The negative effects of lead paint on different physiological systems

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Abstract

Lead (Pb) in paints is a serious public health hazard that has piqued the international community's interest. Lead concentrations in lead-based paints have been assessed in several research conducted across the world. As a result, the goal of this article was to describe the findings of these research, give some knowledge of their human health consequences for law enforcement, and promote public awareness. The most notable gaps found have been highlighted in order to open the door for additional research efforts aimed at producing thorough data on this subject.

Some of the evaluated studies found considerable amounts of lead in paints that were considerably over the allowable limits, despite the many regulatory controls on lead content in paints that exist worldwide. There have been reports of children cases of lead poisoning in a number of nations, including South Africa, France, Morocco, and the US. Lead levels in South Africa (145,000 ppm), China (860,000 ppm), and the US (22,550 ppm) have all been found to be high. 4,485.11 ppm in Thailand, India (104 ppm) and Palestine (6036 ppm).

As a result, tight law enforcement measures pertaining to the progressive removal of paints containing lead and the management of lead content are required throughout the globe.

Keywords

Paints, Lead in paints, Lead exposure, Lead control

1.1 GENERAL INTRODUCTION

Because of its availability, affordability, and physical characteristics, Colorants, ceramics, batteries, fuel, pipelines, and beauty products are just a few of the products that have included lead and its related compounds as components (Bawa, et al, 2015; Johnson, et al, 2009). One heavy metal that is found naturally is lead. It is highly hazardous at very low exposure levels and has both acute and long-term impacts on the environment and human health (Karrari, et al, 2012). In addition, this heavy metal causes cancer and is a neurotoxic (Ismail, and Azlan, 2020). and when exposed to high concentrations in humans, it harms the immunological system, the nervous system, the liver, kidney, and cardiovascular system (Pratinidhi, et al, 2014). Lead poisoning is a problem related to the environment. has long-term, irreversible impacts on health In addition, lead is regarded as one of the anthropogenic contaminants, people can be exposed to lead through contaminated food, water, air, and soil, as well as through previously employed leaded fuel (Monna, et al 2006).

1.2 Metals that are heavy

Heavy metals are naturally occurring elements having an atomic weight greater than five times that of water and a density greater than that of water. Applications for heavy metals are many and include industrial, agricultural, medicinal, and technical fields. This has caused them to become widely dispersed across the ecosystem, which has led to worries about their possible implications on the environment and human health. When present in relatively high concentrations, all heavy metals are hazardous. The group of elements known as heavy metals is heterogeneous, with significant differences in its chemical composition and biological roles. Their toxicity is dependent on a number of variables, including as the chemical species, dosage, and mode of exposure, as well as the age, gender, genetics, and nutritional status of those exposed (Tchounwou, et al 2012).

2. METHODOLOGY

Extensive searches of academic databases, including Science Direct and Google Scholar, produced the publications reviewed in this work. Using life research databases (HINARI, OARE, and AGORA), further papers were discovered. Subject to academic research
like master’s or PhD theses, government reports, and peer-reviewed articles were the main focus. The key phrases were “lead-based paints”, “lead in paints”, “lead poisoning in children”, “children exposed to lead”, “Blood lead levels in humans”, “regulations on lead-based paints” with “control of leaded paints”. The gathered papers’ references were also examined, and those whose titles had anything to do with the study’s objective were found and assessed. All articles discussing the effects of lead on people, lead-based paint, laws, and lead-based paint control met the inclusion criteria. Included were publications on hospitalizations, clinical reports, and epidemiological studies pertaining to lead poisoning.

3. STATEMENT OF THE PROBLEM

One of the most important public health issues facing the globe today is lead poisoning. Over 800,000 people die from lead poisoning every year, with poorer countries suffering the greatest toll, according to UN Environment. There is a connection between lead poisoning and children developing intellectual disability. Lead exposure causes irreversible brain and behavioral damage; there is no safe level of exposure. Pb poisoning is a widespread problem that affects the entire community, but it particularly affects children. It is estimated that about 0.6 million children globally suffer from mental impairment as a result of high blood lead (BPb) levels annually. PVC toys, which are especially harmful to children, and dust from crumbling lead-based paint-coated home walls are significant sources of lead pollution. Paints and PVC toys are manufactured using lead compounds as components. The problems with PVC toys are even worse when they are painted with lead-based paints. The paint industry is growing annually, according to records, which means that unless the international community fully supports the current initiative, led by WHO and UNEP, to phase out lead-based paints and find alternatives to replace the lead additives used in them, the problem of lead poisoning from these products is likely to continue expanding. Several investigations into the levels of lead in paints have discovered significant levels of lead well over the permissible limits. Moreover, elevated amounts of lead (Pb) have been found in human blood samples from individuals linked to lead poisoning from lead-based paints, above the WHO-recommended threshold of 10 mg dL^-1. Cases of lead poisoning in children resulting from exposure to lead dust associated with lead-based paints have also been reported in several countries worldwide. In light of these findings, the purpose of this review study is to clarify the current issues with lead poisoning, specifically as it relates to lead-based paints. There are gaps in the research, and suggestions on how to make things better have been made.

4. OVERVIEW OF PAINTS CONTAINING LEAD

Paint may be any liquid that solidifies into an opaque form after being applied in thin layers to a substrate. Paint is typically used on the outside and inside of buildings, as well as other surfaces that are seen to be significant, as a decorative or protective substance. The term “enamel decorative paint” describes oil-based paints that have been mixed with leaded chemicals, which serve as both anti-corrosive agents and drying catalysts for metal surfaces. Compared to water-based paints, enamel paints are more widely available because of their lower cost (Johnson, 2009).

Paint producers have historically intentionally added lead compounds to paint compositions for a variety of purposes, such as color enhancement, surface protection against rust and corrosion, and drying time acceleration (Kessler, 2014). According to their study, (Johnson, et al 2009) lead (II) chromates (It produces the paint hues orange, red, green, and yellow), lead molybdates (red orange), lead oxides (red lead), and lead (II) carbonate (white lead). are among the frequently utilized lead compounds as pigments. Also out that less harmful alternatives to lead additives, such as non-leaded paints, driers, and anti-corrosive chemicals, are already on the market and have been used since the 1980s. Paint producers create the best paints possible using the available lead alternatives, and they primarily sell their products to nations with stringent laws prohibiting using paints with lead. Paints containing lead produced by many businesses around the world are sold in nations without strict laws regulating lead-based paints and where people are less aware of the risks associated with them. Lead exposure generally puts human health at risk (Tong, et al 2000). However, because children absorb lead more readily through their gastrointestinal tract than adults do, they are thought to be more vulnerable than adults (Meyer, et al 2008). Lead exposure in children has been linked to neurological and behavioral issues like mental retardation and poor memory (Toxic Substances Agency
and Disease Registry, 2015). As seen in Fig. 1 below, Asia leads the world in paint production, followed by Europe, with the oceans producing the least.

![Paint and coatings production worldwide](image)

**Fig. 1.** Paint and coatings production worldwide (Njati, and Maguta, 2019).

5. LEAD EXPOSURE

5.1. Adult exposure to lead

Adults are often exposed to lead through their jobs, where inhalation is the most common method. Occupational exposure occurs when lead-based paint manufacture, application, or removal procedures are not executed safely. According to studies, the following are possible work-related activities that could expose one to lead smelting, mining, refining, and informal lead recycling; using leaded gasoline; producing and recycling lead-acid batteries; soldering; making jewelry; manufacturing ceramics and leaded glass informally and commercially; using leaded paints; disposing of electronic waste; and using leaded water pipes (Clark, et al. 2006). When repainting or removing old, heavily painted surfaces coated with lead-containing industrial paints, construction workers are at a heightened risk of lead exposure due to the considerable lead contamination that is created in massive amounts of dust (Gottesfeld, 2015). When producing, applying, maintaining, repainting, or removing industrial paints, people are typically exposed to high quantities of lead. Lead exposure can also occur outside of the workplace, when individuals of all ages are exposed to lead via the drinking water, contaminated fruits and vegetables, dust, soil, and air (Finster, et al. 2004).

5.2 Lead exposure in children

Children are another group that is very susceptible to lead exposure. This is mostly because they play with toys that have been painted with lead-containing paints, and they are also exposed to lead-contaminated dust and dirt that comes from the breakdown of lead paint (Akkus & Ozdenerol, 2014). To find out how much lead is in PVC toys and other plush toys overall, several studies have been conducted across the world. Results show that most samples had lead tests that were positive (Ghaly, et al. 2013). It has been demonstrated that children are considerably more vulnerable to exposure to particle lead in soil when they consume it through soil or home dust than when they consume paint chips (Patrick, 2006).

6. THE EFFECTS OF LEAD ON HUMAN HEALTH

Lead content has no useful role in the human body; rather, it is a strong and persistent neurotoxin that is predominantly absorbed by eating and inhalation. Stated that when lead enters the human body, it attaches itself to erythrocytes and makes its way via the blood to soft bodily parts including the brain, lungs, muscles, heart, liver, spleen, and kidneys. After about intake, 80% to 90% of the lead is eliminated, with the remaining lead bioaccumulating in insoluble form in teeth, bones, and hair, where it can persist for decades (Meyer, et al. 2008). Industrialized nations have gradually discontinued using lead-based paints in homes due to health risks. Preschool-aged children and pregnant women and their fetuses are the groups most susceptible to the effects of lead, even at extremely low blood lead levels, being an essential component in a child’s growth (Finkelstein, et al, 1998). Lead has the ability to substantially replace the majority of calcium, iron, and zinc in body cells, impairing these ions’ essential functions in the human body (Sanders, et al, 2009). Moreover, Sanders et al, (2009) noted that infants’ vulnerability to lead neurotoxicity is believed to be caused by the absence of a blood/brain barrier, whereas lead’s capacity to substitute calcium is
assumed to be a likely cause of its ability to cross and harm the barrier. Lead exposure affects the cardiovascular, gastrointestinal, neurological, and renal systems in addition to growth and development (Makokha, et al. 2008).

6.1. Lead's neurotoxic effects

The nervous system is the major target of lead poisoning in kids and adults alike. The central and peripheral nerve systems are both affected by lead. The peripheral neural system is severely harmed in adults, but the central nervous system is more severely impacted in kids (Flora et al. 2012). Headache, muscular tremors, delirium, convulsions, paralysis, and coma are the most common symptoms of lead poisoning. Irritability, lack of focus, memory loss, and hallucinations are some of the other symptoms. Lead poisoning in children is related with cognitive impairment because lead disrupts nervous system development (Bellinger, 2005). Many studies have found an inverse connection between blood lead levels and cognitive impairment. According to the World Health Organization's 2010 cautions regarding childhood lead poisoning, lead poisoning causes irreparable brain damage, as well as other repercussions such as reduced IQ, attention impairments, and behavioral abnormalities. (Lanfear, et al. 2000). They studied the relationship between blood lead poisoning and lead concentrations, as well as the results of four cognitive performance tests (reading comprehension, proficiency in math, nonverbal reasoning, and short-term memory) on 4,553 American children aged 5 to 17 years. Findings showed that average scores on the four cognitive ability tests fell with each one milligram the dl-1 increase in blood lead level. Children's reading and math performance has also been shown to suffer when their blood lead levels are below 5.0 milligrams the dl-1 (Chiodo, et al. 2007).

6.2 Toxicty of the immune system

Immune system's primary functions in humans are to defend the body against bacteria, viruses, parasites, and fungus and to eliminate cancerous cells (Marh., et al. 2001). One of the physiological systems most vulnerable to lead's effects is the immune system. Said that because lead is an immunological toxin, it impacts immunity parameters and hormone levels. Lead-induced immunotoxicity changes T lymphocyte and macrophage production and metabolism. (Dietert, and Piepenbrink, 2006). This results in functional changes to the numbers of immunocompetent cells, which in turn causes immunosuppression. This increases the body's vulnerability to cancer, autoimmune illnesses, and infectious agents (Gidlow, 2004).

6.3 Renal toxicity function

A correlation between lead poisoning and kidney disorders in humans has been identified and established by several studies. High lead exposure during an acute episode can cause renal tubular injury. The kidney's glomerulus is damaged by prolonged exposure to high lead concentrations, which impairs the glomerulus's capacity to filter out large molecular weight proteins. Heavy-weight proteins such as albumin and macroglobulin are therefore excreted more often in the urine as a result of this (Adham, 1997). However, long-term lead nephropathy results in permanent kidney failure linked to hypertension and hyperuricemia (Rastogi, 2008).

6.4. Reproductive effects

Numerous negative impacts on both male and female reproductive health are brought on by lead exposure (Bellinger, 2005). Lead is regarded as one of the fetal toxicants that can pass through the placenta in a pregnant women and suffer from a degenerative impact on the growing fetus (Flora, et al. 2012). mentioned a wide range of unfavorable pregnancy outcomes associated with lead exposure, including as early rupture of the membranes, a small birth weight, early delivery, spontaneous abortion, elevated blood pressure throughout the pregnancy, an increase in prenatal fatalities, and limitations on postnatal growth and development. However, it was also noted that males are more vulnerable to diminished libido, aberrant prostatic function, and aberrant spermatogenesis (number, morphology, and motility) as a result of lead exposure (Nriagu, 1988).

6.5. Cardiovascular toxicity

How effectively the cardiovascular system works is determined by the complicated interactions between the immune system, smooth muscle, arterial endothelium, and nervous system. One dangerous heavy metal is lead that also poses a risk to the environment. According to the Agency for Toxic compounds and Disease Registry's priority list of hazardous compounds, lead exposure over an extended period of time clearly
causes major health concerns to humans. (Registy of Diseases and Toxic Substances Agency, 2015). Most risk factors for cardiovascular disease, such as high blood pressure, cholesterol, obesity, tobacco use, sedentary lifestyle, diabetes, and prolonged exposure to lead, are preventable (Sharma, and Purohit, 2014).

The emergence of heart-related conditions like coronary heart disease, peripheral artery disease, and arterial hypertension, and irregular cardiac rhythms has been linked to ambient lead exposure, according to several studies (Prozialeck, et al. 2008).

6.6 Hematological toxicity

After being absorbed, lead enters the bloodstream, where it is bonded to erythrocytes to the extent of over 95% (Patil, et al. 2006).

One of the known clinical signs of lead poisoning in humans is anemia, which is primarily brought via decreased heme synthesis and increased erythrocyte degradation rates (Nikolić, et al. 2008). Haematological results of battery manufacturing employees who had been exposed to lead at work for approximately fifteen years, according to Patil et al (2006). Lead intoxication disrupted heme biosynthesis, resulting in a decrease in erythrocyte counts and haemoglobin concentration.

7. PAINTS BASED ON LEAD AND THEIR LEAD CONTENT

The American Public Health Association’s allowable paint level, which was amended in 2009 and was subsequently reduced from 600 ppm to 90 ppm, was also in use (adapted) in many other nations throughout the world. The “Model Law and Guidance for Regulating Lead Paint” was introduced by UN Environment in September 2017 and included 90 parts per million of lead. Apart from the United States, several nations have adopted the 90 ppm allowable upper limit of paint-soluble lead, but the majority of them continue to use 600 ppm. These nations include the Europe, the Philippines, China, India, Nepal, Tanzania, Kenya, and the Union. This suggests that the two limitations have been applied concurrently starting in 2009 (Kumar, 2009).

Parts per million. The highest value of 63 ppm was reported in samples. The International POPs Elimination Network (IPEN) and Toxic Link collaborate with other partner groups across many nations, conducted preliminary background research in 2008 to ascertain the amount of all lead present in newly manufactured decorative paints sold in developing nations. This action was taken in response to the decision made at the 2008 Dakar, Senegal, Sixth session of the International Forum on Chemical Safety. Paint samples were gathered and analyzed for that study in a variety of nations, including Brazil, Belarus, Mexico, Nigeria, Senegal, South Africa, Sri Lanka, Tanzania, and Thailand. The majority of the samples in every country under investigation showed lead levels over the 600ppm permitted limit, according to the study’s findings (Link, 2009). 84% of the samples that were analyzed in the 2008 Lead levels in enamel paints were measured in India, and the results exceeded the permissible limit of 600 parts per million. The amounts of lead ranged from 25 ppm to 140000 parts per million. (Kumar, and Gottsfeld).

In 2013, IPEN conducted a study financed by UNEP that evaluated 234 enamel paint cans from nine different countries: Uruguay, Argentina, Azerbaijan, Chile, Cote d’Ivoire, Ethiopia, Ghana, Kyrgyzstan, and Tunisia. Sixty-seven percent of the paint samples from five countries (Ethiopia, Azerbaijan, Kyrgyzstan, Cote d’Ivoire, & Tunisia) had an average lead concentration was found to be higher than the current 90 ppm U.S. EPA permissible level. Samples taken from Cote d’Ivoire had the highest lead content, which was measured at 260,000 from Uruguay, while the greatest 1,100 parts per million was found in samples from Chile. The 2013 IPEN/UNEP study said that the laws and regulations governing the maximum allowable concentration of lead content in paints, which was 600 ppm, were to blame for the Uruguayan samples’ low lead concentrations (Njati, Maguta, 2019).

8. LAWS GOVERNING LEAD IN PAINTS

In poor nations, the effects of long-term low-dose lead exposure on public health have received very little consideration. The production, import, sale, and use of lead-based paints for residential and commercial building exteriors are governed by laws, rules, or mandated norms in industrialized nations (North America and Europe) (Adebamowo, et al. 2007). Just four African countries—South Africa, Kenya, Tanzania, and Algeria—have confirmed legal limits for lead content in paints to prevent lead poisoning among their civilian population, according to a recent UN Environment report from 2017 on the status of global legal limits on the production, import, and sale of lead-based paints (Norgbey, S., 2017). Considering the worldwide effort
spearheaded through WHO/UNEP to phase out lead-based paints worldwide, Countries must set restrictions on lead-based paint manufacturing, import, use, export, and marketing. (Violet, 2017). In many poor nations, individuals continue to be exposed to dangerous paints that contain high amounts of lead even if there are readily available, reasonably priced, and safe substitutes. Exposure to lead accounts to 0.6 percent of the world's illness burden, with poor countries bearing a large portion of this burden (World Health Organization, 2009).

9. CONCLUSION

The continued use of lead-based paint in homes has raised concerns around the world (Kumar and Gottesfeld, 2008). The effects of environmental lead contamination are a global health problem. Lead is a cumulative poison that has an effect on most physiological systems. Every human being exposed to lead will suffer the risk of negative health effects, but children, pregnant women, as well as people who frequently work with lead paints are particularly at risk. Exposure to lead often leads to harmful and irreversible health effects, such as learning impairment, behavior disorder, decreased fertility, heart disease, and others.

The International Agency for Research on Cancer has deemed lead a probable human carcinogen based on extensive evidence (Patrick, 2006). Lead poisoning is a risk for adults and children who handle lead-based paint. According to scientific and medical studies, children, especially those under seven years of age, who are exposed to lead are exposed to major consequences. Therefore, reducing exposure to lead is imperative to reduce the harmful health consequences that lead paints have on all people. The third goal of the Sustainable Development Goals for the year 2030, which focuses on ensuring healthy lifestyles and enhancing the well-being of society, will be achieved with the help of effective measures aimed at reducing exposure to lead resulting from lead paint.

The literature review revealed that, even with the development of substitute lead additives in paints and the enforcement of laws in numerous nations, paints with elevated lead content—up to over 270 times the allowable limit—remain extensively produced and utilized, particularly in developing nations. Furthermore, there is little doubt that as people's income rises, so does the usage of paint that contains lead in dwellings. Samples from various nations have been analyzed, and the results show that solvent-based paints and bright color paints (yellow, red, and orange colors, etc.) have greater lead contents than water-based paints. If strict control mechanisms are not put in place for lead paints when they are manufactured, people will remain exposed to high levels of lead, causing and endangering public health now and in the future. Many countries, as well as other international organizations such as the World Health Organization and the United Nations Environment Programme, are calling for measures to address the risks that exposure to lead can cause. It is imperative that developed and poor countries alike respond positively to these calls by implementing the necessary measures to protect the general public from this danger.

9. RECOMMENDATIONS

In light of the results of global studies revealed in this article regarding the lead content of lead-containing paints and the negative health effects on human health, we suggest this

- Adopting and upholding pertinent national, regional, and international laws and rules pertaining to paint manufacturing, import, export, use, and sale in order to prevent lead-based paints with excessive lead content from being sold.
- There is an urgent need to raise public awareness about the dangerous consequences of lead paints.
- To ensure that lead compounds in paints are no longer used, efforts must be made to persuade paint makers to utilize the easily accessible alternatives.
- Manufacturers ought to label items and paints with lead content warnings and indicate the amount of lead present.
- Lead control techniques in various paints are necessary to gradually eliminate environmental sources of lead pollution.

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