Effects of Benzene Exposure on Respiratory Symptoms to Workers in the Informal Footwear Industry

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Abstract

Background: Benzene is a volatile organic solvent. Benzene has been designated as a carcinogen in humans or a cause of cancer by the International Agency for Research on Cancer. The entry of organic solvent vapors into the body can cause various main reactions in the respiratory tract. The purpose of this study was to determine the relationship between benzene exposure intake and respiratory symptoms. Displace to method, here in abstract.

Method: This type of research used cross-sectional design and risk assessment approach. It is conducted in four footwear workshops in Bogor, West Java, during September 2017. This study involved 96 footwear workers.

Results: The most symptoms experienced were cough 50% they were quickly tired or tightness during activity 39.6%, sore throat 33.3%, runny nose 31.3%, issued phlegm or reak 18.8%, shortness of breath 14.6%, snorting nouse 6.3%. The result of the risk assessment was 11.5% of workers had real time non-cancer risk as well as 21.9% of workers who had cancer risk.

Conclusion: There was no correlation between non-carcinogen intakes, carcinogen intakes and respiratory symptoms (p value> 0.05). The findings suggest vigilance against the risk of continuous benzene exposure because it can trigger symptoms of carcinogens or non carcinogens.

Keywords: *Benzene exposure intake, respiratory symptoms, risk assessment.*

Introduction

In Indonesia, industrial development is progressing along with the demands of various product needs. To meet these needs, many large and small scale industries have been established, such as the home industry of Small and Medium Enterprises (SMEs). SMEs have a very important role as a strong and flexible group, and still persist to contribute to the national economy significantly(1). The Ministry of Industry noted the creation of foreign exchange by the footwear industry amounted to USD 4.11 billion or 2.33% of total national exports in 2014, indicating that the footwear industry has the opportunity to continue to increase exports(2). The footwear industry is one of the labor-intensive export commodities where the success of the craftsmen to maintain the presence of the products produced is often not matched by adequate health protection for the risk of their work related to dangerous equipment and materials. Long hours worked and not supported by the required working conditions, often forcing manufacturers to work with fewer ergonomic body positions so they are vulnerable to injury.

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In addition, 70-80% of the workforce engaged in the informal sector generally work in an unfavorable work environment, not organized and the level of welfare is low[3]. Studies[4][5][6] show estimates of carcinogenic and non-carcinogenic health risks due to the exposure of benzene in the process of making primary shoes in the use of glue, because in the process, exposure to organic solvent vapors, especially the benzene contained in the glue can allow health effects if inhaled continuously.

Air pollution in the footwear manufacturing industry has been reported to worsen respiratory and lung function disorders especially in workers who have a long duration of organic solvent exposure[7]. The existence of organic solvents which its use is still widespread, especially in the informal sector, is a challenge to public health. There needs to be ongoing monitoring that can be done through a risk assessment to anticipate the effects that can be caused. This study aims to determine the effect of benzene exposure intake on respiratory symptoms.

Materials and Method

This study was used a cross-sectional study design to describe the effects of individual health due to benzene exposure and risk analysis approaches to obtain benzene exposure intake and risk assessment[8][9][10].

This study involved 96 workers and sampling was carried out using a purposive sampling method. The location of the study was conducted in 4 home footwear industry in Bogor, West Java, in September 2017. The data was processed and presented through a descriptive analysis, Chi square analysis was used to identify the association between carcinogen intake, non carcinogen intake and symptoms of respiratory disorder.

Determining the sample of workers was used by purposive sampling method because the study population in general has characteristics, demographics, socio-economic and certain types of activities. Especially workers in the footwear industry. The calculations of the risk assessment was used by microsoft excel application.

Findings:

Symptoms of Respiratory Disorder: The most symptoms experienced were cough (50%), following sequentially according to their presentation they were quickly tired/tightness during activity (39.6%), sore throat (33.3%), runny nose (31.3%), issued phlegm/reak (18.8%), shortness of breath (14.6%), snorting nouse (6.3%).

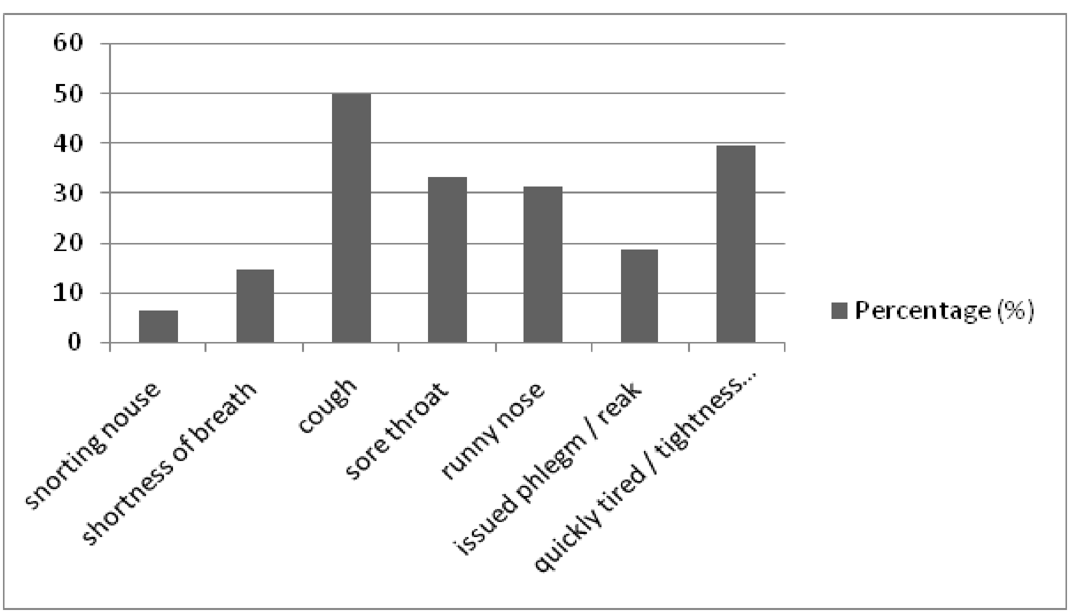

Figure 1. Persentage of Respiratory Symptoms

The entry of organic solvent vapors into the body can cause a variety of reactions, ranging from mild irritation, addiction, kidney disorders, pulmonary edema reactions and disorders of the central nervous system[11]. The main route of exposure is through inhalation, dermal (skin) and oral administration as well as possible[12].

Glue that contains organic solvents in footwear home industry can cause irritation symptoms in the respiratory tract[13], because exposure to volatile organic compound vapors is most important through inhalation[14]. In this study the only organic solvent analyzed was benzene. Absorption through breathing and digestion is faster than absorption through the skin, it is because benzene evaporates faster. About 50% of benzene is inhaled and absorbed after 4 hours exposure at a concentration of about 50 ppm benzene in the air. An in vivo study in humans showed that there was an absorption of about 0.05% of the dose of benzene applied to the skin, whereas in an in vitro study of human skin, benzene absorption was consistently as much as 0.2% after exposure to doses between 0.01-520 microliters per square centimeter[15].

The effect of benzene exposure on the respiratory tract was supported by conditions in the workplace in the room that makes the air more polluted if the window circulation of air is inadequate. Indoor air pollution can worsen the condition of the respiratory tract of workers especially those who have a history of diseases such as asthma, allergies etc. because with these working conditions can support the growth of bacteria[16]. But the results of the review suggested that dietary or nutritional supplements might be somewhat helpful to protect against water pollution-induced respiratory damage[17]

Benzene (C6H6) is a type of chemical that is polycyclic aromatic hydrocarbons (PAH). The nature of benzene which quickly evaporates in the air and is flammable then inhaled through the respiratory tract can irritate the mucous membrane, furthermore it can cause interference with the movement of the cilia so that it cannot clean the airways and due to this irritation also increases mucus production which can cause narrowing of the airways so that respiratory function can be disrupted based on the duration and duration of exposure[18]. Benzene with relatively high instability and solubility, benzene exposure through inhalation poses a greater risk than through skin contact. It has been estimated that size because 60% of the amount inhaled is absorbed in the bloodstream while 1% is absorbed through the skin[19] so that the damaged mucosa and submucosa components of the trachea can reflect its function and predispose to lower respiratory tract disease[20].

Intake of Non Carsinogen and Carsinogen: In this study the concept of exposure assessment was used to measure the amount of exposure carried out to analyze the amount of exposure, it is by calculating the amount of benzene intake that enters to the body.

The calculation of intake of benzene concentration in the work environment is obtained by using the following equation:

$$I = \frac{C.R.t_e.f_e.D_t}{W_b\, t_{avg}}$$

Where, I is intake of benzene exposure the number of risk agents received by an individual per unit of body weight every day (m^3/kg/day); C is Risk agent concentration, Benzene in the air (mg/m^3); R is intake rate (m^3/hour), Normal inhalation rate (EPA, 1997 in Abrianto, 2004)[21]: y = 5.3 In (x) - 6.9 with y = R (m^3/day) and x = Wb (Kg) the inhalation rate can be estimated according to Indonesian anthropometry characteristics; te is Exposure time per day (hours/day) for inhalation; fe is Frequency of annual exposure (days/years (365 days)); Dt is duration of exposure (years), i.e. a long of the respondent lived in the study location until the time of the study, which is stated in real time or 30 years of projected residential default exposure or 25 years for the projected exposure to industrial environment defaults; Wb is weight (kg); tavg is average time period, 30 years x 365 days/year (non-carcinogenic) or 70 years x 365 days/year (carcinogenic).

Table 1. Overview of Workers according to Non-Carcinogen and Carcinogen Intake

Variable	N	Minimum	Maximum	Median	Std. Dev.
Intake Non karsinogen	96	0,00002	0,40597	0,00048	0,083
Intake Karsinogen	96	0,00001	0,17399	0,0002	0,035

The results was obtained from the intake of benzene exposure in respondents ranging from 0,00001 to 0.40597 mg/kg/day have the potential to have a risk of carcinogens and non-carcinogens, so recommending risk management by controlling exposure time, duration of exposure and frequency of exposure and the expected ventilation factors in space a risk factor for increasing pollutant exposure. Whereas Habeebullah[22] obtained an average respondent intake of 1.83E-02 with a risk quotient of 3.04E-04 and excess risk cancer of 0.53. Habeebullah has also projected that benzene has been shown to have a greater risk of cancer and suggested to improve the pattern of activities that could be a risk factor for example in the work environment.

Result was obtained from a health risk assessment reveals that there was a significant potential cancer risk by inhaling doses of benzene at the study site because the levels at all locations exceed the acceptable risk then recommend to improve the quality of fuel by reducing the content of benzene(23).

Risk Characterization: Risk characteristics was obtained from calculating the estimated risk level with the non-carcinogenic risk calculation equation (RQ)(9) as follows:

$$\text{Risk Quotients (RQ)} = \frac{Intake}{RfC}$$

The reference concentration (RfC) value for the real time RQ is 8.6 x 10-3 (mg/kg)/day)(24)

Excees Cancer Risk (ECR)for Carsinogenic Effects: The calculation of the level of carcinogenic risk stated by the ECR was calculated by multiplying the Cancer Slope Factor (CSF) with the carcinogenic assumption of each risk agent according to the equation(9):

$$ECR = Intake_{Cancer} \times CSF$$

Where, ECR is Excess Cancer Risk (Risiko Kanker); $Intake_{Cancer}$ is Total chronic intake (lifetime, ie 70 years); CSF is *Cancer Slope Factor*

Cancer Slope Factor is defined as a quantitative relationship between dose and response, which is an estimate (estimation) of the chances of a person (individual) developing into cancer due to exposure (lifetime) by a potential cancer agent. The acceptable cancer risk threshold was adopted from the US-EPA, which is one case of cancer per ten thousand inhabitants(9).

Table 2. Results of Non-Carcinogen and Carcinogen Risk Assessments for Workers

Risk	Frequency	Percentage (%)
Non cancer Risk		
RQ > 1	11	11,5
RQ ≤ 1	85	88,5
Cancer Risk		
ECR > 1·10-4	21	21,9
ECR ≤ 1·10-4	75	78,1

The result of the risk assessment 11.5% of workers had real time non-cancer risk as well as 21.9% of workers who had cancer risk. It can be seen that benzene inhalation exposure in the informal footwear industry has described risks that will harm health (cancer and non-cancer) through the calculation of RQ (Risk Quotient) and ECR (Excess Cancer Risk) values that exceed the reference level of benzene exposure.If the value RQ ≤ 1 shows an indication that there is no risk of an adverse effect. While RQ>1 indicates an indication of possibility of the risk of adverse effect and needs to be controlled(25). Where this value projects a risk of insecurity if exposure continues. Its indications can be assessed by estimating the risk of cancer and non cancer as well as the symptoms of respiratory disorders that will worsen if exposure continues for long periods without risk control.

Analysis of the Relationship between Non-Carcinogen Intake and Respiratory Symptoms:

Table 3. Mann Whitney Test Results between Non-Carcinogen Intake and Respiratory Symptoms in Workers

	n	Mean Rank	Median (Min-Maks)	p*
Non carcinogenic intake and have symptoms	68	49,68	0,00048(0,00002- 0,40597)	0,519
Non carcinogenic intake and did not have symptoms	28	45,64	0,00052(0,00003 - 0,33706)	
carcinogenic intake and have symptoms	68	49,23	0,000195(0,00001- 0,17399)	0,690
carcinogenic intake and did not have symptoms	28	46,73	0,00022(0,00001- 0,14445)	

*2-independen sample (significant value : P-Value < 0,05)

Analysis of the relationship of non-carcinogen intake with symptoms of respiratory disorders was analyzed by using the Mann-Whitney test. The results of the analysis obtained was 68 workers who have respiratory symptoms have a median non-carcinogen intake of 0,00048 (mg/kg)/day and 28 workers who did not experience respiratory symptoms have a median value of non-carcinogen intakes of 0,00052 (mg/kg)/day. P value 0.519 (p value> 0.05) which means that statistically there was no relationship between non-carcinogen intake and respiratory symptoms.

The results of the analysis obtained was 68 workers who solved respiratory problems had a mean carcinogen intake of 0,000195 (mg/kg)/day and 28 workers who did not experience respiratory disorders had a carcinogen intake of 0,00022 (mg/kg)/day. Value of p = 0.690 (p value> 0.05) which means that statistically there was no relationship between carcinogenic intakes and respiratory symptoms.

The results of this study indicate that there is no significant association between non-carcinogen intake and respiratory symptoms. The concentration of benzene in the working environment in this study was still below 0.5 ppm as the TLV (Thresold limit value) can be one of the factors supporting the insignificant relationship between benzene intake with respiratory symptoms and can be compared with Avis and Hutton data (1993) recorded inATSDR (2007)[12] that acute exposure of 33 and 59 ppm of benzene vapor which irritates mucous membranes, nose can cause sore throat and cough symptoms. However, previous studies conducted by Kurniawidjaja et al.,[13] at 1.40 ppm exposure, have described respiratory complaints in workers associated with benzene exposure in informal footwear workshops where the average value of benzene vapor levels in all workshop sample has more than TLV 0.5 ppm.

Conclusions

The finding of this study shows no correlation between non-carcinogen intakes and carcinogen intakes with respiratory symptoms. The risk assessment result suggest alertness to the risk of continuous benzene exposure because it can trigger symptoms of disease promoted carcinogenesis and non-carcinogenesis.

Conflict of Interest: The authors report no competing interest.

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Ethical Clearance: Taken from Universitas Indonesia Ethics Commission.

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