

Marganda et al./ The Effect of Toluene Exposure on Central Nervous Disorder

## The Effect of Toluene Exposure on Central Nervous Disorder among Printing Workers

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### ABSTRACT

**Background:** The use of toluene in printing dominates the use of metal chemicals. Toluene is used in 75% of printing work activities. Accumulation of toluene concentrations in printing can cause health problems to workers. The purpose of this study was to analyze the effect of toluene exposure on central nervous system disorders in printing industry workers.

**Subjects and Method:** This study was cross sectional in the printing industry in Medan, North Sumatra. The population consists of 50 people with consecutive sampling technique sampling. Data on subjective symptoms of central nervous system disorders were measured by the German version of the Q18 questionnaire. The data were analyzed using multiple logistic regression tests.

**Results:** Subjective symptoms of central nervous system disorders increased with tenure  $\geq 2$  years (OR = 4.19;  $p = 0.018$ ) and smoking (OR = 8.91;  $p = 0.001$ ). Subjective symptoms of central nervous system disorders decreased with age  $\leq 30$  years (OR = 0.17;  $p = 0.004$ ), female sex (OR = 0.50;  $p = 0.002$ ).

**Conclusions:** The most dominant variable affecting the subjective symptoms of central nervous system disorders is the smoking habit variable with a probability value of 0.92 or 92%.

**Keywords:** subjective symptoms, central nervous system disorders, workers, printing industry

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### BACKGROUND

Organic solvents are widely used in printing activities, in addition to lead, copper, and other metals. The organic solvent used is toluene. Toluene ( $C_6H_5CH_3$ ) is a non-corrosive folateil liquid that has a smell like benzene. Workers who use toluene as a solvent cause health problems, such as dizziness, vertigo, eye irritation, skin irritation, respiratory, liver, kidney, and central nervous system disorders (Agency for Toxic Substances and Disease Registry, 2000). The use of toluene in printing dominates the use of metal chemicals. Toluene is used in 75% of printing

work activities. The biggest use of toluene is in automatic cleaning, which is around 50-200 ppm (Svendsen and Rognes, 2000). Toluene is declared safe for the environment and health if it does not cross the threshold. The toluene threshold in the environment is around 50 ppm (American Conference of Industrial Hygienists, 2005). According to Ministerial Regulation No. PER.13/MEN/X/ 2011, the toluene threshold value is 188  $mg/m^3$ .

Nervous disorders due to toluene exposure consist of two types, neurotoxic and neuropathy. The prevalence of neuropathy due to exposure to organic solvents

is greater than neurotoxic. Ropper (2000) defines neuropathy as a clinical symptom due to peripheral nerve abnormalities, extensive non-inflammatory regeneration with symptoms of motor weakness, sensory disorders, autonomic nerves, and weakening of tendon reflexes.

Neuropathy due to toluene exposure that often arises is peripheral nerve neuropathy. Collective peripheral nerve neuropathy is available in 2.4% of the world population (Martyn, 1998). Neuropathic pain is defined as sensory pain or discomfort due to lesions or diseases associated with the somato-sensory nervous system (International Association for the Study of Pain, 2011). The prevalence of neuropathy pain is higher than the prevalence of peripheral nerve neuropathy, which is about 3% of the world's population (Gilron et al., 2006). The presence of peripheral nerve neuropathy and its manifestations (neuropathic pain) in workers disrupts work activities. Offset work is less than optimal. This is compounded by exposure to organic solvents which are the cause of neuropathy.

In Germany, diseases due to chronic exposure to solvents associated with neurotoxic chemicals have been included in the list of occupational diseases since 1997. Because many subjective complaints indicate this disease, early recognition is very important, especially in the workplace with exposure to neurotoxic, sensitive, specific chemicals and practical screening equipment is needed.

Ihrig et al. (2001) concluded that the German version of the Q18 questionnaire was a sensitive and reliable screening questionnaire for complaints related to solvent exposure, but not reliable enough for individual diagnosis. The researcher

also distinguished the questionnaire cut-off point by sex for both men and women. For men, the recommended cut-off point for five or more complaints on the German version of the Q18 questionnaire, while for women, the cut-off point for six or more complaints is recommended as the starting point for further evaluation (Ihrig, et al, 2001). After conducting the initial survey, no workers used masks during work. Of the 6 sample points studied, most experienced several health complaints such as frequent dizziness, sore eyes, disturbances in breathing, and hallucinations.

Based on the description above, the researchers want to conduct a study on the relationship of toluene exposure to subjective symptoms of central nervous system disorders in printing workers in Medan.

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## SUBJECT AND METHOD

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This was an analytic observational study with a cross sectional design. The study was conducted in 6 printing industries in Medan. An examination of ambient air samples for toluene measurements was carried out at the Medan K3 Hall Laboratory.

A sample of 50 workers was selected by consecutive sampling. Data on subjective symptoms of central nervous system disorders were measured using the German version of the Q18 questionnaire.

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## RESULTS

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### 1. Sample Characteristics

Table 1 showed sample characteristics. Table 1 showed that most of the study subjects were at age <30 years (62%) and male gender (76%). As many as 29 workers had tenure less than 2 years. As

many as 70% workers had toluene exposure more than 8 hours/day.

As many as 17 workers (34%) were smokers. A worker (2%) alcohol consumer

and as many as two workers (4%) consumed drugs. As for the use of PPE, there were 43 respondents (86%) who did not use PPE.

**Table 1. Sample Characteristics**

<b>Variables</b>	<b>n = 50</b>	<b>%</b>
<b>Age</b>		
<30 years	31	62
≥30 years	19	38
<b>Gender</b>		
Male	38	76
Female	12	24
<b>Tenure</b>		
≤2 years	29	58
>2 years	21	42
<b>History of Disease</b>		
No	16	32
Yes	34	68
<b>Smoking</b>		
Yes	17	34
No	33	66
<b>Alcohol drink consumption</b>		
Yes	1	2
No	49	98
<b>Drugs use</b>		
Yes	2	4
No	48	96
<b>PPE use behavior</b>		
Yes	43	86
No	7	14
<b>Exposure time</b>		
> 8 hours	35	70
≤ 8 hours	15	30

**Table 2. The Toluene level**

<b>Variable</b>	<b>Mean</b>	<b>SD</b>	<b>Min.</b>	<b>Max.</b>	<b>CI (95%)</b>	<b>p</b>
Toluene level	6.97	13.04	0.019	34.46	3.27-10.68	0.001

## 2. Toluene level

Table 2 described the toluene level in printing industry in Medan. Table 2 showed that the average toluene level was 6.97 mg/m<sup>3</sup> with the lowest level was 0.019 mg/m<sup>3</sup> and the highest level was 34.46 mg/m<sup>3</sup>.

## 3. Subjective Symptoms of Central Nervous System Disorders

Table 3 showed frequency distribution of subjective symptoms of central nervous system disorders among printing workers. Table 3 showed that mostly printing workers did not experience subjective of central nervous system disorders (62%).

**Table 3. Frequency Distribution of Subjective Symptoms of Central Nervous System Disorders among Printing Workers**

Subjective Symptoms of Central Nervous System Disorders	N	%
No	31	62
Yes	19	38

**Table 4. The Results of Chi Square Test**

Independent Variables	Symptoms of CNS Disorders				OR	CI 95%	p
	Positive		Negative				
	n	%	n	%			
<b>Age</b>							
≤30 years old	7	22.6	24	77.43	0.17	0.05 to 0.60	0.004
>30years old	12	63.1	7	6.9			
<b>Gender</b>							
Male	19	50	19	50	0.50	0.36 to 0.69	0.002
Female	0	0	12	100			
<b>Tenure</b>							
> 2 years	12	57.1	9	42.9	4.19	1.25 to 14.09	0.018
≤2 years	7	24.1	22	75.9			
<b>Smoking</b>							
Smoke	12	70.6	5	29.4	8.91	2.34 to 33.91	0.001
Did not smoke	7	21.2	26	78.8			
<b>Alcohol Consumption</b>							
Yes	0	0	1	100	1.63	1.31 to 2.04	0.429
No	19	38.8	30	61.2			
<b>Length of toluene exposure</b>							
> 8 hours/day	15	42.9	20	57.1	2.06	0.55 to 7.77	0.280
≤8 hours/day	4	26.7	11	73.3			
<b>Drug Consumption</b>							
Yes	0	0	2	100	1.66	1.32 to 2.08	0.258
No	19	39.6	29	60.4			
<b>PPE use</b>							
Yes	1	14.3	6	85.7	4.32	0.48 to 39.07	0.163
No	18	41.9	25	58.1			
<b>History of Disease</b>							
Yes	13	38.2	21	61.8	1.03	0.30 to 3.52	0.960
No	6	37.5	10	62.5			

#### 4. Bivariate analysis

Table 4 showed the result of bivariate analysis using Chi square test. Table 4 showed that age <30 years old (OR= 0.17; 95% CI= 0.05 to 0.60; p= 0.004) and gender (OR= 0.50; 95% CI= 0.36 to 0.69;

p= 0.002) decreased the risk of subjective symptoms of central nervous system disorders among printing workers. These relationships were statistically significant.

Tenure >2 years (OR= 4.19; 95% CI= 1.25 to 14.09; p= 0.018) and smoking

(OR= 8.91; 95% CI= 2.34 to 33.91; p= 0.001) increased the risk of subjective symptoms of central nervous system disorders among printing workers.

Alcohol consumption (OR= 1.63; 95% CI= 1.31 to 2.04; p= 0.429), toluene exposure >8 hours/day (OR= 2.06; 95% CI= 0.55 to 7.77; p= 0.280), drug consumption (OR= 1.66; 95% CI= 1.32 to 2.08; p= 0.258), did not use PPE properly (OR= 4.32; 95% CI= 0.48 to 39.07; p= 0.163), and had history of disease (OR= 1.03; 95% CI= 0.30 to 3.52; p= 0.960) increased the risk of subjective symptoms of central nervous system disorders among printing workers, but these rela-

tionships were statistically non-significant.

**5. Multivariate analysis**

Table 5 showed the results of multivariate analysis. Table 5 showed that smoking was positively and statistically significant associated with subjective symptoms of central nervous system disorders among printing workers (b= 5.18; p= 0.042).

Age <30 years old (b= 0.27; p= 0.163), tenure (b= 1.41; p= 0.692), PPE use (b= 0.56; p= 0.737), and length of toluene exposure <8 hours/day (b= 0.32; p= 0.317) were positively and statistically non-significant associated with subjective symptoms of central nervous system disorders among printing workers.

**Table 5. The effects of age, gender, tenure, smoking, PPE use, and toluene level on subjective symptoms of central nervous system disorders**

<b>Independent Variables</b>	<b>b</b>	<b>p</b>
Age	0.27	0.163
Gender	4.35	0.999
Tenure	1.41	0.692
Smoking	5.18	0.042
PPE use	0.56	0.737
Length of toluene exposure <8 hours/day	0.32	0.317

**DISCUSSIONS**

Based on the results of the study by using the German version of the Q18 questionnaire, it was found that there were 19 people who experienced subjective symptoms of central nervous system disorders.

**1. The relationship between age and the risk of subjective symptoms of central nervous system disorders among printing workers**

The results of this study showed that age <30 years old was positively but statistically non-significant associated with subjective symptoms of central nervous system disorders among printing workers

Age was an important variable in the case of subjective symptoms of central nervous system disorders. The ability of the organs of the body would decrease naturally with increasing age. A study by Gamble (2000) stated that age 20-24 years old showed an increase in the incidence of neurobehavioral disorders due to solvent exposure and continued to be constant until the age of 40 years old, then subsequently decreased.

A study by Rusdy (2012) showed a negative relationship between age and neurotoxic incident (r= -0.01), but it was statistically non-significant (p>0.050). This was due to the majority of the study

subjects aged 30-40 years old and neurotoxic symptoms that were felt to be subjective, most of them did not understand the associated neurotoxic symptoms.

## **2. The relationship between smoking and the risk of subjective symptoms of central nervous system disorders among printing workers**

The results of this study showed that smoking was positively and statistically significant associated with subjective symptoms of central nervous system disorders among printing workers.

The results of this study were in line with a study by Ovina (2013) which reported that there was a significant relationship between smoking habits and the prevalence of non-hemorrhagic stroke in the Neurology Poly of Raden Mattaher Hospital.

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### **REFERENCES**

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Agency for Toxic Substances and Disease Registry (2000). Toxicological profile for toluene. Georgia. <http://www.atsdr.cdc.gov/toxprofiles>.

Agency for Toxic Substances and Disease Registry (2001), Toluene Toxicity, Georgia <http://www.atsdr.cdc.gov/csem/toluene/index.html>

Agustina U (2013). Hubungan toluen dengan kadar hippurat urin dan keluhan SSP pada pekerja bengkel, FKM, UNAIR

American Conference of Governmental Industrial Hygienists (1995). Documentation of The Threshold Limit Values (TLVs) and Biological Exposure Indices (BEIs), Washington.

American Conference of Governmental Industrial Hygienist (ACGIH) (2005), TLV® and BEI® docu-

mentation of the threshold limit values for chemical substances and physical agents and biological exposure indices, ACGIH, USA.

American Conference of Governmental Industrial Hygienist (ACGIH) (2008), TLV® and BEI® Based on the Documentation of the Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, ACGIH, USA

Azari MR, Konjin ZN, Pours ZFS, Seyedi MD (2012). Occupational Exposure of Petroleum Depot Workers to BTX Compounds, The International Journal of Occupational Environmental Medicine (IJOEM), 3: 9-44.

Batticaca F (2008). Asuhan keperawatan pada klien gangguan sistem persarafan. Jakarta: SalembaMedika

BPOM RI (2001). Aspek fundamental kajian dan pengendalian risiko bahan kimia. Direktorat Pengawasan Produk dan Bahan Berbahaya. Deputi Bidang Pengawasan Keamanan Pangan dan Bahan Berbahaya, Jakarta.

Chang CJ, Chen CJ, Lien CH, Sung FC, (2006). Hearing loss in workers exposed to toluene and noise. Environmental Health Perspectives. 114(8).

Darwati (2004). Analisis gejala neuropsikologis pada pengguna toluen di unit TBK (Aircraft Cabin Base Maintenance) PT. Garuda Meintenance Facility Aero Asia Cengkareng, Depok.

Darmono (2011), Drug on the central nervous system, Bogor.

Depkes RI, (2008), Profil Kesehatan Indonesia, Jakarta.

Draper THJ, Bamiou DE (2009). Auditory neuropathy in a patient exposed to

- xylene: case report. *The Journal of Laryngology & Otology*, 123:462–465.
- Ekaputri S (2012). Hubungan paparan toluen dengan kadar asam hipurat urine pekerja pengecatan mobil (studi pada bengkel mobil informal di Karasak, Kota Bandung). Fakultas Teknik Sipil dan Lingkungan. ITB
- Environmental Protection Agency (1991), Human health evaluation manual supplemental guidance, Standard Default Exposure Factor. Washington DC.
- Environmental Protection Agency (2005), Integrated Risk Information System: Toluene, <http://www.epa.gov/NC-EA/iris/>
- EPA, (2003), Toxicological Review of Xylenes, In Support of Summary Information on the Integrated Risk Information System (IRIS), U.S. Environmental Protection Agency Washington, D.C
- Gamble JF (2000). Low-level hydrocarbon solvent exposure and neuro-behavioural effects. *Occup Med*, vol 50:81-102, London
- George D. Clayton & Florence D. Clayton, (1994), *Patty's Industrial Hygiene & Toxicology*. 4th edisi vol. 11 Part B.A Willey\_Interscience Publication. John Willey & Sons Inc
- Gilron I, Watson CPN, Cahill CM, Moulin DE (2006). Neuropathic pain: a practical guide for the clinician. *Canadian Medical Association Journal*, 175:265–275. doi: 10.1503/cmaj.060146.
- Huang CC (2008). Polyneuropathy Induced by n-Hexane Intoxication in Taiwan. *Acta Neurol Taiwan*, 17 (1):3-1
- Ihrig A, Triebig G, Dietz MC (2001). Evaluation of a modified German version of the Q16 Questionnaire for neurotoxic symptoms in workers exposed to solvents, Germany.
- International Association for the Study of Pain (2011). IASP pain terminology. Washington, DC: International Association for the Study of Pain. Retrieved from [www.iasppain.org/-AM/Template.cfm.Section.Pain\\_Definitions](http://www.iasppain.org/-AM/Template.cfm.Section.Pain_Definitions).
- International Programme on Chemical Safety (IPCS), (2000). Environmental Health Criteria 214 Human Exposure Assessment, IOMC, WHO, Geneva
- International Programme on Chemical Safety (IPCS), (2000), Air Quality Guidelines Toluene, WHO, Geneva, <http://www.euro.who.int/documenta/iq514toluen.pdf>
- Kolluru RV, Bartell SM, Pitblado RM and Stricoff RS, (1996), *Risk Assessment and Management Handbook: For Environmental Health and Safety Professionals*, New York, McGraw-Hill
- La Dou J (2004). *Occupational and Environmental Medicine*, San Francisco.
- Lemeshow S (1997). *Besar Sampel Dalam Penelitian Kesehatan*, GadjahMada University Press, Yogyakarta.
- Lestari F, Kurniawidjaja LM, Tejamaya M (2008). Laporan akhir kajian risiko kesehatan kerja pada pekerja yang terpajan benzena, toluene dan xylene (BTX) Departemen Laboratorium K3 FKM UI dan Direktorat Bina Kesehatan Kerja Depkes RI.
- Louvar FL and Louvar BD (1998). *Health and environmental risk analysis: Fundamental with application*,

- Volume 2, New Jersey, Prentice Hall PTR
- Lubman DI, Yucel M, Lawrence AJ (2008). Inhalant abuse among adolescents: neurobiological considerations. *British Journal of Pharmacology*, 154:316–326.
- Mansyur M (2007). Manajemen Risiko Kesehatan, *Majalah Kedokteran Indonesia*, 57(10).
- Martyn C, Hughes RAC (1998). *Peripheral neuropathies*. London: BMJ
- Chen MS, Chan A (1999). China's 'Market Economics in Command': Footwear Workers' Health in Jeopardy. *International Journal of Health Services*, 29(4): 793–811.
- Mukono (2005). *Toksikologi Lingkungan*. Surabaya: Airlangga University Press.
- Newman MJ (2012). Classification of diseases and conditions affecting the periodontium, In: Newman, Takei, Klokkerold, Carranza. *Carranza's Clinical Periodontology*. 11 th Ed, 34-54.
- Nusanti S (2007). Efek pajanan toluene pada tingkat apoptosis dan fungsi mitokondria self otoreseptor serta retinal pigment epithelium tikus, FK UI, Jakarta.
- Ovina Y (2013). Hubungan Pola Makan, Olahraga dan Merokok terhadap Prevalensi Penyakit Stroke Non Hemorgik di PoliSaraf RSUD Raden Mattaher Jambi Tahun 2013. *Jambi Medical Journal*. Jambi
- Palar H (2008). *Pencemaran dan Toksikologi Logam Berat*. Jakarta: PT. Rineka Cipta.
- Palencia G, Hernandez-Pedro N, Saavedra-Perez D, Pena-Curiel O, Plata AO, Ordonez G, Flores-Estrada D, Sotelo J, Arrieta O (2014). Retinoic acid reduces solvent-induced neuropathy and promotes neural regeneration in mice. *J. Neurosci. Res.*, 92:1062–1070. doi: 10.1002/jnr.23376
- Peraturan Menteri Tenaga Kerja dan Transmigrasi Nomor Per. 13/ Men/ X/2011 Tahun 2011 tentang nilai ambang batas faktor fisika dan faktor kimia di tempat kerja.
- Pratamasari F (2015). *Kejadian Neuropati Saraf Tepi pada Pekerja Percetakan Offset yang Terpajan Toluena Inhalasi*, Gadjah Mada University Press, Yogyakarta.
- Rahman A (2010). *Prinsip-prinsip dasar dan metode analisis risiko kesehatan lingkungan dalam bahan ajar pelatihan teknik dan manajemen analisis dampak kesehatan lingkungan bagi petugas kesehatan, balai besar teknik kesehatan lingkungan dan pemberantasan penyakit menular* Yogyakarta.
- Ropper AH, Samuels MA (2000). *Disease of peripheral nerve*. Adams & Victor's *Principles of Neurology* (7 th Edition). New York: The McGraw Hill
- Rusdy MDR (2012). *Analisis gejala neurotoksik akibat pajanan pelarut organik xylene pada pekerja pembuatan cat di PT X* [Thesis]. Depok: Universitas Indonesia;
- Sentra Informasi Keracunan Nasional (SiKerNas) Pusat Informasi Obat dan Makanan, Badan POM RI Tahun 2012
- Smeltzer CS, Bare GB (2002). *Buku Ajar Keperawatan Medikal-Baedah*, Jakarta : EGC
- Sophianita (2003), *Hubungan antara Kadar Asam Hipurat Urin Akibat*



- Pajanan Toluen dengan Efek Kesehatan Akut pada Tenaga Kerja Percetakan "X", FK UI, Jakarta.
- Suma'mur (2009). Higiene Perusahaan dan Keselamatan Kerja. Jakarta: CV SagungSeto.
- Svendsen, K, Rognes, K, 2000, Exposure To Organic Solvents in The Offset Printing Industry, Norway, Annals of Occupational Hygiene 44(2):119-24, April 2000.
- Tarwoto, Wartonah, Suryati, E. S, (2007), Keperawatan Medikal Bedah Gangguan Sistem Persyarafan, Jakarta: EGC.
- Toluene Tox Guide-Agency for Toxic Substances and Disease Registry. <https://www.atsdr.cdc.gov/toxguides/toxguide-56.pdf>
- Widada B (2000). Pengenalan Alat Kromatografi Gas, Alat Analisis, ISSN 1852-4777, URANIA, No.23-24
- Wulandari D (2017). Hubungan pajanan senyawa benzena dengan kadar trans-trans muconic acid dalam urin pengrajin sepatu di kelurahan Tambak Oso Wilangun Surabaya, Universitas Airlangga.
- Yuksel G, Karlikaya G, Tutkavul K, Yildirim B, Orken C, Tireli H (2007). Clinical and electrodiagnostic findings of n-hexane neuropathy. J NeurolSci [Turk]. 24:219-225