[1]. The toluene threshold at work is 20 parts/million for 8 hours/day or 40 hours/week. With this dose and duration, almost all people who are exposed do not suffer side effects from toluene[2].

When toluene enters and is distributed throughout the body, toluene is metabolized through enzymatic pathways. If too much amount of toluene enters the body, dangerous toluene epoxide is formed. However,

Corresponding author:
Abdul Rohim Tualeka, Department of Occupational Health and Safety, Public Health Faculty, Airlangga University, 60115, Surabaya, East Java, Indonesia; abdul-r-t@fkm.unair.ac.id; +6281333519732

there is enzyme glutathione that can react with toluene epoxide and form substances that are not harmful to the body.

Toluene epoxide is very reactive and is a free radical[1]. Free radicals can cause lipid peroxidation chain reactions and produce lipid hydroperoxides that are unstable and easily break down into secondary products such as aldehydes and malondialdehydes. Malondialdehyde is then used as a marker of cell or tissue damage due to oxidative stress[3].

Organic solvents can change the lipid structure of cell membranes. This causes the disruption of the mechanism of synaptic membrane transportation and intercellular transportation[4]. Neurological disorders at work due to exposure to organic solvents can cause psycho-organic symptoms such as depression, abnormal emotions, low alertness, memory problems, and decreased mental efficiency[5].

The duration of exposure in one day can greatly affect the health of workers[6]. The duration of exposure is directly proportional to the pollutants that enter the worker's body. Therefore, the longer a person works, the more pollutants are absorbed into his body[7]. So, the concentration of glutathione, malondialdehyde and neurotoxic symptoms that occur due to toluene exposure can be influenced by the duration of daily toluene exposure.

The purpose of this study was to determine the relationship between the safe duration of toluene in hours/day with the concentration of glutathione, malondialdehyde, and neurotoxic symptoms that occur in workers in the Osowilangun Shoe Home Industry.

Materials and Methods

This research was observational used a quantitative approach and cross-sectional design. The population in this study was 38 workers in the Osowilangun Shoe Home Industry. Samples were taken using the accidental sampling method resulted 25 respondents. Data was collected in August 2019.

The safe duration of toluene was obtained through calculations with the following formula (Tualeka, 2015).

tE (hours/day)=Wbtavg×RfCC×R×fEDt

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

W_b = weight (kg)

T_{avg}= average time period (30 years×365 days/year) = 10950

RfC= reference concentration of toluene = 5 mg/m^3

= RfC (mg/m3) × R (m3/hari)Wb (kg) = RfC (mg/kg/day)

C = risk agent concentration (mg/m^3)

R = respiration rate (m^3/hour)

= 5,3 × ln(Wb)-6,924

f_E = annual exposure frequency (day/year)

D_t = duration of exposure (years)

Respondent characteristics data including were taken using a questionnaire. The concentration of toluene in the air was measured by the NIOSH 1501 method with the gas chromatography technique, carried out by the Work Safety and Health Technical Implementation Unit Surabaya. Measurement of glutathione and malondialdehyde concentrations was carried out blood analysis at the Nutrition Laboratory of Airlangga University. Neurotoxic symptoms are identified using the German version of the Q18 questionnaire, the respondent will be declared to have neurotoxic symptoms if had ≥5 "Yes" answer[8].

Result and Discussion

Toluene Safe Duration (Hours/Day)

Table 1. Respondent's Safe Duration (hours/day)

Respondent	Wb (kg)	RfC (mg/kg/ hari)	C (ppm)	C (mg/m3)	R (m3/hour)	fE (day/year)	Dt (year)	tE (hour/day)
1.	60	1.233	289.30	1088.004	0.616	364	25	0.133
2.	70	1.115	289.30	1088.004	0.650	208	30	0.193
3.	51	1.366	15.00	56.41224	0.580	312	15	4.977
4.	105	0.845	30.50	114.7049	0.740	364	30	1.049
5.	70	1.115	30.50	114.7049	0.650	312	48	0.765
6.	55	1.303	62.70	235.8032	0.597	312	25	0.714
7.	69	1.126	62.70	235.8032	0.647	312	40	0.446
8.	41	1.558	58.50	220.0078	0.532	312	22	0.870
9.	78	1.037	25.50	95.90082	0.674	364	25	1.506
10.	46	1.455	15.00	56.41224	0.557	364	30	2.133
11.	75	1.065	36.90	138.7741	0.665	364	25	1.040
12.	84	0.987	137.50	517.1122	0.690	364	15	0.465
13.	65	1.171	30.50	114.7049	0.634	312	25	1.469
14.	50	1.383	30.50	95.90082	0.576	364	20	1.882
15.	53	1.334	25.50	1088.004	0.589	364	25	0.133
16.	70	1.115	289.30	220.0078	0.650	312	13	1.472
17.	60	1.233	58.50	34.97559	0.616	312	30	4.014
18.	55	1.303	9.30	95.90082	0.597	364	20	1.882
19.	65	1.171	25.50	114.7049	0.634	312	25	1.469
20.	46	1.455	30.50	235.8032	0.557	260	5	4.286
21.	85	0.979	62.70	517.1122	0.693	364	20	0.349
22.	68	1.137	137.50	154.5696	0.644	364	30	0.778
23.	55	1.303	41.10	517.1122	0.597	364	6	1.163
24.	78	1.037	137.50	36.47992	0.674	364	25	3.958
25.	55	1.303	9.70	1088.004	0.597	364	40	0.083
Average								1.489

The average safe duration in hours/day for Osowilangun shoe home industry workers was 1,489 hours. ACGIH (2019) recommends a toluene threshold value of 20 ppm, for 8 hours/day or 40 hours/week. The safe duration of toluene in the Osowilangun shoe home industry does not reach 8 hours even though not all places have a toluene concentration of more than 20 ppm. This is in accordance with Scheepers research entitled Assessment of Exposure of Gas Station Attendants in Sri Lanka to Benzene, Toluene and Xylene (BTX) with a reduction in work duration to 40 hours/week can reduce BTX concentrations in workers' blood to safe limits[9]. Repeated toluene exposure can cause cognitive impairment in mice[10].

Glutathione Concentration

Table 2. Respondent's Glutathione Concentration, Malondialdehyde Concentration, and Neurotoxic Symptoms

Respondent	Glutathione concentration (µg/L)	Malondialdehyde concentration (MU)	Neurotoxic Symptoms
1.	14.600	11.857	Yes
2.	40.850	5.423	Yes
3.	40.583	6.277	No
4.	58.349	3.817	Yes
5.	49.790	4.543	Yes
6.	49.257	4.603	No
7.	46.176	4.717	No
8.	19.812	11.683	Yes
9.	27.873	10.023	No
10.	40.241	6.497	No
11.	45.453	4.737	Yes
12.	28.067	9.670	Yes
13.	34.383	8.683	No
14.	35.942	7.643	No
15.	30.578	9.317	No
16.	34.357	8.923	Yes
17.	31.415	9.177	No
18.	26.622	10.323	Yes
19.	26.356	10.843	No
20.	38.719	7.363	No
21.	39.937	7.203	No
22.	24.796	11.030	Yes
23.	43.969	5.017	No
24.	41.420	5.283	Yes
25.	21.829	11.517	No
Average	35.655	7.847	

Based on table 2, the average glutathione concentration in the Osowilangun shoe home industry workers was 35,655 µg/L. Glutathione is one of the antioxidants produced by the body and often used as a measure to determine the effects of increased free radicals. Glutathione can react with radical substances to form substances that are no longer harmful to the body[11]. Lack of glutathione causes a high risk of oxidative damage[12]. Exposure to harmful chemicals can reduce the amount of glutathione in the body[13]. The longer exposure to free radicals, the free radicals have the potential to accumulate and can reduce the body's glutathione[14].

Malondialdehyde

The average concentration of malondialdehyde of workers in the Osowilangun shoe home industry was 7,847 MU. When there are more free radicals in the body than antioxidants, oxidative stress occurs[3]. The more concentration of malondialdehyde in the body, the more oxidation processes in the cell membrane[15]. If not getting exposure to free radicals, the levels of malondialdehyde in the body become lower because lipid peroxidation in normal conditions can still be overcome by natural antioxidants produced by the body[16]. Therefore, people who get free radical exposure will have higher levels of malondialdehyde in the body compared to people who are not exposed[17].

Neurotoxic Symptoms

Neurotoxic symptoms were determined using a Q18 questionnaire, stated as having neurotoxic symptoms if there were ≥5 answers of "Yes" out of 18 questions. Based on table 2, 11 workers experienced neurotoxic. A study shows that one of the health effects caused by exposure to benzene, toluene and xylene that exceeds the threshold, is central nervous system disorders[18]. However, other studies conducted on workers exposed to toluene in a car painting workshop located in Surabaya show that toluene concentrations that are still below the threshold have been found by workers who show complaints of the central nervous system[19].

Relationship of Toluene Safe Duration (Hours/ Day) and Glutathione Concentration

The association between the safe duration of toluene in hours/day and glutathione concentration was was very weak (r=0.139). When the safe duration of toluene increases, the concentration of glutathione also increases. An increase of safe duration meant the amount of toluene exposure was getting smaller. The results of studies on mice that were exposed to toluene in different time periods showed that the longer the exposure time, the lower the amount of glutathione [20].

Exposure of toluene can cause a decrease in glutathione. Gas station workers with high toluene exposure have lower glutathione concentrations compared to the control group[21,22]. A research conducted in Korea showed that there was a significant relationship between toluene metabolism and glutathione[23]. However, studies conducted on mice given organic solvent for 3 days showed that toluene did not affect the amount of glutathione in the body[24].

Relationship of Toluene Safe Duration (Hours/ Day) and Malondialdehyde

Through the Pearson correlation test, the relationship between the safe duration of toluene in hours/day with malondialdehyde concentrations was very weak and had negative direction (r=-0.146). An increasing of safe duration of toluene in hours/day would decrease the concentration of malondialdehyde. The higher the safe duration of toluene, the less toluene exposure received by the worker. The results of studies on mice that were exposed to toluene in different time periods showed a greater increase in malondialdehyde in mice that were exposed to the same amount of toluene but in a longer period[20].

Research in groups who abuse toluene shows that there is an increase in the concentration of malondialdehyde compared to the control[25]. Workers on gas station who get a lot of exposure to benzene, toluene, and xylene, shows that the average concentration of malondialdehyde in these workers is higher than in the control group[21]. Moreover, workers who inhaled thinner experienced an increase in the concentration of malondialdehyde compared to the control group[26].

Relationship of Toluene Safe Duration (Hours/ Day) and Neurotoxic Symptoms

The relationship between the safe duration of toluene

in hours/days was weak and had a negative direction (φ=-0.223), i.e. an increase in the safe duration in hours/day decreases the likelihood of neurotoxic symptoms. This is consistent with Kang's research which states that higher or longer exposure of toluene can cause not only a decrease in attention and concentration, but also a motorized performance deficit[27]. Millions of workers who are often exposed to organic solvents can be concluded suffering from neurotoxic[28]. However, Pratamasari stated that there was no relationship between exposure to air in toluene and peripheral neuropathy. Body weight, length of work and education are factors of exposure to toluene found[29].

Conclusion

The safe duration of toluene in hours/day for workers in the Osowilangun shoe home industry is very weakly related to the concentration of glutathione and malondialdehyde and is weakly related to neurotoxic symptoms. If there is an increase in the safe duration of toluene in hours/day there will be an increase in glutathione but a decrease in malondialdehyde and a decrease in the possibility of neurotoxic symptoms.

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