The Impact of Lead (Pb) on Health

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ABSTRACT

This systematic literature review aims to evaluate the neurodevelopmental, behavioral, and physiological impacts of lead (Pb) exposure in both children and occupationally exposed populations. Using the PRISMA framework, we reviewed 13 peer-reviewed studies published between 2013 and 2023. The studies include a range of methodologies- longitudinal, cross-sectional, experimental, and systematic reviews assessing lead exposure's health effects. Databases were screened based on inclusion criteria focused on cognitive, behavioral, or physiological outcomes linked to lead levels in blood or tissues. Across studies, childhood lead exposure was consistently associated with lower intelligence scores, behavioral disorders (e.g., aggression, hyperactivity, depression), and increased risks for mental health conditions. Occupational exposure, particularly among gas station workers and forecourt attendants, was linked to chronic fatigue, sleep disturbances, and potential neurodegenerative conditions like ALS. The neurotoxic mechanisms included oxidative stress, neurotransmitter disruption, and long-term accumulation in bones. Notably, even low-level lead exposure resulted in significant adverse effects, with no safe threshold identified. These findings underline the critical need for public health interventions including environmental regulation, routine blood lead screening, protective workplace protocols, and early childhood monitoring. Prevention and awareness programs are essential to reduce lifelong harm from lead exposure, particularly in vulnerable populations.

I. Introduction

Air pollution is caused by infrastructure development activities, transportation, industry and household activities that produce waste (Satmiadji et al., 2022). Recent studies have shown that lead exposure can significantly reduce cognitive function, affecting both children and adults by causing intellectual decline and behavioral disturbances (Ramírez Ortega et al., 2021). Exposure to Pb during childhood has been linked to reduced cognitive abilities in older age, highlighting its lifelong impact (Lee et al., 2022). In occupational settings, particularly among gas station workers, lead exposure occurs through the inhalation of fine particles, which can be toxic even at blood lead levels below 50 µg/dL (Al-Rudainy, 2010). Alarmingly, research also indicates an increased risk of developing Amyotrophic Lateral Sclerosis (ALS) among gas station attendants, potentially related to elevated lead concentrations in the body (Koski et al., 2023).

Despite these findings, several research gaps remain. First, much of the existing literature focuses primarily on children, with limited studies investigating the chronic impact of Pb

exposure on adults, especially in high-risk occupations such as fuel station attendants. This gap is particularly concerning given that adult lead exposure has been linked to cardiovascular and central nervous system effects, yet occupational standards may not adequately protect workers (Schwartz & Hu, 2007). Second, the relationship between the duration of occupational exposure and blood Pb levels is still unclear and inconsistently reported. For instance, studies in developing countries have shown elevated blood lead levels among battery manufacturing and recycling workers, but the correlation with exposure duration varies, suggesting the need for more longitudinal research (Gottesfeld & Pokhrel, 2011).

Third, the effectiveness of personal protective equipment (PPE) in lead-exposed workplaces remains under-evaluated. A study in Uganda's clay industry showed only 60% of workers consistently used PPE, with non-compliance linked to higher injury rates, highlighting the need for better PPE usage and assessment in similar settings (Sarah & Prudence, 2025). These gaps underscore the importance of further research to address occupational health risks and inform effective policy interventions.

Pollutants in the air such as carbon monoxide (CO), nitrogen oxide (NO), sulfur dioxide (SO2) and particles. These pollutants are very dangerous if they enter the body through the human respiratory system, these pollutants are very easy to enter the human body because they have a general size of less than 10 µ. Particles that are widely found in the environment such as dust and lead (Naria, 2005) **.**

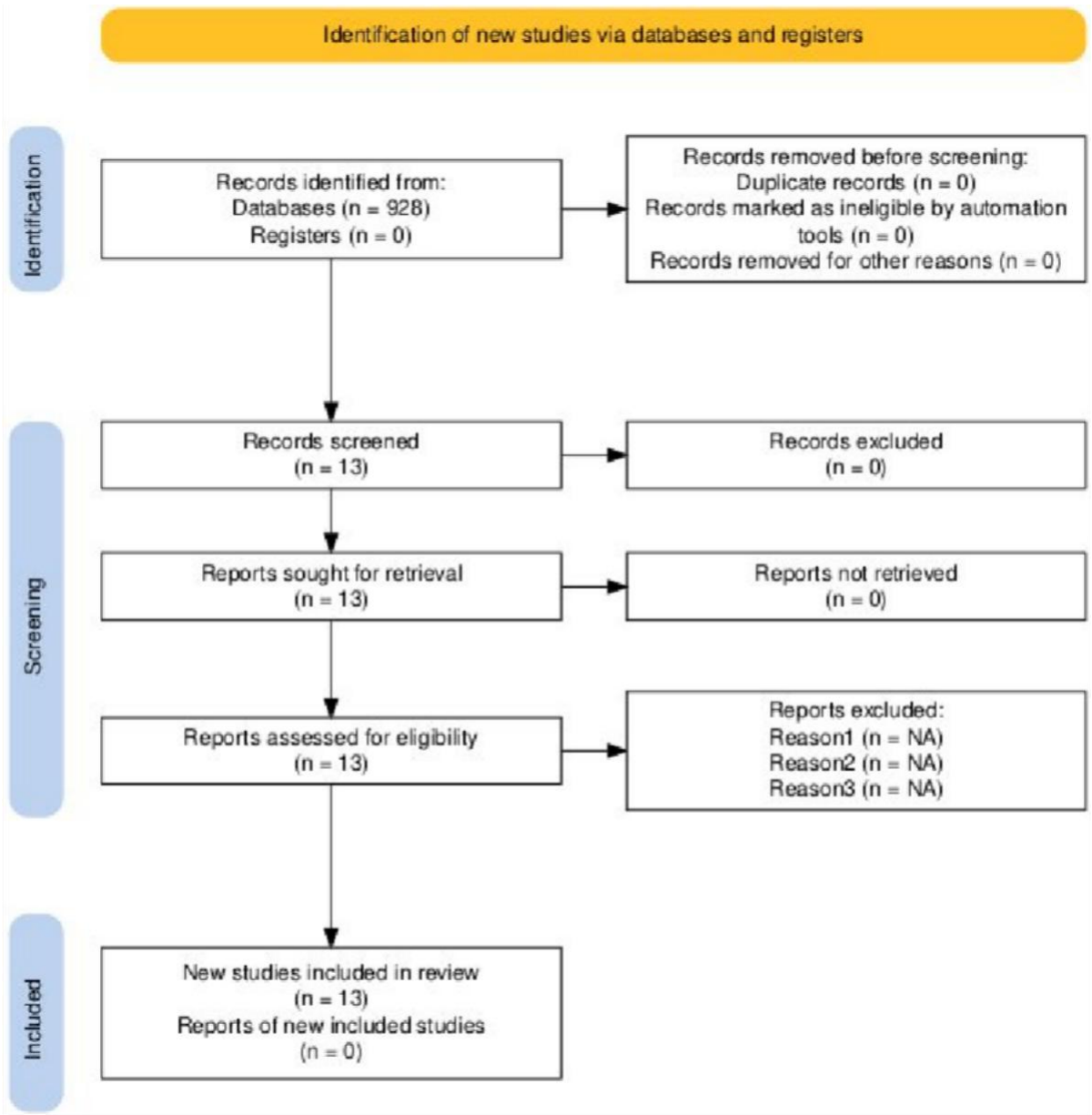
Lead or black lead or *plumbum* (Pb) is a metal that is widely used by humans. Lead is resistant to corrosion, solid and has a low melting point. Lead is usually used as an additive/complementary material for gasoline, coating iron pipes, welding, battery stones and batteries (A Marianti & Prasetya, 2013). Lead in gasoline is used to improve fuel quality, anti-*knock* , corrosion prevention, antioxidant, metal activator, condensation and coloring agent (Naria, 2005). Although it has a good effect for vehicles but not for humans, the presence of vehicles that use leaded gasoline will cause humans to experience lead poisoning. Chronic or acute exposure to lead will interfere with the health of the body. Lead enters the body through various ways such as the process of breathing, eating, swallowing, or drinking substances containing lead. To find out the presence of lead poisoning or to find out the level of lead in the body, medical personnel are needed. This is because lead accumulation can be detected from blood, bones, and hair. In hair, lead will be bound to sulfhydryl groups. (A Marianti & Prasetya, 2013). The safe level of lead for children according to *the World Health Organization* (WHO) is 10 µg/dl of blood, while for adults it is 10-25 µg/dl of blood. (Naria, 2005) **.**

Children are individuals who are very susceptible to Pb pollution, with Pb entering the child's body will cause various diseases including a decrease in *Intelligent Quotient* (IQ). The fetus in the womb can also be affected by Pb, because the mother accidentally inhales hazardous substances, especially Pb, which will then flow through the blood and penetrate the placenta. In addition, Pb content can also enter breast milk (ASI) so that it can interfere with the growth of the baby's brain. Not only the fetus is threatened with losing the quality of intelligence but also children in their growth period, where research has found that children who have high Pb levels will significantly have below average IQ. Every 10µg/dl increase in Pb levels in the blood will cause a decrease in IQ by 4-6 points. The effects of Pb not only have an impact on IQ, but also affect the digestive system, urination, hematopoietic and nervous systems (Syahrizal, 2009).

This literature review study is essential for synthesizing current evidence on the health impacts of lead (Pb) exposure, with particular emphasis on vulnerable populations such as children and occupationally exposed adults like gas station workers. A critical gap exists in understanding the chronic effects of Pb exposure in adults, as most existing research focuses primarily on pediatric populations, despite known associations with cardiovascular and neurological impairments in mature individuals. Furthermore, the relationship between duration of occupational exposure and blood Pb levels remains inconsistently documented, necessitating a comprehensive analysis of longitudinal data across different exposure settings. Additionally, emerging evidence linking prolonged Pb exposure to neurodegenerative disorders such as amyotrophic lateral sclerosis (ALS) underscores the urgency of revisiting occupational safety standards. By consolidating global findings, this review aims to provide evidence-based recommendations for strengthening public health interventions and regulatory frameworks to mitigate Pb-associated health risks.

II. Methods

The method used in this study is a literature study namely systematic review. A systematic review is a rigorous and structured method of synthesizing research evidence to answer specific research questions by identifying, appraising, and analyzing all relevant studies based on predefined criteria. In this study, the author uses data obtained from a literature study which means collecting information related to the topic of the research. The data will then be analyzed using a descriptive method that not only describes the facts but also provides understanding along with explanations (Habsy, 2017). Literature study is a scientific study that focuses on a particular topic by providing an understanding of the development of the topic. This study allows for identifying theories or methods, developing existing theories or methods, and finding gaps between theory and relevance in the field or to research results (Cahyono et al., 2019). Journals obtained through the process of searching for journals obtained from various *publishers* via *Google Scholar, Research Gate*, *Elsevier* have criteria in searching for articles in the form of original articles, full text and *open access*.



Graph 1 Identification, screening and included criteria of this systematic review.

III. Results and Discussion

The collective examination of selected studies underscores the profound impact of lead (Pb) exposure, particularly among children and occupationally exposed adults, with a pronounced emphasis on health, developmental, neurological, and behavioral outcomes. Numerous investigations indicate that no level of lead exposure can be considered safe, as even low-dose chronic exposure is linked to long-term adverse effects. Research focusing on childhood exposure consistently reveals negative associations between lead exposure and cognitive development, behavior, intelligence, and mental health, highlighting the vulnerability of developing systems to neurotoxicants. In occupational settings, studies on workers, such as gas station attendants, identify chronic health complaints and potential associations with neurodegenerative conditions like ALS, further emphasizing the pervasive risks of lead exposure in high-risk environments. Environmental and physiological studies provide nuanced insights,

with some reports suggesting minimal physiological impact in specific populations due to limited exposure or effective protective measures. Methodologically, the reviewed studies encompass longitudinal, cross-sectional, observational, and systematic reviews, contributing to a diverse evidentiary base. PRISMA-compliant systematic reviews synthesize robust evidence on cognitive impacts, while descriptive and experimental studies furnish empirical data on exposure levels and symptomatic manifestations. Mechanistically, lead's interference with the central nervous system, induction of oxidative stress, and disruption of neurotransmitter systems elucidate its extensive behavioral and cognitive repercussions. Given lead's propensity to accumulate in bones and tissues, the long-term health implications remain significant, underscoring the necessity for vigilant monitoring, preventive policy implementation, targeted screening, and public education to mitigate these risks effectively.

Table 1. The included journal articles

Researcher	Method	Results
Reuben et al., 2019	Longitudinal research with data from large samples	Childhood lead exposure linked to negative personality traits in adulthood. There is a higher risk for mental health disorders such as depression and anxiety. Emphasizing the need to reduce lead exposure to prevent long-term impacts.
Salsabilla et al., 2020	Observational research with cross-sectional design	Blood lead levels in children are negatively associated with their health and development. Children with high lead levels tend to experience cognitive development problems and behavioral disorders. Emphasis on the importance of screening and reducing lead exposure to protect children's health.
Ramírez Ortega et al., 2021	Literature Review and Experimental Study Research	Lead exposure over the lifetime is associated with significant cognitive decline. Identifying multiple mechanisms of lead neurotoxicity, including oxidative damage and neurotransmitter dysfunction. Emphasizing the importance of early intervention and prevention to reduce the long-term impacts of lead exposure.
Arianty et al., 2020	Systematic Review Research	There is a negative relationship between blood lead levels and children's intelligence levels. Children with higher lead levels tended to have lower intelligence scores. Highlighting the need for prevention and monitoring of lead exposure to protect children's cognitive development.
Nurjazuli et al., 2021	Literature Review	Exposure to Lead from the environment has a significant contribution to stunting in toddlers. Exposure to this heavy metal inhibits the absorption of nutrients from food, leading to nutritional deficits and decreased physical growth. There was a negative change between Pb exposure and children's cognitive scores, indicating that the long-term effects of this exposure affect not only physical growth but also mental development in children.

Researcher	Method	Results
Grover & Jhanda, 2017	Literature Review	Lead is a harmful metal that impacts nearly every system in the body, particularly targeting the central nervous system. Various body tissues, such as blood, bone, hair, teeth, nails, urine, and umbilical cord blood, can indicate lead levels, but blood is the most commonly used biomarker in research. Children are more susceptible to the negative effects of lead than adults. Both elevated and low levels of lead exposure in children are linked to brain damage, intellectual disabilities, hyperactivity, behavioral issues, antisocial behavior, violence, and juvenile delinquency. There is no safe threshold for lead exposure, and its effects during childhood can continue into adulthood, making it a significant public health concern.
Mohandoss & Thavarajah, 2017	Literature Review	Well-known health effects, especially in children who are most vulnerable. These general health effects begin to appear from birth through childhood. As they grow up with this metal in their bodies, they can develop more severe problems such as cardiovascular disease and violent or criminal behavior later in life. There is no safe level for lead; even small exposures can cause serious problems in exposed individuals. Reciprocal exposure from the air is responsible for a variety of health and behavioral problems such as increased anxiety, aggression, and attention problems observed among these children.
Hou et al., 2013	Questionnaire Survey	Blood lead levels were significantly negatively correlated with adaptive behavioral development intelligence, gross motor performance, fine motor performance, language development, and individual social behavior ($P < 0.01$). Compared with healthy children, more children with lead poisoning have abnormal behavior, especially social withdrawal, depression and unusual body movements, aggression and destruction.
Simbolon, 2018	Sampling Techniques	The concentration of Pb metal in sediment and green mussels is far above the quality standard so that green mussels from these waters are not suitable for consumption by the public.
Prasetya, 2021	Survey Methods, Questionnaires, and Laboratory Examination	There is no relationship between blood lead and the quantity of cells in the blood. Morphological examination of blood cells did not find any cell abnormalities and no *basophilic stippling was found.* Despite being exposed to vehicle smoke every day, street children do not experience lead poisoning and blood cell abnormalities.

Researcher	Method	Results
(Fajar et al., 2022)	Descriptive Quantitative Research	The study found that the majority of gas station workers were aged ≤30 years, male, and had been employed for ≥3 years, factors that contribute to increased risk of lead (Pb) exposure due to its cumulative nature. Most workers adhered to PPE protocols, especially during the COVID-19 pandemic, though improper use may have limited effectiveness. Common health complaints included fatigue (91.4%), headaches, irritability, sleep disturbances, and difficulty concentrating. These symptoms were more prevalent among workers with longer employment, normal BMI (18.5–24.9), and even among those compliant with PPE use—likely due to prolonged exposure, insufficient PPE knowledge, and poor hygiene practices. The findings align with previous studies indicating that chronic low-level Pb exposure significantly affects workers' physical and mental health.
(Koski et al., 2023)	Observational research with an analytical approach	The study explored the correlation between ALS (Amyotrophic Lateral Sclerosis) and occupational exposure to lead, particularly among gasoline station forecourt attendants. It was observed that these workers had significantly elevated blood lead concentrations, which increased with the number of years worked. This elevated lead exposure, likely from inhaling petrol fumes, is considered a potential risk factor for ALS. Several studies supported this connection, showing that long-term low-dose lead exposure can lead to clinical symptoms similar to ALS. Lead is known to accumulate in bones, and from there, it can enter the bloodstream and reach the brain and spinal cord, where it may affect motor neurons, the primary cells involved in ALS. Although the exact mechanisms are unclear, lead is known to induce oxidative stress and potentially interfere with neurotoxic proteins involved in ALS pathology. The study suggests that the risk of ALS among forecourt attendants could decrease in the future due to the global phase-out of leaded gasoline.
(Windusari et al., 2019)	Observational analytic study with a cross-sectional approach.	Blood analysis using the Shimadzu 6300 Atomic Absorption Spectrophotometer showed that lead (Pb) levels in all respondents were below 2.995 ng/nL, indicating that Pb was not detected in their blood. This absence of detectable lead is likely due to short exposure duration, consistent use of personal protective equipment (PPE) by the workers, and potentially low Pb content in current vehicle fuels. Although no Pb was found, regular monitoring is recommended due to the ongoing risk of exposure in fuel station environments.

The advancement in transportation and industry has caused some areas in Indonesia to no longer be a healthy place for children to develop. Every day a child must inhale exhaust fumes, especially other lead that can be inhaled by children. Research conducted by Soesanto on lead in the blood of school children in Surabaya (in dense traffic areas ranged from 16.3 pg/dl to 39.7 pg/dl. Albalak et al. in 2003 stated that the blood of elementary school children in DKI Jakarta aged between 6 and 12 years had been contaminated with lead. (Syahrizal, 2009). Children absorb lead 4-5 times more than adults. Infants, children, and pregnant women are the individuals most susceptible to the side effects of lead exposure. (Bell & O'Grady, 2004). Lead can enter the human body by being inhaled, swallowed, or absorbed through the skin. Almost all inhaled lead will be absorbed by the body, while swallowed lead is usually absorbed by 20-70%, and children absorb more than adults. The following is a table of the level of Pb poisoning in the blood of children and its effects on their health and development.

Lead or black lead or plumbum (Pb) from motor vehicles is very dangerous, the lead gas produced comes from the combustion of gasoline additives, in the form of Tetraethyl Lead (TEL) and Tetra Methyl Lead (TML). The research results are also supported by previous studies that contain links between lead and psychological disorders in the following table:

Table 2 The effect of Lead level Poisoning in Children

Group	Lead Levels in Blood	Effects on Children
1	1-9 µg/dL	Learning Disorders
2a	10-14 µg/dL	Hearing Loss, Slow Growth, Learning Problems
2b	15-19 µg/dL	
3	20-44 µg/dL	Headache, Weight Loss, Nervous System Disorders
4	45-69 µg/dL	Anemia, Severe Abdominal Pain
5	>69 µg/dL	Brain damage leading to death

source: center for disease control and prevention (2000)

According to the World Health Organization (WHO), children who are severely poisoned by lead can experience mental retardation and behavioral disorders, in addition lead poisoning can also cause a decrease in intelligence quotient (IQ), and behavioral changes (increasing the risk of antisocial behavior), trigger permanent intellectual disabilities, or brain development disorders, in high levels can cause kidney damage, seizures, loss of consciousness, and even death. The toxic effect that attracts much attention is the toxic effect of Pb on infants and children. Low levels of Pb cause irreversible brain damage that affects learning/memory disorders and decreased intellectual capacity. Previous research results have shown that exposure to lead can affect children's intelligence. The United States has the highest proportion of lead levels, namely 5 - 9.9 µg / dL, which has the potential to reduce IQ by 7.4 points. This finding is consistent with previous studies, which estimate a decrease in total IQ of 4.1-5.4 points for every 10 µg / dL increase in blood lead levels at ages 4, 9, and 11 years. Other studies have also shown a decrease in IQ of around 4.9 points at lead levels between 5 and 9.9 µg/dL. Lead exposure can be caused

by various factors, including vehicle emissions, old housing, poor neighborhoods, used battery smelting, polluted waterways, household appliances, parental education, industrial activities, canned foods, paint formulations, baby chew toys, and dust in the home (Arianty et al., 2020).

Combustion gas from gasoline contains compounds PbBrCl, PbBrCl.2PbO, PbCl2, Pb(OH)Cl, PbBr2, and PbCO3.2PbO, among these compounds PbCO3.PbO is the most dangerous compound for health (Gusnita, 2012). The Threshold Limit Value (TLV) for lead levels in the blood is 10 μg/dL, but according to the California Department of Public Health (CDPH) if lead is detected in the blood > 5 μg/dL it will cause health problems. Because of its cumulative nature, if exposed to Pb continuously or high enough it will cause health problems, one of which is complaints in the central nervous system (Humairo & Keman, 2017). This happens because Pb that is absorbed through inhalation will enter the bloodstream, then penetrate the body's tissues and cells through the endothelium and fenestra capillaries, including entering the nerve tissue. Nervous or brain tissue is protected by a special vessel structure (brain blood barrier), making it difficult for toxins to enter, but according to Wang (2011), Pb is able to pass through the brain blood barrier.

The entry of Pb into the brain will affect the brain, especially the cerebral cortex, cerebellum and hippocampus, in addition to the possibility of damage to the structure of blood vessels in the brain so that it can cause bleeding and swelling in the brain. Through examination with Magnetic Resonance Imaging (MRI), it was found that Pb initially affects the gray matter of the prefrontal. The reduction of gray matter from the prefrontal is related to the emergence of criminal behavior, and antisocial personality disorder. Pb levels in the blood also affect the process of neurotransmitter delivery in synapses. Pb2+ ions will cause spontaneous augmentation in the transmission of neuron synapse impulses. This augmentation causes inhibition of the release of neurotransmitters including serotonergic synapses. Serotonergic synapses are synapses that have the neurotransmitter serotonin, while the neurotransmitter serotonin is one of the neurotransmitters responsible for influencing behavior. Normal Serotonin levels function to maintain emotional stability. Serotonin also plays a role in personality traits of depression and anxiety, and is involved in brain development. Serotonin disorders will cause increased aggressive and impulsive behavior (Aditya Marianti et al., 2015). According to Schneiders (1955), aggressive behavior is an emotional outburst in the form of destruction of goods and objects with deliberate elements expressed through words (verbal) and non-verbal behavior (Susantyo, 2011). In addition to behavioral disorders, there are symptoms that can arise such as experiencing anxiety, numbness, fatigue, hands often shaking and tingling, decreased memory, frequent cramps, body aches, irritability and ringing in the ears (Humairo & Keman, 2017).

Continuous use of leaded gasoline will be very dangerous for Indonesian people and even the world, because Pb emissions from exhaust gases will cause air pollution wherever the vehicle is, According to the Environment Project Agency, it was found that around 25% of Pb is in vehicle smoke filters and 75% pollutes the air. (Purwoko & Prastiwi, 2019) Gasoline combustion will produce 0.09 grams of lead per 1 km. Imagine if in Surabaya, every day there are 1 million transportation units moving 15 km, it will emit 1.35 tons of Pb/day (Gusnita, 2012).

Lead (Pb) exposure has a significant impact on mental health and development in both children and adults. In children, lead exposure can cause serious cognitive impairments,

including reduced IQ and developmental delays. Research indicates that even low levels of lead in the blood (<10 μg/dL) can contribute to declines in intellectual ability and neurodevelopment, affecting children's learning and social behavior (Setiawati et al., 2020). Children exposed to lead are also more likely to experience behavioral problems, such as hyperactivity and aggressiveness, as well as difficulties in emotional regulation. Additionally, lead exposure has been linked to an increased risk of attention deficit hyperactivity disorder (ADHD) and other behavioral disorders (Kustiningsih et al., 2020). Meanwhile, in adults, lead exposure is associated with various mental health issues, including depression and anxiety. Studies show that adults exposed to lead have a higher risk of mood disorders and cognitive decline. Lead can damage the central nervous system, contributing to memory loss and reduced critical thinking abilities (Prasetya, 2021). Furthermore, long-term exposure to lead has also been linked to an increased risk of neurological diseases such as dementia. Thus, both children and adults are highly vulnerable to the negative effects of lead exposure, making it crucial to raise awareness about these dangers and take appropriate preventive measures.

In order to overcome this, the Ministry of Environment (KLH) has implemented the 'Blue Sky' program. This program is an annual routine monitoring of the quality of gasoline and diesel fuel in Indonesia. The goal is to control the quality of fuel consumed by the community, so that the data obtained can gradually encourage producers to produce environmentally friendly/unleaded fuel. In 2006, KLH monitored 30 cities in Indonesia, one of which was Surabaya. The results showed that fuel marketed in Indonesia showed improvement, where in 2006 gasoline still contained an average Pb of 0.038 gr/l, while in 2007 the average Pb value was 0.0068 gr/l. Of the 30 cities monitored, 10 cities had undetectable lead content (Gusnita, 2012). There are efforts to eliminate leaded gasoline that have been initiated in Indonesia as stated in Law No. 23/1997 and the instruction of the Indonesian Minister of Environment and Forestry in 2000 for the gradual elimination of leaded gasoline throughout Indonesia, initially targeted for 2005 but in reality until now it has not been completed.

In addition, motorized vehicles that do not use BBM (Fuel Oil) are needed, so the innovation of electric vehicles emerged. One of them is an electric car. Electric cars do not use combustion engines as driving power but use electric motors so that their emissions are zero. At this time electric vehicles have begun to be sold freely on the market. The battery used as an energy source is in accordance with EPA (Environmental Protection Agency) standards (Santi, 2001).

To overcome this problem, the government has a big role to play in controlling lead (Pb) pollution. With the authority it has, the government can design city plans and traffic signs that allow vehicles to run smoothly, control Pb pollutants periodically during vehicle tax and impose sanctions on violators. In addition, efforts to reduce Plumbum pollution in the air are not only the government's task, but also the responsibility of the entire community (Devi Nuraini Santi, 2001). For this, it can be done by providing intensive information about the impact of Pb on health and the environment and how to overcome it, especially for the elderly.

Recent findings from a study of gas station workers reinforce these concerns. The majority of the respondents were young adults (≤30 years), male, and had worked for ≥3 years factors that increase vulnerability to cumulative Pb exposure. Despite compliance with personal protective equipment (PPE) protocols, particularly during the COVID-19 pandemic, symptoms

such as fatigue (91.4%), headaches, irritability, and difficulty concentrating were common. These symptoms were more frequent among those with longer employment duration, normal BMI, and even among those using PPE, suggesting that exposure may still occur due to improper PPE use, limited safety training, or poor hygiene practices. Blood analysis, however, showed Pb levels below detection (<2.995 ng/nL), possibly due to shorter exposure durations and the reduced Pb content in modern fuels. Nevertheless, the risk of exposure remains, particularly in high-traffic urban areas, supporting the need for regular health monitoring.

Moreover, long-term occupational exposure to Pb has been associated with neurodegenerative diseases such as Amyotrophic Lateral Sclerosis (ALS). Research indicates that elevated blood lead levels in workers increase proportionally with years of employment and may serve as a risk factor for ALS. Lead can accumulate in bones and later migrate into the bloodstream, reaching the brain and spinal cord and disrupting motor neurons the key cells affected in ALS. While the exact mechanisms are unclear, oxidative stress and interference with neurotoxic proteins are believed to play a role. With the global phase-out of leaded gasoline, such risks may decrease in the future, but current exposures in occupations like fuel handling remain concerning.

By knowing these impacts, it is expected that public awareness will arise, especially parents, to educate and control their children to make efforts to minimize exposure to the impacts of Plumbum (Pb) itself, such as increasing the use of masks everywhere, especially when using motorized vehicles and on the road. In addition, efforts to reduce Pb in the air are not only the government's task, awareness is also needed for each individual, so it can be done by knowing the impacts of Pb on health and the environment and how to overcome them, and for drivers, vehicle owners, mechanics or technicians can find out the causes of increasing Pb pollution and know how to drive a vehicle properly and correctly so as to maintain engine efficiency and fuel consumption. Driving methods that cause wasteful fuel and cause pollution such as drivers playing the gas pedal when the vehicle stops (Santi, 2001).

IV. Conclusion

Lead exposure poses severe health risks, particularly to children and occupationally exposed adults, causing cognitive, developmental, and neurological impairments. Studies confirm that no level of lead exposure is safe, with chronic low-dose exposure linked to long-term harm. Occupational settings reveal associations with neurodegenerative diseases like ALS, while environmental factors highlight persistent risks despite regulatory efforts. Preventive measures, including policy enforcement, public education, and regular monitoring, are crucial to mitigate these dangers. Addressing lead exposure remains a critical public health priority to safeguard vulnerable populations

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