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Risk Assessment of Lead Exposure in The Oil Change Process with Dream Model

Burhan Maritsal Chakim[1]*, Moudy Putri Perdana[1] Abir Reva Ayuningtyas[1], Ameylia Devi Ardianingsih[1], Muhammad Raihan Aly Assidiq[1], Harisha Fadil[2]

[1]*Department of Public Health, Faculty of Medicine, Universitas Negeri Semarang, Indonesia*
[2]*Western Australia School of Mines, Faculty of Science and Engineering, Curtin University, Australia*

*Correspondence to: *maritsalchakim@students.unnes.ac.id*

Abstract:
Lead (Pb) is an inorganic chemical element (95%) commonly found in soil, rocks, and plants. The use of fuel and oil containing lead is relatively high in Indonesia. Motorcycle or machine repair shop workers are at high risk of lead exposure, especially when removing used oil. Workers are exposed to oil containing lead while removing used oil from the engine, cleaning the engine cover with gasoline, opening the oil bottle cap, and pouring oil. Even, these processes can lead to lead poisoning. This study aims to evaluate workers' risk of lead exposure during the oil-removing process at Repair Shop X. This descriptive study used a semi-quantitative approach with a Dermal Risk Exposure Method (DREAM). This study involved a total of 5 workers at Repair Shop X in the process of removing motorcycle oil. The actual dermal exposure value reached 340.36 based on the sum of the four activities. This was considered in the very high exposure category. Meanwhile, based on the activity obtained by calculating worker hygiene and work environment. The total exposure value was 306.33, which is a very high category. Therefore, using Personal Protective Equipment (PPE) such as gloves and maintaining worker and work environment hygiene by cleaning with water regularly can help minimize lead exposure.

Keywords: lead exposure; risk assessment; oil

INTRODUCTION

Oil or engine lubricant functions to lubricate motor components from engine friction so that they are not easily rusted and damaged. Prolonged friction coupled with high temperatures and dirt from the engine will cause oil to contain heavy metals such as lead (Pb), copper (Cu), and iron (Fe). Hasyim in Mangesti et al. (2019) report an increase in lead concentration in oil from 0.3954 ppm to 0.5672 ppm. Used oil contains lead compounds (Pb), which are toxic materials. Lead is an inorganic chemical element (95%) commonly found in soil, rocks, and plants. Lead has a soft nature with a grayish-blue color and a melting point of 327.4°C and a boiling point of 1,620°C (Tangio, 2013). Mechanic workers are at high risk of lead exposure when changing used oil. Rahmadhani (2021) reports that mechanic workers who have worked for more than 10 years face a lead exposure of 25 ppm, which is included in the heavy category, while those who have worked for 5-10 years face a lead exposure of 10 ppm. In Indonesia, the use of fuel and oil containing lead is still quite high. Another study (Budianto, 2020) focusing on lead (Pb) levels in the blood of repair shop workers found that eight workers have lead (Pb) levels exceeding the threshold. Repair shop workers in Makassar had blood lead levels of 44 µg/dL to 452 µg/dL, which exceeds the WHO standard of 40 µg/dL (Nilawati et al., 2018).

Lead can enter the body through direct exposure, breathing, and pollution. A previous study (Council et al., 1993) reported that 0.06% of lead that sticks to the skin can be absorbed. Lead that enters the body will be transported and distributed in the blood, and this can result in disorders in the body's organs. WHO sets the safe limit for lead exposure in hair, namely 0.2 mg/kg. Measuring lead levels in hair as a bioindicator can describe lead exposure that enters the body because hair contains sulfhydryl groups, which can bind lead (Shimo et al., 2023). The 1999 OSHA mentions that the permissible exposure limit is 50 µg/m3 per 8 working hours.

Lead that enters the body will cause poisoning. Symptoms caused by lead poisoning are abdominal pain, anemia, constipation, weight loss, central nervous system disorders, and even miscarriage (Prasetya, 2021). Lead poisoning can cause other disease effects. Besides, lead poisoning has the potential to cause diseases in multisystemic organs, such as decreased IQ and neurological symptoms (Arianty et al., 2020). Chronic lead exposure can cause damage to the nervous system, hematopoiesis, blood circulation, hearing, and heart function. Symptoms of lead exposure can be divided into two: general and specific symptoms. General symptoms include dizziness, abdominal pain, dementia, seizures, and coma, while the particular symptom is a blue line on the gums (Mani et al., 2020). Low-level environmental lead exposure is a risk factor that can cause cardiovascular disease and death in the United States (Lanphear et al., 2018). Who reports that lead pollution contributes 0.2% to work-related deaths and 0.6% to work-related disabilities (Arianty et al., 2020).

The most commonly found lead poisoning is due to chronic exposure. Workers who are exposed will not immediately experience symptoms. Chronic lead exposure can potentially increase uric acid and bilirubin levels in the blood (Dobrakowski et al., 2016). Workers in repair shops have the potential to experience lead poisoning if exposed for an extended period and exceed the specified limit. The amount of lead exposure when workshop workers change used oil on the engine must be considered. Lead exposure can be assessed by using the DREAM (Dermal Exposure Assessment Method) model. This model can initially assess the chemical risk of exposure routes through the skin, either solids or liquids. The DREAM model can estimate actual and potential skin exposure to chemicals (B. V. A. N. W. D. E. Joode et al., 2005). Potential exposure is the exposure value on clothing and exposed skin, while actual exposure is exposure after corrections are made to existing PPE. This study aims to determine the extent of lead exposure in repair shop workers who are changing used oil using the DREAM model (Dermal Exposure Assessment) Method. The DREAM model can be successfully applied to assess dermal exposure in epidemiological surveys and occupational hygiene (B. van W. De Joode et al., 2005). This study is limited to analyzing the risk of exposure levels and lead distribution to the skin, whether inhaled or not.

A study focusing on lead exposure in lead mines used the DREAM model and revealed that the DREAM model can be used to assess lead exposure. This model is simple and inexpensive. Another study (Muzaqi & Tejamaya, 2019) on using the DREAM model in Cold Fogging activities described exposure from various activities such as pouring insecticide into bottles, mixing, and spraying. Each activity can be assessed for head, body, and hands risk exposure. Another study also used the DREAM model on pesticides in rice fields (Wong & Brown, 2021). This study discusses the risk of pesticide exposure and recommends using PPE. Based on the explanation above, the DREAM model can be used to analyze lead exposure in repair shop workers. This study can be a reference material, and repair shop workers should use PPE when removing used oil.

METHODS

This descriptive study used a semi-quantitative approach to evaluate the risk of lead (Pb) exposure to workers when removing oil at Workshop X. This study used a Dermal Risk Assessment Method (DREAM) because this model can identify and analyze the risk of chemical exposure through the dermal pathway, which is relevant to work activities in the repair shop environment. This study involved five mechanics working at Repair Shop X. They work for six working days in 1 week with eight working hours per day. The estimated average number of visitors who change oil is 30 people per day. Data collection methods were interviews, observations, and documentation.

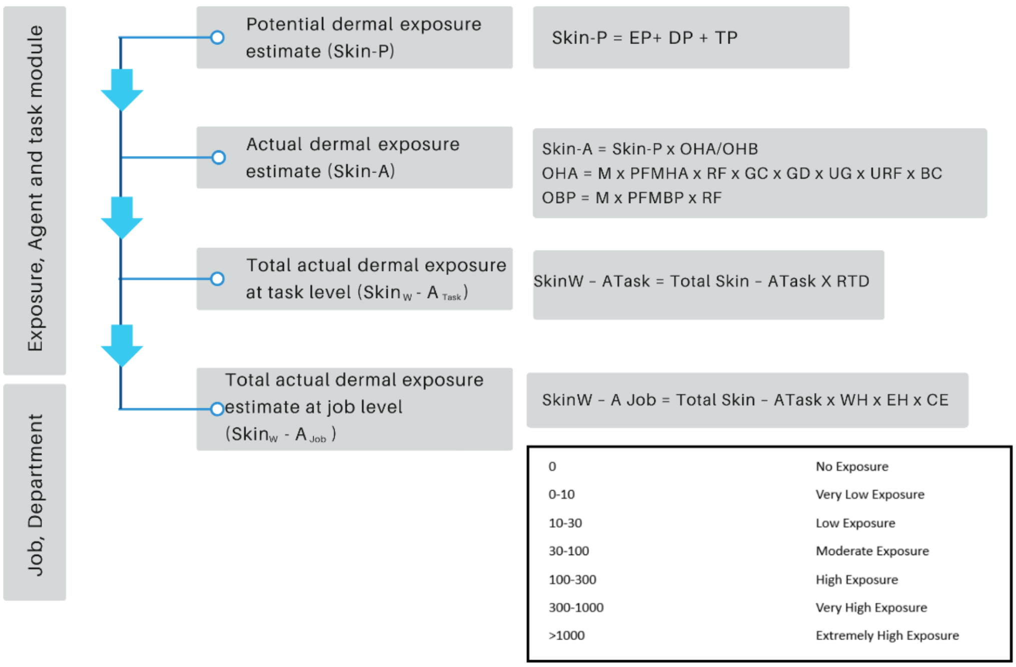

Figure 1. Research Design using the Dermal Risk Assessment Method (DREAM)

The DREAM model consisted of four stages. The first is to determine Skin-P or total oil exposure to workers. This was done by adding up potential emissions (EP), potential deposition (DP), and potential transfer (TP). Emission is exposure from direct sources such as splashes, deposition is exposure through the air (<100 µm), and transfer is exposure through direct contact with oil-contaminated equipment. The calculation must consider physical and chemical properties (form, concentration, and evaporation). The next stage was determining Skin-A, which is exposure after correction with PPE (OHA on the hands, OHB on other parts of the body). The next stage was analyzing the Skin w-A task, which is exposure with consideration of duration and frequency or RTD (exposure time per day). The next analysis was Skinw-A job, which is an analysis based on environmental conditions and worker habits (worker hygiene, environmental hygiene, and further exposure). After successfully finding it, it is calculated and categorized, as shown in Figure 4 (Muzaqi & Tejamaya, 2019).

RESULTS AND DISCUSSION

Toxic lead can be found in used oil or new oil. A study (Alamsyah, 2023) revealed that Pb content in new oil and used oil reaches 0.7069 mg/L and 6.0574 mg/L, respectively. The process of removing used oil has the potential for oil exposure. Oil poisoning can occur if workers are exposed, swallowed, and inhaled. Lead absorption is influenced by particle size and solubility. Lead absorption through the skin is lower than inhalation or oral (0.3%). However, when workers are exposed to lead on the skin or clothes and are not immediately cleaned, the lead that sticks will be at risk of being swallowed or inhaled.

In this study, the authors analyzed the Potential dermal exposure estimate (Skin-P), Actual dermal exposure estimate (Skin-A), and Total Actual dermal exposure at the task level (SkinW-ATask). The Potential dermal exposure estimate (Skin-P) value is the total exposure value of lead in oil change workers without considering the clothing or PPE used. Based on Table 2, of the four oil changing activities, namely removing oil, cleaning the engine cover, opening the oil bottle cap, and pouring oil, the highest Skip-P is found in cleaning the engine cover with gasoline (287.1) to remove residual oil stuck to the engine cover. This figure is included in the high category because workers are splashed with gasoline when the cleaning process uses gasoline mixed with old oil. In addition, the risk due to transformation (contact exposure) between the skin and oil on the hands is also high. The most exposed part of the body is the hands because they touch the oil. The lowest is when the process of closing the oil bottle (8.1) is considered in a very low category as the exposure is only due to direct contact with the cap that is exposed to oil.

Table 2. Potential Dermal Exposure Estimate (Skin-P) Values in Oil Removing Work

No	Exposed Body Parts	Skin P			
		Removing Used Oil from the Engine	Cleaning the engine cover with gasoline	Opening the Oil Bottle Cap	Pouring the Oil
1	Head	2.7	8.1	0	2.7
2	Upper arm	8.1	24.3	0	8.1
3	Lower arm	8.1	24.3	0	8.1
4	Hand	**90**	**171**	**8.1**	**108**
5	Front body	2.7	8.1	0	2.7
6	Back	0	0	0	0
7	Lower body	2.7	2.7	0	8.1
8	Lower calf	8.1	24.3	0	8.1
9	Feet	2.7	24.3	0	2.7
Total		**125,1**	**287.1**	**8.1**	**148.5**
Category		***High***	***High***	***Very low***	***High***

Actual Dermal Exposure Estimate (Skin-A) is the value of oil exposure in workers after correction for clothing and PPE factors. Repair shop workers do not use PPE such as gloves. They only wear short shirts, cotton pants, and open sandals as foot coverings. As a result, the exposure value on the skin will increase. Based on Table 3, the oil-removing process that has the most significant exposure potential is cleaning the engine cover using gasoline (5150.66), where emissions or splashes of gasoline mixed with water hit the hands, arms, face, and calves. The position of the repair shop workers when cleaning is squatting with a spray distance close to the body. The lowest exposure value is in the oil-removing process (243). The part of the body with the highest risk of exposure from the four processes is the hands because, in all processes, hands always touch the tools exposed to oil.

Table 3. Actual Dermal Exposure Estimate (Skin-A) Value in Oil Removing Work

No.	Exposed Body Parts	Skin A			
		Removing Used Oil from the Engine	Cleaning the engine cover with gasoline	Opening the Oil Bottle Cap	Pouring the Oil
1	Head	0.24	0.73	0	0,73
2	Upper arm	0.73	2.19	0	0,73
3	Lower arm	2.43	7.29	0	2,43
4	Hand	**2700.00**	**5130.00**	**243**	**3240,00**
5	Front body	0.24	0.73	0	0,24
6	Back	0.00	0.00	0	0,00
7	Lower body	0.24	0.24	0	0,73

8	Lower calf	0.73	2.19	0	0,73
9	Feet	0.81	7.29	0	0,81
Total		2705,43	5150.66	243	3246.40
Category		***Extremely high***	***Extremely high***	***Very high***	***Extremely high***

After measuring the Actual Dermal Exposure Estimate (Skin-A) Value, the researcher measured the total actual dermal exposure at the task level (SkinW-ATask). The total actual exposure was used to estimate the relative job duration, namely the exposure time per day. On average, each worker removes used oil 6 times/day. The time required to remove used oil is around 60 seconds, and it takes 40 seconds to clean the bottle cap, 15 seconds to open the oil bottle, and 30 seconds to pour the oil. In the calculation of the Relative Duration Estimate (RTD) in each process, the RTD value is obtained (0.03) with a category of <11 minutes/day. Based on Table 4, the total SkinW-ATask value in the four processes is (340.39) with a very high exposure category. Cleaning the engine cover has the highest value (154.52).

Table 4. Total actual dermal exposure at task level (SkinW-ATask)

No.	Activity	Total Skin W-Atask value	Category
1	Removing used oil from the engine	81.16	*moderate exposure*
2	Cleaning the engine cover with gasoline	154.52	*high exposure*
3	Opening the oil bottle cap	7.29	*very low exposure*
4	Pouring the oil	97.39	*moderate exposure*
Total		**340,36**	***very high exposure***

The next stage is comparing the total SkinW-ATask value with the environmental conditions and worker behavior with the correction of the worker hygiene section, work environment hygiene, and continuous exposure estimates. Workers wash their hands 2-10 times per shift with water or 2-5 times with soap, then the WH value of (0.3). The workshop environment is dry-cleaned daily and wetly (sprayed) every week. The value of EH and CE is the same, namely 0.3, where workers take a shower and change clothes after work. The SkinW-A Job value is (306.33), which is considered in the very high category.

Table 5. Total actual dermal exposure estimates at job level (SkinW-AJob)

Total Skin W-Atask Value	Work Hygiene (WH)	Estimation of Work Environment Hygiene (EH)	Estimation of Continuous Exposure (CE)	*SkinW-AJob*	Category
11345,49	0.3	0.3	0.3	306.33	*Very High Exposure*

Many factors cause high exposure values when removing oil. Exposure only focuses on the potential for movement or route to workers, without considering the entry of chemicals into the body. The influencing factors are the absence of PPE used, exposure time, type of work, position of workers when doing the work, tools used, environment, and habits. Tozun et al. (2009) explain that lead exposure can be reduced by using PPE. The recommended PPE is latex gloves because the part of the body that is often exposed is the hand. The squatting position when removing the oil poses a high risk of body parts being exposed to lead. After completing each job, workers are recommended to clean their hands using soap and water to reduce exposure.

CONCLUSION

Based on the results of the study on the risk of dermal exposure among workers in repair shop X, the total actual dermal exposure at the task level reaches 340.36, which is included in the very high exposure category. In the first work activity, the total actual dermal exposure in removing used oil from the engine reaches 81.16, which is considered moderate exposure. Second, the total actual dermal exposure in cleaning the engine cover with gasoline is 154.52, which is in the high exposure category. Third, the total actual dermal exposure in opening the oil bottle cap is 7.29, which is considered to be a very low exposure category. Lastly, the total actual dermal exposure in pouring oil is 97.39, which is in the moderate exposure category. Meanwhile, the total value of the actual dermal exposure estimate at the job level is 306.33, which is very high exposure. The risk of lead exposure is equally very high based on the estimation of duration and frequency of work environment conditions. Therefore, countermeasures are needed to reduce lead exposure, such as using PPE in the form of gloves, maintaining worker and work environment hygiene, and being careful when removing oil.

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