Relationship Between Working Periode and Using PPE with Hb Levels of Gas station Officers with Benzene Exposure in Cimahi City

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ABSTRAK

Gas station Stasiun pengisian bahan bakar memiliki risiko paparan benzena. Paparan benzena dapat menyebabkan anemia atau penurunan kadar hemoglobin, yang berkaitan dengan lama paparan, masa kerja, dan penggunaan Alat Pelindung Diri (APD). Penelitian ini bertujuan untuk mengetahui hubungan antara lama masa kerja dan penggunaan APD dengan kadar hemoglobin pada pekerja stasiun pengisian bahan bakar di Kota Cimahi. Studi ini menggunakan desain potong lintang pada 100 peserta dari 10 SPBU. Data masa kerja diperoleh melalui kuesioner, penggunaan APD diukur dengan observasi, dan pengukuran kadar hemoglobin dilakukan menggunakan alat Hb meter. Uji statistik univariat dilakukan dengan distribusi frekuensi, dan uji bivariat menggunakan Korelasi Spearman. Hasil menunjukkan bahwa 22% pekerja menggunakan APD dalam kategori kurang, 42% telah bekerja lebih dari 5 tahun, dan 35% pekerja SPBU di Kota Cimahi memiliki kadar hemoglobin rendah. Hasil analisis statistik menunjukkan bahwa terdapat hubungan signifikan antara lama masa kerja dan kadar hemoglobin pada pekerja SPBU (nilai p=0,001), sedangkan hubungan antara penggunaan APD dan kadar hemoglobin menunjukkan nilai p=0,390. Kesimpulannya, terdapat hubungan signifikan antara masa kerja dan kadar Hb pekerja SPBU, tetapi tidak ada hubungan antara penggunaan APD dengan kadar hemoglobin.

Kata kunci: Benzene, SPBU, Hemoglobin, APD, Masa kerja

ABSTRACT

Gas stations have risks of benzene exposure. Benzene can cause anemia or decreased hemoglobin levels, due to the length of exposure, period of work, and use of Personal Protective Equipment. The purpose of this study to determine relationship between length of service and use of PPE on hemoglobin levels at gas station workers in Cimahi City. The study was conducted with a cross-sectional design on 100 participants from 10 gas stations. The working period was collected using a questionnaire, the use of PPE is measured by observation, and the measurement of hemoglobin levels is measured using an Hb meter instrument. The univariate statistical test uses frequency distribution and the bivariate uses the Spearman Rank Correlation. The results showed that 22% use PPE in the less category, 42% have worked for more than 5 years, and 35% of gas station workers in Cimahi City had low hemoglobin levels. The results of statistical analysis of the relationship between length of service and hemoglobin levels of gas station attendants in Cimahi City showed a value of p=0.001, and the relationship between the use of PPE and hemoglobin levels of gas station workers showed a value of p=0.390. The results showed that there was a significant relationship between length of service and Hb levels of gas station attendants, and there was no relationship between the use of PPE.

Keywords: Benzene, Gas station, Hemoglobin, PPE, Years of service.

1. INTRODUCTION

Polluted air can cause damage to the environment and threaten human life. Technological advances contribute to worsening air pollution conditions, due to the increasing number of sources of air pollution produced by various technologies that continue to develop. Air pollution arises due to the presence of contaminants or pollutants in the air. Each type of

pollutant has a different effect from other types. Several substances cause air pollution in the workplace, including gas stations (Bestari et al., 2020). Benzene is one of the substances included in the poison of air pollution (Arnold et al., 2013).

Data from the International Labor Organization (ILO, 2018) shows that every year 2.4 million people in the world die due to occupational diseases. Work accidents can occur anywhere in various workplaces and industries. In 2017, at several gas stations in various regions covering all business entities operating in Indonesia, gas station officers did not fully understand the risks at gas station and their mitigation. For example, the danger of filling fuel, the risk of inhaling hydrocarbon gas and others. Research conducted at a gas station in Cimahi illustrates one evidence that the implementation of Occupational Safety and Health (OSH) has not been maximized, namely that 100% of the gas station officers did not use complete PPE (Nur'aini, 2019). 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 (Bestari et al., 2020). During the refueling process fueled cars, workers inhale gasoline vapors and may also be exposed to them hands and arms increase contact with benzene compound (Alves et al., 2017).

A study confirmed that the highest ambient concentration of benzene was found at gasoline stations compared to other sites in public areas e.g., schools, public transport stations (Chaiklieng, Suggaravetsiri, & Autrup, 2019). Gas station attendants are exposed to various toxic substances found in fuel. Benzene stands out among these toxic chemicals; depending on the concentration, it can cause mucosal irritation or even pulmonary edema and affect hemoglobin levels. A large number of gas station attendants are unaware of the risks associated with benzene poisoning (Ferla, Oliveira da-Rocha, Dias de-Oliveira, Barioni, & Barioni, 2022).

Long-term exposure to benzene, a known human carcinogen, can cause blood disorders by affecting the bone marrow, causing anemia, excessive bleeding, damage to the immune system and DNA. A study of the hematological parameters of 60 male oil station workers in Waset Province with working duration varying from 1 to 20 years, working an average of 8 hours per day, showed that at the start of work they showed normal values for hemoglobin, white blood cells, and platelets during the first 10 years of work. However, as the duration of work increased, there was a gradual decrease in these parameters, indicating a negative impact of benzene exposure on hematological health (Hameed, Alhusein, Salim, & Hussein, 2009).

Behavior in using PPE must be correctly by gas station officers who are prone to health problems. Because gas stations are the main source of several volatile organic compounds, including benzene. Benzene is a chemical that is a colorless or light-yellow liquid at room temperature and is highly flammable. Outdoor air can contain low levels of benzene from motor vehicle exhaust, industrial emissions, and gas station. The air around hazardous industrial waste sites or public fuel filling station (SPBU) can contain higher levels of benzene than in other areas. People who work in industries that make or use benzene have a higher risk of exposure. If exposure to benzene originating from gas station fuel cannot be reduced, it will result in an increased risk of health problems or occupational diseases due to hematological disorders (Centers for Disease Control and Prevention, 2018). Benzene compounds are also known as compounds carcinogenic and proven to cause changes chromosomes in spinal cord cells, high exposure to benzene will cause health problems (Ariobimo, Yudison, & Irsyad, 2023). Filling workers at petrol stations are also affected due to evaporative losses during filling (Kashif & Hanif, 2019).

Research conducted on 29 gas station attendants in Makassar showed that, over the past year, they have experienced various health complaints. These included headaches or dizziness (69%), a sensation of unsteadiness or dizziness when rising from a seated or squatting position (48.3%), shortness of breath or chest discomfort (24.1%), coughing (65.5%), loss of appetite (37.9%), sore, watery, or burning eyes (17.2%), nausea, gastric issues, or ulcers (55.2%), and itchy or burning skin (6.9%). The results of an examination of the hematological profile of petrol station operators in Makassar City showed that 10.3% had abnormal hemoglobin levels. Review of several literatures, exposure to benzene can also cause hematological diseases such as anemia, leukemia and myelodysplastic syndrome (Hardi, Martiana, Adriani, & Suharni, 2022).

The results of research in Surabaya showed that the average benzene level in the work area of gas station operators was 3.8 mg/m3. An exposure analysis via inhalation, assuming an exposure frequency of 8 hours per day and a typical duration of 3 years, revealed the highest average exposure levels for non-carcinogenic effects as follows: lifetime exposure (0.428 mg/kg/day), 3-year exposure (0.0427 mg/kg/day), and real-time exposure (0.0348 mg/kg/day). For carcinogenic effects, the highest average exposure levels were lifetime exposure (0.1981 mg/kg/day), 3-year exposure (0.0197 mg/kg/day), and real-time exposure (0.0153 mg/kg/day).

This shows that the longer the duration of exposure, the higher the intake value for benzene levels (Rafika, 2016). The results of research

conducted on gas station officers concluded that benzene could accumulate in the body over a long period of time, the accumulation of benzene in the body in particular gas station officers can be influenced by several factors, including long working hours and smoking habits. Apart from blood and urine specimens, it can be used to determine the accumulation of benzene in a person's body (Susilawati & Adelia, 2023).

The science of Occupational Safety and Health (OSH), as a science among other things, studies hazard control, has five hazard control techniques. It is known as the hazard control hierarchy, namely Elimination (removing sources of danger), Substitution (replacing sources of danger with safer materials), Engineering Control (modification or changing the source of danger to make it safer), Administration (making work regulations), Personal Protective Equipment. Some work activities require appropriate protective equipment. Personal protective equipment needs to be provided as needed. Workers must be trained before using PPE. For example, using safety shoes, visibility vests, glasses, helmets, and so on. While these tools are important, they are the least effective solution, as they attempt to mitigate possible risks rather than eliminate them altogether (Ajslev, Møller, Andersen, Pirzadeh, & Lingard, 2022).

For gas station officers, the most likely control measure is personal protective equipment (PPE). Gas station officers need PPE to protect themselves from air pollution such as smoke or substances that are harmful to health. Results of researchers' observations at three gas stations in Cimahi City, it was found that all gas station officers wore shoes and did not use face shields or googles. Of the three gas stations, at one of the gas stations all the gas station staff wore masks, while all the gas station staff at the other two gas stations did not wear masks. Apart from that, it was seen that some gas station officers were wearing long-sleeved work clothes, while others were wearing short-sleeved work clothes. Some gas station attendants also wear hats and others don't wear hats. Some others wear gloves, others don't wear gloves. The working period of gas station officers also varies with the maximum working period found to be more than 35 years with a working duration of 8 hours per day. The results of short interviews also found that several gas station officers complained of dizziness.

There has been a lot of research on the use of PPE, but not much has been linked to hemoglobin levels. Based on this, it is felt that research is necessary to determine the relationship between length of work, use of PPE and hemoglobin levels in the blood of employees at gas stations. From research on gas station employees, data was obtained that the longer the work period, the more influence the Hb levels will have, especially those caused by exposure to benzene

from the petrol being sold. Most PPE use and benzene exposure are associated with air pollution and respiratory disorders. Therefore, researchers intend to conduct research to determine the relationship between length of service, use of PPE and Hb levels of workers at gas stations.

2. METHODS

This research was a cross-sectional study. The independent variables in this research are work period and use of PPE, with the dependent variable being hemoglobin levels. The instruments used were a participant data entry sheet, an observation sheet on the use of PPE, and an Hb meter. The research population was gas station officers who served as fuel filling operators in Cimahi City. The population is gas station officers in Cimahi City who are tasked with being fuel filling operators. From the results of a preliminary study, it is known that the total population of 13 gas stations in Cimahi City is 220 people. Sampling was taken using a quota sampling technique of 100 people taken from 10 gas stations in Cimahi City. The instruments used in this research were respondent data forms, observation sheets and hemoglobin meters. The respondent data form is used to identify work period, the observation sheet is used to identify the use of PPE. Hemoglobin meter is used to identify hemoglobin levels. The validity of the hemoglobin meter was tested by comparing the measurement results with the Sysmex XS-800i hematoanalyzer, which is commonly used in clinical laboratories. The data collected was analyzed univariately using frequency distribution and bivariate analysis using cross tables and statistical tests. To test the relationship between length of service and Hemoglobin level, use Correlation test to determine the relationship between PPE use, length of service and Hb levels. Multivariate regression was used to show the influence of length of service and PPE both on Hemoglobin level simultaneously.

3. RESULT AND DISCUSSION
3.1. Characteristics of Respondent

This research has received an ethical certificate from the Health Research Ethics Committee (HREC) Immanuel Health Institute Number 080/KEPK/IKI/VII/2023. The result of this study shows there were 100 gas station officers in Cimahi City who were willing to participate as respondents, with 56 male officers and 44 female officers. The ages of gas station officers vary, the youngest being 17 years old and the oldest being 58 years old. The working period of gas station officers also varies with the longest working period, up to 27 years, with a working duration of 8 hours per day. The working time pattern of gas station officers is divided into 2 and 3 work shifts. For gas stations with a 2-shift working time pattern, generally the first shift starts

from 06.00 to 14.00, the second shift starts from 14.00 to 22.00. For gas stations with a 3-shift work pattern or 24-hour gas stations, the shift is added with a third shift which starts at 22.00 until 06.00. The first shift and second shift are generally filled with 6-7 people, and the third shift is generally filled with 3-5 people. The night shift schedule makes gas station officers do not sleep all night while working, the day shift schedule also makes gas station officers go home from work and go to bed late at night.

Every gas station officer generally has the same habit, only using personal protective equipment in the form of work clothes and shoes. This is required by management for gas station officers, but other equipment such as hats, eye protection, gloves and masks are returned to the respective gas station officers. Regarding the use of masks, gas station officers who did not wear masks stated that this was done because the officers had to do: smile, greet, and salute customers and felt uncomfortable when wearing masks. Likewise with gloves, operator officers stated that they had difficulty handling change when using gloves. Gas station officers never carry out routine medical check-ups either on individuals or at company facilities. If a gas station officer experiences complaints of health problems, the gas station officer generally checks with a doctor through his insurance facility (BPJS). Table 1 showed the characteristics of respondents.

Table 1 shows that most respondents had a working period of ≤ 5 years, namely 58 people (58.0%). Respondents who used PPE in the sufficient category were only 22 people (22%), and respondents who had low Hb levels were 35 people (35%). The relationship between independent and dependent variables was shown on table 2. In table 2, the statistical test used is rank spearman correlation, so the data used is numerical data that has not been grouped. Meanwhile, the data used to present data in Table 2 is in a cross table using grouped data. Table 3 explained the relationship between length of service, the use of PPE and Hb levels among gas station attendants. The test analystic was using simple linear regression regarding to the normality data

distribution of independent variabel, which is Hb levels.

Table 2 shows that 58 respondents who had a new work period or less than 5 years, it turns out that 81.0% had normal or high Hb levels, while the majority of long-term work also had normal Hb levels, namely 42.9%. There were still some respondents who were not using PPE well, namely 78 people. Workers who have not used PPE are caused by many factors, including inadequate provision of PPE by company owners, as well as workers' unwillingness and ignorance of the importance of using PPE when working. Most respondents who used PPE in a good condition had relatively normal/high Hb levels (Damayanti, Hilintang, & Widajati, 2019).

The results of statistical tests using Spearman's Rank for work period and using PPE with Hb levels, both obtained p value <0.05. The correlation coefficient value for the relationship between length of work and Hb levels was negative at 0.511, while the coefficient correlation value between the use of PPE and Hb level was positive at 0.360. Based on the results of this research, it can be concluded that there are both relationships between length of service and Hb level and between the use of PPE and Hb level in gas station operators in Cimahi City. The longer the work period, the worse the Hb level, while the better the use of PPE, the better the Hb level.

The amount of exposure received also depends on the exposure time, the longer the exposure time, the more exposure you receive. The work duration of gas station officers in Cimahi City is 8 hours per day, with an average work period of 6.9 years. The length of service varies with a range of 0.1 to 27 years. In this study, the author correlated length of service with hemoglobin levels in gas station officers in Cimahi City, showing a value of p=0.005 (<0.05), which means there is a significant relationship between length of service and hemoglobin levels in gas station officers in Cimahi City. The results of this research are in line with research conducted which stated that there is an influence of length of work on hemoglobin levels in workers who are exposed to motor vehicle fumes (Indwek, Agustina, & Mumpuni, 2022).

Table 1. Respondents Characteristics

Variables	Frequency	Percent
Years of service		
New (≤5 years)	58	58.0
Old (>5 years)	42	42.0
Using PPE		
Poor	78	78.2
Good	22	22.0
Hb Levels		
Low	35	35.0
Normal/High	65	65.0
Total	100	100.0

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Table 2. Crosstabulation and Statistical Analysis Between Independent and Dependent Variables

Variables	Hb levels				Total		p-value	r
	Low		Normal/high					
	f	%	f	%	f	%		
Years of service								
New (≤5 years)	11	19.0	47	81.0	58	100.0	0,000**	-0.511
Old (>5 years)	24	57.1	18	42.9	42	100.0		
Using PPE								
Poor	8	36.4	14	63.6	78	100,0	0,000**	0.360
Good	27	34.6	51	65.4	22	100.0		

*Significant at 0.01

Table 3. Multiple Regression Analysis Between Length of Service, using PPE and Hb Level

			Coefficients^a				
	Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	
		B	Std. Error	Beta			
1	(Constant)	11.691	1.263		9.257	0.000**	
	The use of PPE	0.196	0.098	0.177	2.003	0.048**	
	Length of service	-0.145	0.025	-0.509	-5.758	0.000**	

a. Dependent Variable: Hb level

This research is in line with research conducted in Iraq regarding the relationship between length of work and at gas stations and blood Hemoglobin levels for filling workers in Al-Najaf City have proven that the longer the working period, the more hemoglobin levels in the blood decrease (Muhsin, 2020). If workers are exposed to benzene in the gas station environment for a long time, it can result in a decrease in hemoglobin levels in the blood and can cause anemia. Benzene contains gasoline which can have an impact on blood hemoglobin levels (Arnold et al., 2013).

The results of this study are not in line with the results of Nenotek's (2019) research conducted on gas station officers in Kupang City, which showed that there was no significant relationship between length of service and hemoglobin levels. The research results are also in line with the research results of regarding the relationship between work period and Hb levels in gas station operators in Pedurungan District, Semarang City, stated that there was no relationship between work period and Hb levels in gas station operators (Khotimah, 2023). The results of this study are different from research conducted in Kupang and Semarang city. It is possible that workers who have worked for a long-time experience adaptation, so it does not have much of an effect on the condition of their hemoglobin, because of the use of personal protective equipment that can protect against exposure to benzene in the work environment.

3.2. Using Personal Protective Equipment and Hb levels

The amount of exposure versus exposure time is also influenced by using PPE. No matter how long and how much exposure, if PPE is used properly, it can reduce the risk of impact from that exposure. The average use of PPE for gas station officers in Cimahi

City is categorized as being in the adequate range. The use of PPE by gas station officers in Cimahi City is in the "insufficient" category as much as 22%, and in the "sufficient" category as much as 36.4%. In this study, the author correlated the use of PPE with hemoglobin levels in gas station officers in Cimahi City using rank spearman correlaton analysis. The results of the analysis show a p value = 0.001 (>0.05), which means there is significant relationship between using PPE and hemoglobin levels in gas station officers in Cimahi City. The use of good PPE in accordance with the provisions can prevent a decrease in hemoglobin levels in the blood caused by pollutants in the work environment at gas stations.

This research is not in line with the results of research conducted on gas station officers in Kupang City which also shows that there is no relationship between the use of PPE and hemoglobin levels in gas station operator officers (Josua, 2019). Research that shows there is no relationship between the use of PPE and Hb levels caused by benzene levels in the environment, which are still below the danger threshold. In Cimahi City, benzene levels in the air are still within safe limits. ACGIH (American Conference of Governmental Industrial Hygienists) sets a maximum limit for the amount of exposure to benzene vapor in the air within a certain period of time, for a work duration of 8 hours per day, gas station officers may be exposed to a maximum of 0.5 ppm. In Indonesia, average benzene threshold value during working hours, namely the average benzene level in the work environment for 8 hours per day or 40 hours per week is also set in circular letter Number.01 of 1997 with a value of 0.5 ppm. This means that with a concentration of 0.5 ppm, officers are still relatively safe working for 8 hours per day.

The most common human exposure to gasoline is through inhalation, especially when refueling at gas

stations. For people who only occasionally come to refuel, the effects of this exposure can already be felt, especially for people who work at gas stations, of course they experience exposure every day. It was reported from several gas stations in the DKI Jakarta area that there were approximately ten employees from each gas station who complained of shortness of breath every day, then the shortness of breath felt worse when the employee experienced another illness, for example flu (Indrayana, Nur, & Arismunandar, 2021). Other research also states that there is no relationship between knowledge and attitudes and behavior in using personal protective equipment at PT Sarandi Karya Nugraha Sukabumi (Rachman, Yulianto, Djojosugito, Andarini, & S.Djajakusumah, 2020).

Among gas station officers in Cimahi City who had low hemoglobin levels, this may have occurred due to other factors. From brief interviews, it was found that 62.9% of them admitted going to bed after midnight. The habit of sleeping past midnight, also known as staying up late, can affect hemoglobin levels in the blood. Research in Sidoarjo on prospective donors at PMI shows that there is an influence of sleep quality on hemoglobin levels in the blood. Of the two groups, good and poor sleep quality, in the good sleep group 100% had normal hemoglobin levels, whereas in the In the poor sleep group, 39% had low hemoglobin levels (Ariani, Sudiwati, Panggayuh, & Khofifah, 2022). Air quality monitoring, occupational safety and health have been implemented as a form of prevention against work accidents. The step for implementing safety and health is to use personal protective equipment while in the field (Manurung, Oktoriana, & Suharyani, 2023).

3.3. Multivariate Analysis of the Influence of Length of Service, use of PPE and Hb Levels Together

The results of multivariate analysis using linear regression showed that there was a joint influence between length of work, use of personal protective equipment and hemoglobin levels in workers at gas stations. The equation value obtained is Y= 11.691-0.145(Length of service) +0.196 (Using of PPE). The meaning of this equation is, if the value of PPE use and working period is equal to 0, the Hb level is 11.691 mm Hg. If we assume that the value of PPE usage is constant, then for every 1 unit decreased in the working period, the Hb level will increase by 0.196 units. Likewise, if the work period value is constant, and there is an increase in the PPE use score of 1 unit, then there will be a decrease in Hb levels of 0.145 units.

The results of multivariate analysis show that if the length of work increases, it will cause a decrease in hemoglobin levels in the worker's blood. The use of PPE can apparently prevent a decrease in Hb levels in

the blood. Taken together, it can be seen in the equation that Hb levels in workers are influenced by length of service and use of PPE. The lower the work period and the better the use of PPE, the more likely it will be to prevent a decrease in Hb levels. Human exposure to benzene cannot be avoided, so it requires measurement of benzene that occurs in work environments that use oil and gas. Measurements are carried out so that benzene levels in the environment can be observed and prevent exposure to excessive amounts of benzene while working.

4. CONCLUSION

The results of the study showed that there was a significant relationship between length of service and Hb levels, and also there was a relationship between the use of PPE and hemoglobin levels in gas station officers in Cimahi City. The higher the working period, the more risk of low Hb levels. The recommended suggestion is that the use of PPE is still required for gas station officers, although in this study there was no relationship, there are still many employees who do not use PPE when working, which will increase the risk of anemia. The better the use of PPE, the lower the Hb levels caused by the chemical compound benzene in the workplace. Together, working hours will reduce Hb levels and good use of PPE can prevent decreasing Hb levels. Therefore, it is necessary to educate workers at gas stations to use PPE correctly and appropriately so that there are no problems with Hb levels in their blood.

REFERENCES

Ajslev, J. Z. N., Møller, J. L., Andersen, M. F., Pirzadeh, P., & Lingard, H. (2022). The Hierarchy of Controls as an Approach to Visualize the Impact of Occupational Safety and Health Coordination. *International Journal of Environmental Research and Public Health*, *19*(5). https://doi.org/10.3390/ijerph19052731

Alves, L. P., Vieira, D. S. P., Nunes, L. S. S., Cruz, L. P. S., Reis, A. C. S., Gomes, Í. V. S., … Esteves, M. B. (2017). Relationship between Symptoms, Use of PPE and Habits Related to Occupational Exposure to BTEX Compounds in Workers of Gas Stations in Bahia, Brazil. *Journal of Environmental Protection*, *08*(05), 650–661. https://doi.org/10.4236/jep.2017.85042

Ariani, N. L., Sudiwati, N. L. P. E., Panggayuh, A., & Khofifah, K. (2022). Pengaruh Kualitas Tidur Terhadap Kadar Hemoglobin Calon Pendonor Di Utd Pmi Kabupaten Sidoarjo. *Care : Jurnal Ilmiah Ilmu Kesehatan*, *10*(1), 139–147. https://doi.org/10.33366/jc.v10i1.3214

Ariobimo, M. P., Yudison, A. P., & Irsyad, M. (2023). Identifikasi Senyawa Benzena pada Kabin Mobil. *Jurnal Ilmu Lingkungan*, *21*(1), 15–21. https://doi.org/10.14710/jil.21.1.15-21

Arnold, S. M., Angerer, J., Boogaard, P. J., Hughes, M. F., O'Lone, R. B., Robison, S. H., & Robert Schnatter, A. (2013). The Use of Biomonitoring Data in Exposure and Human Health Risk Assessment: Benzene Case Study. *Critical Reviews in Toxicology*, *43*(2), 119–153.

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https://doi.org/10.3109/10408444.2012.756455

Bestari, M. A. D., Tualeka, A. R., Alayyannur, P. A., Arini, S. Y., Russeng, S. S., Rahmawati, P., & Susilowati, I. H. (2020). Relationship between Benzene Concentrations with Erythrocyte, Hemoglobin, and Health Complaints of workers in Surabaya Printing Industry. *Indian Journal of Forensic Medicine and Toxicology*, *14*(4), 3112–3119. https://doi.org/10.37506/ijfmt.v14i4.12079

Centers for Disease Control and Prevention. (2018). Facts About Benzene. Retrieved from https://emergency.cdc.gov/agent/benzene/basics/facts.asp

Chaiklieng, S., Suggaravetsiri, P., & Autrup, H. (2019). Risk Assessment on Benzene Exposure Among Gasoline Station Workers. *International Journal of Environmental Research and Public Health*, *16*(14). https://doi.org/10.3390/ijerph16142545

Damayanti, U., Hilintang, R. P., & Widajati, N. (2019). Determinant Factors Affecting the Compliance with the use of Personal Protective Equipment (PPE) in Gas Plant. *Malaysian Journal of Medicine and Health Sciences*, *15*, 45–48.

Ferla, L. G., Oliveira da-Rocha, G. H., Dias de-Oliveira, R. T., Barioni, É. D., & Barioni, E. (2022). Risk Perception of Automotive Fuel Poisoning among Gas Station Attendants. *Revista Brasileira de Medicina Do Trabalho*, *20*(3), 422–429. https://doi.org/10.47626/1679-4435-2022-745

Hameed, F. R., Alhusein, A. A., Salim, A. A., & Hussein, M. L. (2009). Effect of Benzene on Some haeMatological Parameters of Oil Station Workers. *Ibn Al-Haitham Journal For Pure And Applied Science*, *22*(4).

Hardi, I., Martiana, T., Adriani, M., & Suharni. (2022). Operator SPBU Rawan Menghadapi Masalah Kesehatan Utamanya pada Gangguan Hematologis dan Gangguan Status Gizi. *Research Journal of Pharmacy and Technology*, *15*(3), 966–0. https://doi.org/10.52711/0974-360X.2022.00161

ILO. (2018). *ILO Report 2018, Improving the Safety and Health of Young Workers/International Labor Organisation.*

Indrayana, M. R., Nur, I. M., & Arismunandar, P. A. (2021). Hubungan Paparan Uap Bensin terhadap Kejadian Dispnea pada Pegawai SPBU. *Universitas Islam Bandung*, 7–12.

Indwek, D. D., Agustina, W., & Mumpuni, R. Y. (2022). Studi Literatur: Pengaruh Lama Kerja terhadap Kadar Hemoglobin pada Pekerja yang Terpapar Asap Kendarahan Bermotor. *Jurnal Penelitian Perawat Profesional*, *4*(2), 383–392.

https://doi.org/10.37287/jppp.v4i2.892

Josua, N. (2019). Hubungan antara Masa Kerja, Penggunaan APD, dan Kebiasaan Merokok terhadap Paparan Benzene pada Petugas Operator SPBU di Kelurahan Tuak Daun Merah Kota Kupang Tahun 2019. Poltekkes Kemenkes Kupang.

Kashif, S. U. R., & Hanif, A. (2019). Assessment of volatile organic compounds at gasoline filling stations and possible impacts on human health in Lahore, Pakistan. *Pakistan Journal of Scientific and Industrial Research Series A: Physical Sciences*, *62*(2), 98–103. https://doi.org/10.52763/PJSIR.PHYS.SCI.62.2.2019.98.103

Khotimah, K. (2023). Hubungan Lama Kerja dan Kadar Hemoglobin Pada Petugas Operator Stasiun Pengisian Bahan Bakar Umum (SPBU) di Kecamatan Pedurungan Kota Semarang (Politeknik Kesehatan Semarang). Retrieved from http://repository.poltekkes-smg.ac.id/index.php?p=show_detail&id=35560

Manurung, R., Oktoriana, S., & Suharyani, A. (2023). Pengaruh Emisi Kendaraan Terhadap Kandungan Logam Timbal (Pb) Tanah dan Bulir Padi pada Lahan Sawah di Kecamatan Tebas Kabupaten Sambas. *Jurnal Ilmu Lingkungan*, *21*(1), 1–7. https://doi.org/10.14710/jil.21.1.1-7

Muhsin, F. A. R. (2020). Relation between working in petrol station and blood hemoglobin levels for the filling workers in Al-Najaf city/Iraq. *Indian Journal of Forensic Medicine and Toxicology*, *14*(2), 565–569. https://doi.org/10.37506/ijfmt.v14i2.2908

Nur'aini, A. N. (2019). *Pengetahuan Dan Perilaku Penggunaan Alat Pelindung Diri (APD) Pada Petugas Stasiun Pengisian Bahan Bakar Umum (SPBU) Gunung Batu Cimahi Tahun 2019*. Poltekkes Kemenkes Bandung.

Rachman, L. A., Yulianto, F. A., Djojosugito, A., Andarini, M. Y., & S. Djajakusumah, T. (2020). Hubungan Pengetahuan dan Sikap terhadap Perilaku Penggunaan Alat Pelindung Diri di PT Sarandi Karya Nugraha Sukabumi Relationship between Knowledge and Attitude with Behavior of Using Personal Protecticve Equipment in PT Sarandi Karya Nugraha Sukabumi. *Jurnal Integrasi Kesehatan Dan Sains (JIKS)*, *2*(2), 154–159.

Rafika. (2016). *Analisis Risiko Pajanan Benzena terhadap Operator SPBU Kota Surabaya*. Institut Teknologi Adhitama.

Susilawati, & Adelia, R. (2023). Analisis Paparan Benzena pada Petugas Operator SPBU di Wilayah Kota Medan Kecamatan Medan Timur. *Zahra*, *3*(4), 354–361.