Analysis of Pb Levels in the Paint at Developing and Developed Countries (2010-2019): A Bibliometric Analysis

Analisis Kadar Pb pada Cat di Negara Berkembang dan Maju (2010-2019): Suatu Analisis Bibliometrik

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Abstract

Lead exposure is estimated to account for 0.6% of the world's health problems, with the highest-burden on developing countries. The purpose of this study is to study the difference in lead levels in paint in developed and developing countries. This research is a literature review. This method collects research from scientific articles from around the world that describe lead levels in developing and developed countries. The articles selected after going through inclusion and exclusion criteria are 28 journals. The article comes from five developing countries (Brazil, India, China, Indonesia, and South Africa) and five developed countries (United States, United Kingdom, France, Canada, and Japan). The result of this study is that paints in developing and developed countries have high levels of lead. Lead levels in paint in developing countries, namely, Brazil 59,000 ppm; India 134,000 ppm; China 1,677 ppm; and Indonesia 2254 ppm. Lead levels in developed countries are 62,934 ppm; England 152,000 ppm; Canada 24,000 ppm; France 149 ppm; and Japan 1,800 ppm. The conclusion of this study is that lead levels in paint in developing and developed countries are different. Lead levels in developed countries are higher than in developing countries, but both exceed the established quality standard of 90 ppm.

[*Paparan timbal diperkirakan menyumbang 0,6% dari masalah kesehatan dunia, dengan beban tertinggi di negara berkembang. Tujuan dari penelitian ini adalah untuk mengkaji perbedaan kadar timbal pada cat di negara maju dan berkembang. Penelitian ini merupakan studi literatur. Metode yang digunakan dalam penelitian ini adalah dengan mengumpulkan penelitian dari artikel ilmiah dari seluruh dunia yang menggambarkan tingkat timbal di negara berkembang dan maju. Artikel yang dipilih setelah melalui kriteria inklusi dan eksklusi sebanyak 28 jurnal. Artikel tersebut berasal dari lima negara berkembang (Brasil, India, China, Indonesia, dan Afrika Selatan) dan lima negara maju (Amerika Serikat, Inggris, Prancis, Kanada, dan Jepang). Hasil dari penelitian ini adalah cat di negara berkembang dan negara maju memiliki kadar timbal yang tinggi. Brasil 59.000 ppm; India 134.000 ppm; Cina 1.677 ppm; dan Indonesia 2254 ppm. Kadar timbal di negara maju adalah 62.934 ppm; Inggris 152.000 ppm; Kanada 24.000 ppm; Prancis 149 ppm; dan Jepang 1.800 ppm. Kesimpulan dari penelitian ini adalah kadar timbal dalam cat di negara berkembang dan negara maju berbeda. Kadar timbal di negara maju lebih tinggi daripada di negara berkembang, namun keduanya melebihi baku mutu yang ditetapkan yaitu 90 ppm.*]

I.   Introduction

Lead is a dangerous compound widely used that causes environmental contaminants and causes health problems in many parts of the world [1]. In the process of the lead, the industry is usually used as a sheath of wires, paints, glaciers, and ammunition bullets. In human life can be exposed to lead from objects related to human life processes such as in work that uses paint materials, such as paint milling, paint installation, sanding of objects containing paint, and cutting of paint-based materials (WHO, 2016). The lead circulating us has many sources, including gasoline, industrial waste, paint, soldering in canned food, and water pipes. The spread path to reach people can be through (such as air, household dust, street dirt, soil, water, and food (O'Connor et al., 2018). Lead is a toxic metal commonly used by the public. Lead exposure is estimated to account for 0.6% of the world's health problems, with the hyphens in developing countries. Reduced use of lead in gasoline, paint, plumbing, and soldering wording reduce lead levels in the blood. However, this is still a problem for developing countries due to the significant amount of lead exposure (WHO, 2016).

In 1977 the Consumer Product Safety Commission (CPSC) set the threshold value on paints at 0.06% or 600 ppm. In 2009 the CPSC set a change in the standard threshold value of a lead in home paints and paints associated with human life to 0.009% or 90 ppm. But there are still many items with paint coatings related to human life that have lead content exceeding 50% of the standard lead content

(Tarrago and Brown, 2017). Leaded paint is still used in many countries and is a major source of lead poisoning in children. Leaded paint is still sold in many countries, although the country has imposed a ban on leaded paints (UNEP, 2019). China, as a supplier of Lead (Pb) in paint and, is still widely used in many developing countries (O'Connor et al., 2018). WHO has designated lead as one of the top 10 public health co-ration chemicals that require action from every country to protect the health of workers, children, and women of productive age. Lead is dangerous for all ages, especially in children. This is because growth in the nervous system is the main target of lead exposure (UNEP, 2019).

The main focus of the world's lead removal is now turning to lead content in paints. WHO has been preparing a lead removal plan on painting since 2009 at the International Conference on Chemicals Management (ICCM). The purpose of this removal is to remove leaded paint to prevent exposure to children and minimize lead exposure in the workplace due to leaded paint (WHO, 2016). Besides, the removal of lead in paint is one way to realize some of the SDG's goals. At 3.9 points, it says that by 2030 it is expected to reduce the death and pain rate due to chemicals and water, air, and soil pollution. Besides, at point 12.4, it is mentioned that by 2020 it is expected to achieve environmental management of chemicals and all waste materials through life cycles, through international coordination, and significantly reduce chemical contamination in the air, water, and soil to minimize the impact on human health.

ILPPW (2019) it is stated that children living in middle and low-income countries, who are poorly regulated or do not even have policy rules regarding the use and exposure of leaded paints, have a great risk of exposure to lead. Countries that have set rules against lead paint ban only 37% of countries, while 40% of countries do not have a policy on the use of lead in paint and the remaining 23% have no data available regarding lead use in their country (UNEP, 2019). In the WHO's business strategy (2012), the action plan in 2014-2020 is to raise awareness and add public information as capital to achieve the global alliance goals by 2020. The goal of the global alliance by 2020 is to expect all countries to have regulations, regulations, standards, or procedures to control the production, import, sale, and use of lead (WHO & UNEP, 2013). Therefore, the entire country of 2020 is expected to be free of leaded paint exposure. Developing countries must catch up in tackling lead in paint to protect communities and achieve targets from global alliances.

II. Literature Review

Sources of lead pollution vary widely; all places can be a medium of lead pollutants (Tarrago and Brown, 2017). The main source of lead pollution today is lead-containing paints. Paint is very easy to find in human life; almost every object uses paint as a coating material. Paint is commonly used on the walls of indoor and outdoor houses. Paint is also commonly used as paint for architectural house

structures. Besides, paint also leads to paint sold to the community for anti-corrosive on the house, such as the use of bicycles, windows, gates, and other objects with iron surfaces. Paint is also commonly used for industries such as automotive coatings and toys (Kessler, 2014).

Developing countries with low incomes tend to have worse health systems than developed countries. Many deaths in developing and poor countries occur due to disease conditions that should be preventable. Precautions ranging from government policies to the promotion of public health for preventing purposes are often ignored in developing and low-income countries (Putri, 2019). Preventive measures using health promotion can increase awareness and improve people's behavior. Meanwhile, promotive servants to the community are expected to improve public health and prevent the public from healthy.

Developing countries have a considerable gap compared to developed countries. A study showed that in developed countries, 47% of respondents, who are people in the country, agreed that the health system applied in the country is quite good. Expectations for health continue to increase in developed countries so that the country's health system is getting better.

III. Methods

This research is research with a method of literature review. This method collects research from all scientific writings according to the topics studied. Writing can be a research journal, peer review article, thesis, or book (Shukla, 2017). The literature used is related to lead content in paints in developing and developed countries. This method was chosen because the issue of lead in paint is an issue for communities around the world—International Health Organizations such as those who have targeted eliminating lead content in paint by 2020. Therefore, research on lead in paint is widely conducted in various countries to blind still exist or not lead in paint in developing and developed countries. This research uses secondary data. The main data source used in this study is data derived from several journal articles obtained from several electronic database sources. The databases used are Google Scholar (2011-2020), PubMed (2011-2020), Science Direct (2011-2020), Springer (2011-2020). The keywords used in the search are "Lead-based paint", "blood lead levels", "health effect of lead", "developed countries", "developing countries", and "Children. The population of this study is an international and national research article from developing and developed countries. The journal article selected is an article that deals with lead levels in paint in developing and developed countries. Each developing and developed country is selected in each of the five countries, with a total population of 10 countries. The selected developing countries are Brazil, India, China, Indonesia, and South Africa. The selected developed countries are the United States, the United Kingdom, France, Canada, and Japan.

The study used four procedures for processing data. The first procedure is to organize or organize the literature results that have been obtained from the electronic database. After that, the step is to rotate the literature that has been obtained into one summary, making it easy to identify. The third procedure is to identify the data that has been confiscated to look for interesting issues related to the topic of research. The latter procedure is to formulate the information that has been obtained according to the research question that you want to research (Taylor, 2013). The formulation techniques used are PICO (Population, Intervention, Comparison, Outcomes). The populations in this study are developing and developed countries. The intervention in this study was the content of lead in paints used in the country.
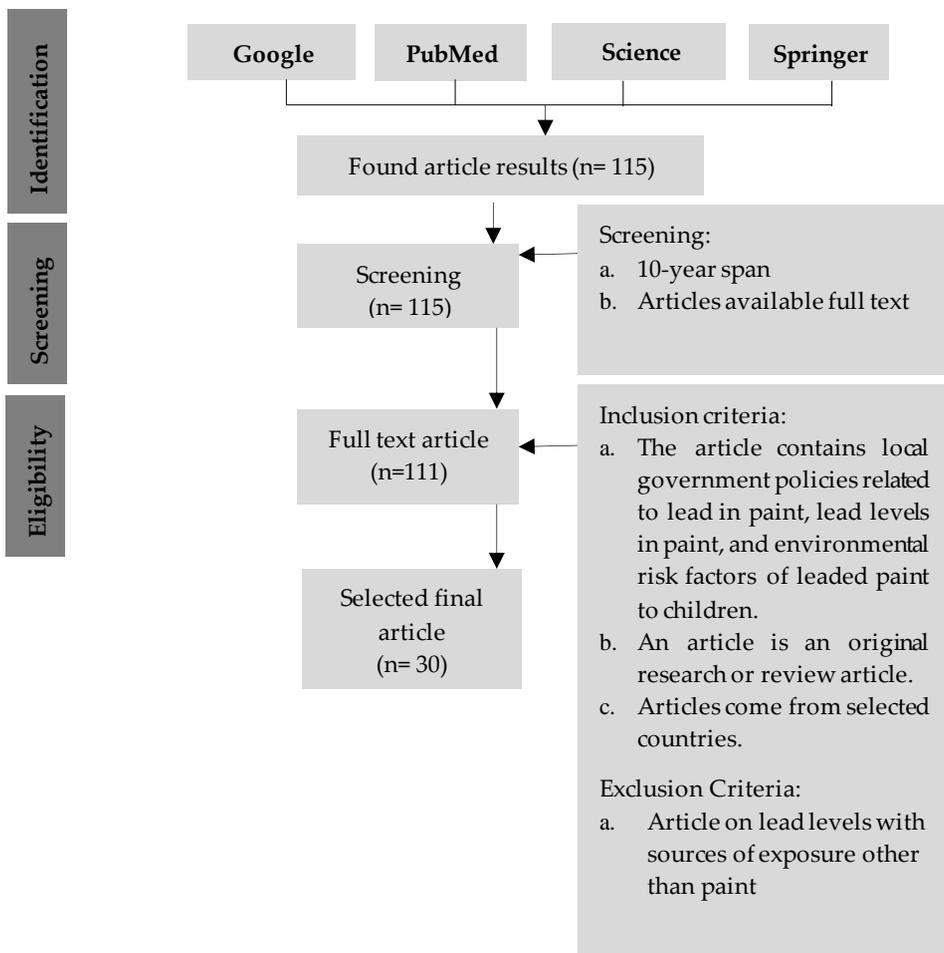

Figure 1. Operational Framework of Literature Study of Differences in Lead Levels in Paint and Health Impacts Caused in Developing Countries and Developed Countries

The literature review method is a method of collecting research from all scientific writings according to the topics studied. Posts can be research journals, peer review articles, thesis, or books (Shukla, 2017). This method has advantages in analyzing and extracting deeper data than original research. However, this research can only be done if there is already research that discusses it. Besides, the downside of this study is the lack of research information about original data and direct events at the research site and the frequent occurrence of bias. Therefore, the research literature review should apply some selections in the selected journal article.

IV. Results

National Per capita Income Growing and Developed Countries

Table 1. Classification of state income source

Group	1 July 2020	1 July 2019
Low income	< 1,036	< 1,026
Lower-middle income	1,036 – 4,045	1,026 – 3,995
Upper-middle income	4,046 – 12,535	3,996 – 12,375
High income	> 12,535	> 12,375

(Source: World Bank, 2020a)

Based on Table 1, per capita income is done Division based on current state income divided into four groups: low income; lower-middle; upper-middle; and high income. State income is grouped by Gross National Income (GNI) per capita or commonly called national income per capita. GNI is the total market value of all domestically produced goods and services (GDP) plus income paid to the country by other countries in a given quarter or year. The use of GNI was chosen by the World Bank because it uses the same method as the Division of operational loan policies. GNI is the easiest indicator that is closely related to other non-financial measures such as life expectancy, quality of life, children's mortality rate, and school participation rate (World Bank, 2020b; 2020c).

The World Bank created several groups for 189 member states and 28 other countries with a population of more than 30,000 to be authenticated so that some people who want to use the data can classify it into several groups and compare the data based on their share. Some of the group divisions conducted by the World Bank are geographical divisions; based on income; and operational loan policies. The Division of this category changes over time (World Bank, 2020b; 2020d).

Table 2. Income per capita of developing countries

Economy	Group	GNI/Capita/$ (2019) per 1 July 2020
Brazil	*Upper- middle income*	9,130
India	*Lower- Middle Income Economies*	2,130
China	*Upper- middle income*	10,410
Indonesia	*Upper- middle income*	4,050
South Africa	*Upper- middle income*	6,040

(Source: World Bank, 2020a)

Based on Table 2 the World Bank compiles a country as a developing country and a developed country from per capita income. Developing countries are countries with low income and middle-income opinions. Based on these divisions Brazil, India, China, Indonesia, and South Africa are among the developing countries.

Table 3. Income per capita of developed countries

Economy	Group	GNI/Capita/$ (2019) per 1 July 2020
United States	*High-Income Economies*	65,760
England	*High-Income Economies*	42,370
Canada	*High-Income Economies*	46,370
France	*High-Income Economies*	42,400
Japan	*High-Income Economies*	41,690

(Source: World Bank, 2020a)

Based on Table 3, Developed Countries are countries with high income. Meanwhile, the United States, the United Kingdom, Canada, France, and Japan are developed countries.

V. Discussions

Government Policy on Lead Levels (Pb) in Paint in Developing and Developed Countries

Table 4. Lead Content in Paints in Developed and Developing Countries according to IPEN 2020

Countries	Highest Level of Lead in Paint (ppm)	Highest Lead Level (ppm)	Research Year
Developing countries			

Countries	Highest Level of Lead in Paint (ppm)	Highest Lead Level (ppm)	Research Year
Brazil	600	59,000	2014
India	90	127,0000	2015
China	90	116,000	2016
Indonesia	-	102,000	2015
South Africa	600	195,000	2009
Developed Countries			
United States	90	-	
England	90	-	
Canada	90	-	
France	90	-	
Japan	-	No Data	

(Source: IPEN, 2020)

Based on Table 4, The International Pollutants Elimination Network (IPEN) is a world organization that interests all countries to make people's lives healthier and the environment free from production; use, and dispose of hazardous materials.

IPEN has been researching lead levels (Pb) in paints in developing countries on leaded paint removal since 2009 and has conducted 100 studies from 59 countries. IPEN research from 5 developing countries found the highest lead content in India in 2015. IPEN cooperates with non-governmental organizations to conduct such research. Research has examined more than 3,300 paints and has found many paints have high lead levels exceeding 10,000 ppm (IPEN, 2020).

Research conducted by IPEN in various countries can be seen on the website in the form of a world map. Based on the results of the study, many countries that have lead levels exceed the quality standards set by the global alliance of 90 ppm (UNEP, 2019). Most countries that have high lead levels are countries listed as developing countries by the World Bank. The countries that are recorded still have high levels of lead in paint are Brazil, India, China, Indonesia, and South Africa. No lead content was found in paints in developed countries that exceeded the quality standards set in each country. Examples of developed countries successfully removing lead in paint are the United States, Britain, France, Japan, and Canada. Japan is a special exclusion country because the data on the paint content in that country is quite closed. However, Japan was one of the countries that initiated the removal of lead. Japan proves successful in eliminating lead content in paints despite not setting specific quality standards (Murao & Ono, 2012).

Table 5. Lead Levels in Paints Highest in Developing Countries in the last ten years (2011-2020)

Countries	Regional Maximum Limit (ppm)	Research Samples	Highest Level of Lead in Paint (ppm)	Research Year	Reference
Brazil	600	Scraps of house and building painting	59,000	2014	(Clark et al., 2014)
India	90	Playground paint	134,000	2014	(Clark et al., 2014)
China	90	Dust the paint in the house	1,677	2018	(Shen et al., 2018)
Indonesia	600*	Home Paint	2,254	2015	(Cahyadi et al., 2015)
South Africa	600	Paint dust in the house	145,000	2014	(Mathee, 2014)
Average			**68,386**		

Lead levels in the highest paints in developing countries were found in the South African country of 145,000 samples from the study in house paint, lead levels exceeding the limit set at 600 ppm.

The research was conducted to examine the content of lead-containing paint in 4 countries, namely Brazil, India, Armenia, and Kazakhstan. The research was conducted by collecting 25 samples from each country, paint collection from October 2010 to December 2011, and tested from September 2011 to February 2012. The results of the study stated that all brand new paints that emerged after the enactment of regulations restricting the use of lead in paints in Brazil and India had high lead levels and exceeded the quality standards set in the country. Brazil sets the quality of lead used in paints at 600 ppm, but some paint brands have more than that level. Lead levels in paint are the highest in the country at 59,000 ppm. India has strict standards of use, adopting IPEN's 90 ppm rule of use of lead in paint. However, as many as seven new paint samples, which have never been studied before, contain lead levels of more than 90 ppm. The highest lead level of some paint samples in the study was 134,000 ppm.

In a study conducted in China by Shen et al. (2018), the research was conducted on 100 paint-coated children's toys purchased in three of the ten best online shopping in China, namely JD; Taobao (TB), and Tmall (TM). The results of the study found that the highest lead content of the paint-coated toy was 1,677 ppm. This level exceeds China's designated paint usage limit of 90 ppm. While in the research conducted by Cahyadi et al. (2015) in Indonesia, the samples used were

three wall paint products, six enamel paint products; 1 antifouling paint product; 1 alkyd paint product; and 1 street marking paint product. The highest levels of lead are found in enamel wall paint containing lead levels of up to 2,254 ppm. Indonesia has set a standard for the use of lead in paint of 600 ppm, but this regulation is not coercive. The regulations set out in SNI 8011 of 2014 on the use of lead in paints are voluntary for manufacturers.

In a review article written by Mathee (2014) in South Africa, it was mentioned that 145,000 co-concentrating lead was found in the famous children's toy. The toys in the study were purchased in regular stores and supermarkets. Lead research is still very rare in South Africa, especially regarding the source of lead exposure in the paint. However, South Africa is one step ahead of Indonesia, which is also a developing country. South Africa has set strict rules by limiting the use of lead in paint to 600 ppm.

Ismawati et al., (2013) states that the majority of paint samples sold in Indonesia will not be allowed to be sold in the United States or most other developed countries, and more than a third of samples can be classified as extremely dangerous because they contain lead above the internationally defined minimum limit of 90 ppm (part per million) (Fidiani & Setradianshah, 2015).

Table 6. Highest Lead Level in Paint in Developed Countries in the last ten years (2011-2020)

Countries	Regional Maximum Limit (ppm)	Research Samples	Highest Level of Lead in Paint (ppm)	Research Year	Reference
United States	90	Scraps of house and building painting	62,934	2016	(Hunt, 2016)
England	90*	Playground paint	152,000	2016	(Turner et al., 2016)
Canada	90	Dust the paint in the house	24,000	2014	(Levallois et al., 2014)
France	90*	Home Paint	149	2011	(Oulhote et al., 2011)
Japan	Lead-Free	Paint dust in the house	1,800	2012	(Yoshinaga, 2012)
Average			**48,177**		

Based on Table 6 of some of the Highest Lead Levels in Paint studies in developed countries over the past ten years, research with home Paint samples

and on paint-coated children's toys conducted in the United States, United Kingdom, Canada, France, and Japan all exceeded the standard stipulated quality between 90 ppm.

Some studies found that lead levels (Pb) in the highest paint in the Developed World were found in the UK of 152,000 samples from the study in playground paint, lead levels exceeded the maximum limit set at 90 ppm. Research conducted by Hunt (2016) in the United States involved 13 paint samples from exterior pieces of old houses or buildings. The results of this study showed the lead levels in the paint pieces reached 62,934 ppm. This result is certainly higher than the set usage limit of 90 ppm. Meanwhile, higher lead levels were found in Turner et al. (2016) research in England conducted in 47 playgrounds in 5 parts of south-west England. Results from the study showed 102 play tools had lead levels of up to 152,000 ppm. This result exceeds the UK's set usage limit of 90 ppm (Turner et al., 2016).

A study of lead content in house paints in Canada conducted by Levallois et al. (2014) also showed high levels of lead. The research was conducted on homes with children aged 1-5 in the Montreal area from September 2009 – March 2010 (Levallois et al., 2014). The highest lead level is 24,000 ppm, and the median data is 1,300 ppm. The results of this study exceeded the Canadian government's set lead use limit of 90 ppm. A similar study was conducted in France by Oulhote et al. (2011), which measured lead levels in paint in the homes of 484 children who had lead levels of $25 μg/dL. The results of this study showed a not very high lead level of 149 ppm. However, this figure still exceeds the lead level limit set by EU REACH, one of the EU organizations, which has also been set by France at 90 ppm.

Another study, conducted by Yoshinaga (2012) on 108 homes in Japan. The highest lead dust found was 1,800 ppm, and the average was 97.8 ppm (Yoshinaga, 2012). Most homes in Japan do not use paint; lead dust may be found from household furniture paint or ornaments of houses. The levels of lead found are quite high, but the average content is not much different from the limit set by IPEN, which is 90 ppm. Japan does not publish lead restriction rules in paints used in its countries, but Japan was one of the countries that pioneered the reduction of lead use in paint. Japan has a business organization that regulates lead restrictions in paints that house most paint companies in Japan. It is called the Japan Paint Manufacturers Association (JPMA). The organization always publishes the amount of paint produced by Japan and the number of lead levels in the paints produced by each company.
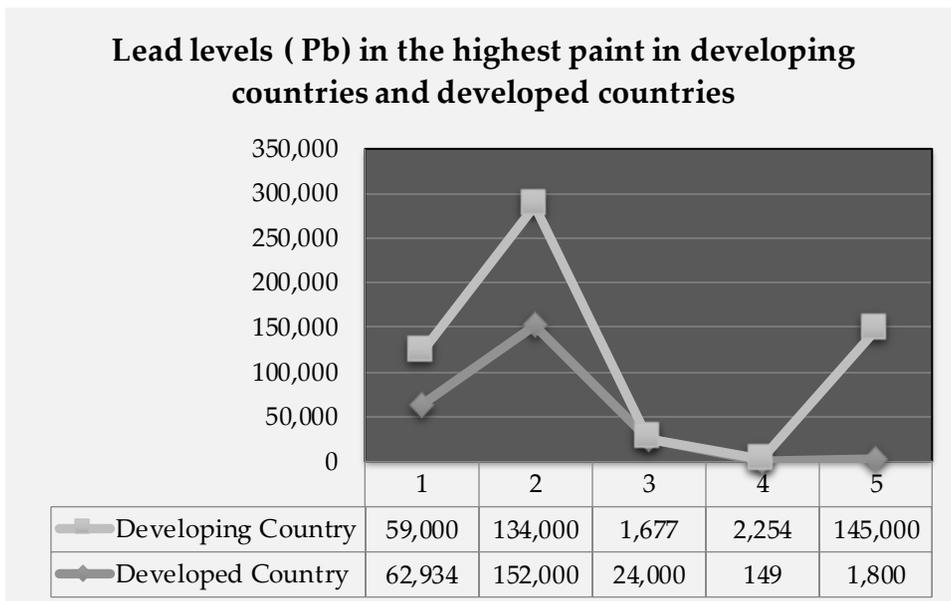
Lead levels (Pb) in the highest paint in developing countries and developed countries

	1	2	3	4	5
Developing Country	59,000	134,000	1,677	2,254	145,000
Developed Country	62,934	152,000	24,000	149	1,800

Figure 2. Comparison of Lead Levels (Pb) in paint in Developing Countries (Brazil, India, China, Indonesia, and South Africa) and Developed Countries (USA, France, UK, Canada, and Japan) is presented in the following chart.

Based on figure 1, the results of lead levels (Pb) studies in paints conducted from several Developed Countries showed results that lead levels (Pb) were found to be higher than in developing countries. The enactment of the policy on the restriction of lead in paint is not proven to guarantee that the country is free from exposure to leaded paint, but the quality standard stipulated by the State will be less than that of developing countries which is 90 ppm. Most developed countries enact mandatory laws, regulations, or standards to protect the health of their citizens from lead in paint. The policy is related to prohibiting the production, import, sale, or use of leaded paint for the interior or exterior of houses. Applicable standards in the United States set an upper limit of 90 parts per million (ppm) of lead weight against total dry weight for decorative paints and various other paint categories. Other countries have set mandatory limits in the range of 90 to 600 ppm of total lead against dry weight (Ismawati et al., 2013).

The Institute for Health Metrics and Evaluation (IHME) estimates that in 2016 lead exposure accounted for 540,000 deaths worldwide due to the long-term effects on health. The highest burden was in low- and middle-income countries. The IHME also estimates that in 2016, lead exposure accounted for 63.8% of the global burden of idiopathic developmental, intellectual disability, 3% of the global burden of ischemic heart disease, and 3.1% of the global burden of stroke (Salsabilla et al., 2019)

The results of research conducted in developing countries, that Indonesia's policy on restrictions on leaded paints is still voluntary, but lead levels in paints were found to be lower than those of South Africa and Brazil. The country sets the lead quality standard in the paint at 600 ppm, as does India, which sets the lead quality standard in the paint by 90 ppm. Also, Brazil, which sets lead quality standards in paints at 600 ppm, has lower lead levels than India, which sets the lead quality standard in the paint at 90 ppm. Leaded paint in developing countries is still widely used, and in production (O'Connor et al., 2018). For example, in China, as the world's largest paint producer. Often paints from China sold on the market have lead levels higher than the established quality standard (Wu et al., 2018).

However, the implementation of a restrictive policy with the determination of quality standards for lead in paint was shown to lower lead levels in paint in some developing countries such as Brazil and India (Clark et al., 2014). In Clark et al. (2014) research, paints of the same brand were measured in the period before policy enforcement and after policy. As a result of the study, lead levels in paint changed drastically, Brazil before the policy of lead levels in paint, lead levels in yellow paint were 170,000 ppm but, after the policy on lead quality standards in paint, lead levels dropped to 9 ppm (Clark et al., 2014). This is in line with the results of research in developed countries in tables 5.4 and 5.6. Lead levels in paints in developed countries are no longer found in paints sold today. Lead levels are found in old buildings and goods purchased abroad. This fact can be evidence that the application of policies regarding lead quality standards in paints successfully reduces lead exposure in the paint.

However, the data shown in the results still has many drawbacks because they are not measured simultaneously over the same time and with the same sample.

VI. Conclusion

The Division of country categories by World Bank is divided into four groups, namely low income, lower-middle, upper-middle, and high income. The Division is based on GNI per capita per country. The category is used as a reference for the World Bank to classify countries into developing and developed countries. Developing countries are low-income and middle-income countries. Meanwhile, developed countries are high-income countries.

The policy on lead quality standards in each country is different, but according to IPEN recommendations, the ideal lead quality standard is 90 ppm. Most developed countries have followed these quality standards. However, in developing countries, the quality of lead in paint is still diverse. In Brazil and South Africa, it is 600 ppm; China and India are 90 ppm; while Indonesia still sets lead quality standards in painting, volunteering at 600 ppm.

The results of lead level research in paint in Developed Countries found that there are higher rates than in developing countries. This was evidenced by Turner's et al. (2016) research found lead levels (Pb) at 152,000 with playground paint samples, while a 2014 Mathee study found the highest levels of lead in the Developing World were 145,000. But both are more standard quality that has been set which is 90 ppm.

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