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A Toxic Threat to Indonesia's Human Capital

Prevalence and Impact of Lead Paint in Indonesian Homes

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Abstract

About 27,000 Indonesians died of lead poisoning in 2019. Where mandatory lead-free standards are absent, as is the case in Indonesia, lead paint is among the most common sources of poisoning. Tests for lead in interior paint conducted in a nationally representative sample of households in December 2023 found that at least 44.8 percent of Indonesians live in homes with lead paint, rising to at least 57.9 percent among those living in homes with any visible interior paint. Indonesian children are more often at risk than adults, with about 46 percent aged five or younger—about 10.2 million children—living in homes with lead paint. Deteriorating lead paint puts 14.1 percent of children aged five or younger at risk of more severe exposure, with the poorest 40 percent of Indonesians more than twice as likely to report deteriorating lead paint. Calibrating the Integrated Exposure Uptake Biokinetic Model for Lead in Children model to these estimates suggests that lead paint exposure alone may push 21 percent of children aged five or younger over the 5 micrograms per deciliter blood lead threshold, equivalent to 55 percent of Indonesia's total estimated cases among children in the Global Burden of Disease database. New lead paint continues to accumulate in the environment: tests conducted on the most popular paint varieties on the market found that 77 percent contained unsafe levels of lead. The results show that poisoning risks from lead paint are high and widespread in Indonesia, and that lead contaminated paint supply chains remain dominant.

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Prevalence and Impact of Lead Paint in Indonesian Homes

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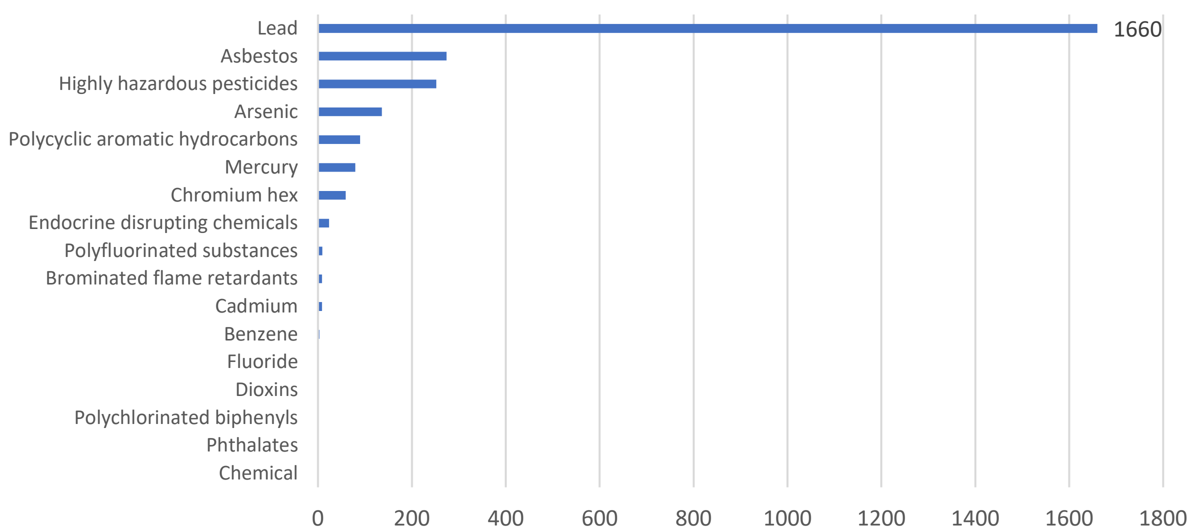
Introduction

Lead is the world's most damaging environmental toxin, and as one of the four countries most affected by lead poisoning, Indonesia's challenge is especially urgent. Except at high levels, there are few outward signs or symptoms of lead poisoning, and most cases go undiagnosed and untreated. Poisoning causes permanent brain damage, with life-long harms especially detrimental for children. Lead is thus one of the world's largest preventable causes of human capital loss, significantly damaging children's brain development, leading to reduced intelligence, learning disabilities, attention disorders, and behavioral problems. The Institute for Health Metrics and Evaluation (IHME) estimates that more than 8.2 million, and as many as 12 million Indonesian children have elevated blood lead levels (BLLs) above 5 µg/dL (Rees & Fuller 2020). On average, blood lead levels of 5 µg/dL are expected to permanently lower IQ by between 3.2 and 3.8 points. In pregnant women, lead can cross the placental barrier, increasing the risk of miscarriage, premature birth, low birth weight, and developmental issues in the fetus. Lead exposure in adults causes high blood pressure, heart disease, kidney damage, and an increased risk of stroke. There is no safe level of lead exposure.

The global cost of lead exposure was between US$2.6 trillion and US$9 trillion in 2019—equivalent to between 3 and 10 percent of global GDP (Larson & Sánchez-Triana, 2023). Of this cost, 77 percent was the welfare cost of cardiovascular disease mortality, and 23 percent the present value of future income losses from IQ loss. In a recent study on the health impacts of chemicals of special health concern, experts singled out lead as the leading cause of premature death and lost years of healthy life among the substances studied (Marti et. al. 2024). At 1.7 million deaths and 40.5 million disability adjusted life years (DALYs) lost per year, lead kills or seriously damages the health of more people than 15 major sources of chemical pollution combined (Figure 1).

Figure 1: Global premature deaths from 16 common chemical pollutants per year, in thousands.



Source: Marti et. al. (2024)

Indonesia is one of the countries most affected by lead poisoning. The effects of lead kill between 20,000 and 40,000 Indonesians annually and cost society from 500,000 to 1 million DALYs per year (Zhou et. al., 2022). For perspective, this suggests that lead killed more Indonesians in 2021 than all traffic fatalities in that year combined,[3] and in terms of DALYs, lead exposure caused a greater loss of health than the country's total cases of blindness and deafness. Though there are no nationally representative blood lead surveillance studies for Indonesia,[4] site specific surveillance suggests elevated blood lead levels are at least as prevalent as estimates from Zhou et. al. (2022) and the Global Burden of Disease database suggest. Prihartono et. al. (2019) study blood lead levels of children 1 to 5 years old who reside both near and significant distances from informal used lead-acid battery (ULAB) recycling locations in Jakarta. The authors find 47 percent of children had BLLs above 5 µg/dL and 9 percent had BLLs above 10 µg/dL. Worryingly, no differences in average BLLs were observed between children at varying distances to ULAB locations, suggesting additional sources of contamination may further contribute to prevalent lead poisoning. Mallongi et. al. (2020) find average level in blood were of 25.2 µg/dL in randomly selected participants in communities along coastal areas of Makassar. Lestari et. al. (2018) find severe cases of lead poisoning prevalent in the study area of Tegal District. These are indicative of many site-specific studies corroborating estimates of a high national prevalence of lead poisoning in Indonesia.

Leaded paint is one source among several contributing to lead poisoning. Legacy soil pollution resulting from leaded gasoline contributes significantly to lead poisoning in Indonesia, as elsewhere in the world where leaded gasoline was extensively used. Testing of consumer products by the NGO Pure Earth (2021) identified a range of significant sources with positive lead tests found for 60 percent of locally produced metallic cookware, 33 percent of cosmetics, 10 percent of children's toys, and 97 percent of decorative paints tested in Indonesia. The highest maximum lead level in metallic cookware contained lead concentrations at more than 180 times the reference level of concern for poisoning. For paints, the median lead content was found to be 35 times the reference level of concern (90 ppm). Finally, a suspected 200 illegal lead smelting sites have been identified across the country (Haryanto, 2016; Prihartono et. al., 2019). A lack of systematic published data leaves unknown the contributions from other potential lead poisoning sources, including water and in industrial processes.

The health and disability related impacts of lead exposure cost Indonesia between 0.8 and 1.7 percent of national income per year, before considering the wider impacts on productivity and lost earnings. Using value of a statistical life (VSL) estimates to health impact statistics from Zhou et. al. (2022) suggests lead poisoning costs Indonesia between $PPP 32 and 64 billion per year in health and disability, equivalent to 0.8 to 1.7 percent of GNI in PPP in 2023 (See Annex A for details). The health-related costs of lead poisoning alone thus outweigh the total projected 2025 state budget for health, by about 30 percent (budget of Rp197.8 trillion compared to Rp257.3 trillion lead poisoning related costs). Such elevated costs of lead poisoning suggest exceptionally high rates of return on prevention and abatement activities. Global benchmark cost-benefit

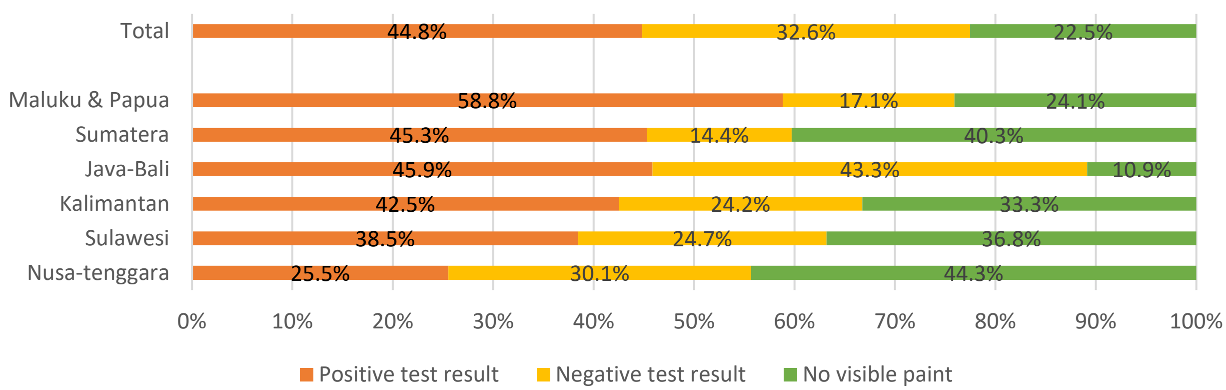
[3] The global burden of disease database estimates 18,631 traffic fatalities in Indonesia in 2021.

[4] Preparation for Indonesia's first nationally representative BLL surveillance survey is underway as of this writing.

estimates for lead paint pollution control measures suggest a return on investment of between 17–221x (Gould, 2009).

This study reports findings from a nationally representative survey conducted by the World Bank that finds lead paint is a critical source of exposure in Indonesia. Nearly 45 percent of Indonesians—123 million people—were exposed to lead from the paint in their homes in December 2023 when the survey was conducted. About 77 percent of Indonesians lived in a dwelling with visible interior decorative paint (and about 75 percent in housing with visible exterior paint). Within this subset, 58 percent lived in homes with paint that tested positive for lead. Children were slightly more often at risk, with 46 percent of children aged five or younger—about 10.2 million children—found to be living in homes decorated with paint that contained lead.

Figure 2: Home interior paint test results.[5]



Lead paint is one of the primary sources of poisoning in countries where it is prevalent. With the phaseout of lead additives from gasoline and other fuels (completed in Indonesia in 2006), lead from paint has become one of the primary sources of poisoning globally (alongside smelting/battery recycling, water contamination, unsafe cookware, and adulterants in food). A review of 12 epidemiologic studies covering 1,297 children found that even low levels of lead in paint can contribute to elevated blood lead levels in children (Lanphear et. al., 1997). Specifically, the geometric mean blood lead level for children in homes with median environmental lead levels from paint in the United States was estimated at around 4.0 µg/dL, with predicted blood lead levels rising correspondingly with higher concentrations in interior paint dust. A large literature has documented similar exposure and blood lead level patterns elsewhere in the world, for instance in France, Mexico, Canada, South Africa, India, among many others (Etchevers, 2014; Romieu et. al., 1995; Levallois, 2014; Ahamed et. al. 2009; Khan et. al. 2010).

[5] Notes: Results from the World Bank WEHS survey, December 2023. Lead paint tests were conducted only in homes with visible interior decorative paint. A total sample of 3,106 households were selected for interior paint tests, 1,886 of these tests were positive for lead.

Paint that is old, chipping, or at risk of creating dust is more likely to cause lead poisoning. In the survey, about 11.5 percent of Indonesians live in dwellings with positive lead tests and who classified the paint in their home as in poor or deteriorating condition. The potential risk of concentrated exposure posed by deteriorating paint rose to 14.1 percent of children aged five or younger. At the time of the test, the average age of indoor paint was 5.13 years, with no significant differences between the age of paint that tested positive for lead and paint that tested negative, suggesting that new lead paint is being added to homes at a similar rate to previous years.

The Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) model calibrated to the survey findings suggests lead paint may push as many as 21 percent of children aged 0-5 over the 5 µg/dL blood lead threshold. The IEUBK model uses empirical studies of lead exposure and BLL to approximate expected BLL of children after accounting for local or individual conditions. For lead paint exposure, the primary source of concern is dust within the home. The IEUBK model default is 1200 µg/g, compared to the counterfactual of 200 µg/g in background ambient exposure. Varying this parameter allows for simulations of the contribution of lead paint exposure under varying scenarios. In performance evaluations, the model has been shown to generate accurate distributions (Brown et. al. 2023). Modeled estimates of blood lead levels suggest about 4.5 million more Indonesian children aged 5 or below may have blood levels above the 5 µg/dL threshold than would be the case if only ambient levels of lead in the environment prevailed (i.e., in the absence of lead paint exposure in addition to baseline environmental exposure). Benchmarking to the IHME estimates for the number of Indonesian children with blood lead levels at or above that level suggests lead from paint is equivalent to 55 percent of estimated cases in the Global Burden of Disease database (though multiple sources of exposure that are not measured in the survey may push blood lead levels beyond those estimated in the model). More than half (56 percent) of the modeled increase is due to moderately increased risk among those with lead paint in “good” condition—while expected to be less harmful than cases deteriorating paint, lead paint in good condition nonetheless generates toxic dust and is more common. More concentrated harms are expected among those with lead paint in “poor” or “very poor” condition. Estimates suggest that between 70 and 83 percent of children living in dwellings with paint in “poor” or “very poor” condition have blood lead levels above 5 µg/dL.

Most local retailers continue to sell paints that contain lead, and in some cases, producers falsely claim no added lead content. About 77 percent of popular paint brands currently available to consumers and tested as part of the World Bank study were found to contain lead, and no paint colors were found to be systematically lead-free (including 136 tests across 26 brands). Of the 10 tests conducted on shades of blue, 9 tested positive for lead. Of the 48 tests of shades of white, 36 tested positive for lead. The results of these tests are of similar magnitude to a lab-based paint testing study from the Nexus3 Foundation (Ismawati et. al., 2021), which found out of 120 analyzed paints, 73 percent contained lead concentrations above 90 ppm (the UN/WHO recommended safety limit), and 39 percent had extremely high concentrations above 10,000 ppm. A similar study conducted in 2013 found 77 percent of paints contained lead (Ismawati et. al., 2013). As in previous studies, the results indicated that paints tested by the World Bank in Indonesia did not carry meaningful information about their lead content on the labels. Some brands falsely claim to be “lead free” or have "no added lead" while still containing significant levels of lead.

Although lead-use is strictly regulated in many countries, key standards are only voluntary in Indonesia. In recognition of the severe health risks, government regulations of lead in paint are widespread, and UN model legislation bans the use of in paint above concentrations of 90 ppm.[6] The World Health Organization tracks binding lead paint restrictions in 94 countries, including nearly all advanced economies. Although Indonesia’s regulatory standards identify a 600-ppm limit for lead in enamel decorative paints (SNI 8011:2014), with a lower standard (90 ppm) recently adopted, these are voluntary guidelines only.[7] Neither domestically produced nor imported paints in Indonesia are currently regulated under any binding lead content standard and are not required to report lead concentrations on paint packaging.

Lead Poisoning

The nervous system, and particularly the brain, is especially sensitive to lead toxicity. Due in large part to its disruptive effects on calcium-dependent process, lead interferes with the synthesis and regulation of neurotransmitters, contributing to a spectrum of mental health disorders. This is particularly concerning in children, for whom lead exposure can cause substantial cognitive deficits, behavioral problems, and a marked decrease in intelligence. Causal links have been established between lead exposure and developmental intellectual disability, attention-deficit hyperactivity disorder (ADHD), and more severe neurodegenerative diseases such as Alzheimer’s and Parkinson’s. The cognitive and behavioral impairments associated with lead exposure in children often result in long-term educational and social challenges, contributing to impaired functioning and underachievement in affected populations.

Crawford et. al (2023) find that addressing lead contamination in Indonesia would substantially improve learning outcomes. Indonesia lay 92 points below the global average in the World Bank’s most recent Harmonized Learning Outcomes assessment (408 compared to the global average of 500). Policy simulations from Crawford et. al. (2023) suggests that lead exposure alone accounts for more than a quarter of that gap (25 points out of 92).

Even moderate levels of lead poisoning severely affect the prevalence of intellectual disability. For instance, in a population with an average intelligence quotient (IQ) of 100 and a standard deviation of 15, a common threshold for disability would be two standard deviations below the mean, or in this case, an IQ of 70 or less. If IQ is normally distributed as is typically the case, this suggests that about 2.3 percent of the population would be living with disability. However, if lead poisoning were to lower the average IQ by 3 points, consistent with a blood lead level of around 5 µg/dL, the population below the 70-point threshold would surge to 3.6 percent, an increase of about 57 percent in the disabled population. High intellectual ability would fall commensurately.

[6] The UN model legislation accessed here.

[7] One exception is paint applied to children’s toys, which is subject to a binding lead content standard.

In this example, the share of the population with an IQ of 130 and above would be expected to fall by about 39 percent.

Lead toxicity profoundly affects the hematological and cardiovascular systems, causing many of the longer-term health costs of lead exposure. Lead inhibits the enzymes involved in hemoglobin synthesis, contributing to anemia which in turn exacerbates the effects of malnutrition and other health conditions prevalent in Indonesia. The chronic presence of lead in the bloodstream also increases the risk of other hematological disorders and contributes to systemic inflammation. In adults, chronic lead exposure is causally related to hypertension (high blood pressure), which is a significant risk factor for cardiovascular diseases, including coronary heart disease and stroke. Moreover, lead exposure has been implicated in the acceleration of atherosclerosis, the buildup of fatty deposits in the arteries, which further increases the risk of heart attacks and strokes.

The kidneys are particularly vulnerable to lead exposure, as they are involved in filtering and excreting lead from the body. Chronic lead exposure can lead to nephrotoxicity, which manifests as reduced kidney function and chronic kidney disease. The accumulation of lead in the renal tissues disrupts the normal filtration processes, leading to long-term damage and increasing the risk of kidney failure, especially in populations with additional risk factors such as diabetes and hypertension.

Lead exposure also poses severe risks to reproductive health, particularly among women of childbearing age. Lead can cross the placental barrier, exposing the developing fetus to its toxic effects. Prenatal exposure to lead is associated with adverse pregnancy outcomes, including preterm birth, low birth weight, and spontaneous abortion. Additionally, lead exposure during pregnancy can lead to developmental delays and cognitive impairments in infants, compounding the intergenerational effects of lead toxicity.

Lead in Paint

Lead compounds have historically been widely used in the production of solvent-based paints due to their advantageous chemical properties—lead is used to cheaply produce vibrant colors, to increase drying efficiency, and improve corrosion resistance. But the dangers of lead additives in paint have long been appreciated and were widely discussed as early as the 1700s. Germany began partially restricting its use in 1886, and France became the first country to fully prohibit lead in paint in 1909. Since then, more than 94 countries have moved to ban lead in paint beyond minute concentrations. The UN promotes model legislation that caps lead in paint at 90 ppm.

In Indonesia, bright colors, especially yellow and orange paints, most frequently contain very high lead concentrations, exceeding safe levels by orders of magnitude. A recent study of paints in 25 countries found nearly all paints tested in Indonesia contained lead, with the median content 35 times the reference level (Pure Earth, 2021). Nippon Paint's yellow road-line paint was found to contain 250,000 ppm of lead, and when tested in 2021, decorative paints from brands like Ftalit and Emco Lux contained lead concentrations of 150,000 ppm and 140,000 ppm, respectively (Ismawati et. al., 2021). Importantly, both studies as well as the World Bank survey find that lead is not confined to brightly colored paints in Indonesia. Although less frequent, lead was detected in paints across a variety of colors, including those typically perceived as safer due to their more subdued hues. For instance, many grey and white paints, which are generally expected to contain lower levels of pigmentation, have still been shown to have high lead concentrations, in both the World Bank study and in previous studies from the Nexus3 Foundation and Pure Earth. This widespread use of lead across different paint colors can be attributed to several factors, including the potential contamination of raw materials used in paint manufacturing, the use of lead for its rapid drying properties, the cross-contamination of production lines, and the use of lead-based additives beyond pigments, such anti-corrosive agents. Interviews with local paint manufacturers found intentions of curtailing the use of lead in paint in some cases hinged on whether binding restrictions were imposed.[8]

There are affordable alternatives for all uses of lead in paint. Lead replacements have been available for many decades, but recent advancements have been made in developing chemical alternatives to lead in paint formulations. Titanium dioxide (TiO2) became the most common replacement for lead-based white pigments since the 1950s, offering high brightness and opacity. Iron oxides, which non-toxic and often more cost effective than lead chromate, provide color stability and UV resistance, are reliable substitutes for red, yellow, and brown pigments. More recently developed iron oxides are brighter and cleaner than past formulations, offering even greater advantages. The price of lead chromates, the common lead pigment used for bright yellow and red coloring, is increasing globally while organic pigments and chrome replacements are decreasing in price as demand grows for lead-free alternatives. Additionally, organic pigments, such as phthalocyanine blue and quinacridone red, are now widely used to produce a broad spectrum of colors, including vibrant reds, yellows, and blues. Bismuth vanadate (BiVO4) has also gained prominence as a yellow pigment. In the domain of drying agents, where lead compounds were traditionally employed to accelerate the drying process, alternatives such as cobalt driers (e.g., cobalt octoate) have been adopted. Manganese, zirconium, calcium, and zinc driers are also being increasingly used as safer alternatives to lead-based driers, improving the surface drying and reducing issues such as wrinkling in paints. Lead-free mixed driers have become the norm in Africa and Europe, often for cost-related reasons even where binding regulations are absent. For anti-corrosion applications, zinc phosphate has become a widely accepted non-toxic alternative to lead-based agents like lead tetroxide.

Data and modeling

Household Survey

Primary data were collected in a nationally representative household survey conducted in Indonesia from November through December 2023. The sample design was a three-stage procedure: in the first stage, 505 primary sampling units (PSUs) were selected with probability

[8] For instance, in response to evidence that their products contain lead, a spokesperson for PT Dana Paint stated that "If there is a stipulation from the government that the maximum Pb in solvent-based paint is 90 mg/kg, then we will follow that rule." (Ismawati et. al., 2021)

proportional to population. This stage was stratified to ensure geographic coverage in all provinces (including a total of 225 districts). In the second stage, households were selected to participate in the survey from within each PSU using a simple random sampling procedure, using the household listing information. The survey was conducted in person with 5,056 households comprised of 17,455 individuals across Indonesia.

The third stage was a random selection for testing for lead in paint. Conditional on there being any visible decorative paint in the interior of the home, a sodium rhodizonate swab-type presence or absence lead paint test was conducted by trained survey teams on painted interior surfaces such walls and windowsills. A total sample of 3,106 households were selected for interior paint tests.[9] A total of 1,886 of these tests were positive for lead. Test results were double entered. First, a photograph of the completed test was taken next to the reference chart supplied by the manufacturer.[10] The test results were recorded on location by the survey enumerator. The photograph of each test was then centrally reviewed for consistency.

The testing procedure was designed following a literature review which suggested sodium rhodizonate tests are reliable for indicating the presence of lead in paint. The chemical sodium rhodizonate reacts with lead to form a distinctive color, providing an indication of lead presence on tested surfaces. Assessments of test reliability also suggest a low risk of "false positive" results. A comprehensive assessment of tests conducted by the US Environmental Protection Agency found that all test kits evaluated respond to less than 1 µg of lead in solution (EPA, 1993) and found all commercially available sodium rhodizonate tests used in real world conditions yielded positive responses to paint with lead in relatively high concentrations. Likewise, an assessment of sodium rhodizonate tests by Scharman and Krenzelok (1996) found tests achieved 92 percent accuracy across a range of ambient temperatures (with low risk of false positives). Compared with lab-based and handheld XRF analyzer-based methods, swab tests have the advantage of low cost and scalability. These features were well suited to the objective of national testing conducted in this study. However, sodium rhodizonate tests have two limitations. First, swab type tests do not provide a direct measure of the concentration of lead in paint, rather, they test for the presence or absence of lead. Analysis that requires concentrations of lead in paint must instead rely on secondary sources, which in the case of Indonesia are available from Ismawati et. al. (2021) and Pure Earth (2021). The second limitation is that there are some forms of lead (especially lead chromate) which rhodizonate only detect with difficulty and can thus, in some circumstances, yield false negative results (i.e., the test indicates no lead was detected, when lead was in fact present). This issue typically arises in cases of small quantities of lead chromate, especially in concentrations lower than 1 mg/cm^2 (Rossiter et. al., 2000). In practice, it is unlikely this limitation meaningfully affected the results of this study as the positive test rate was high. Given the low risk of false positives, a high positive rate suggests the types of lead in common use in Indonesia are amenable to testing with sodium rhodizonate, though the results cannot

[9] Balance tests comparing income, location, and household demographics confirm the random selection procedure was successful.
[10] The tests were manufactured and distributed by Webetop.

fully rule out greater prevalence of lead chromate in low concentrations than was found. More details on the accuracy of these tests are included in Annex C.

Market Survey

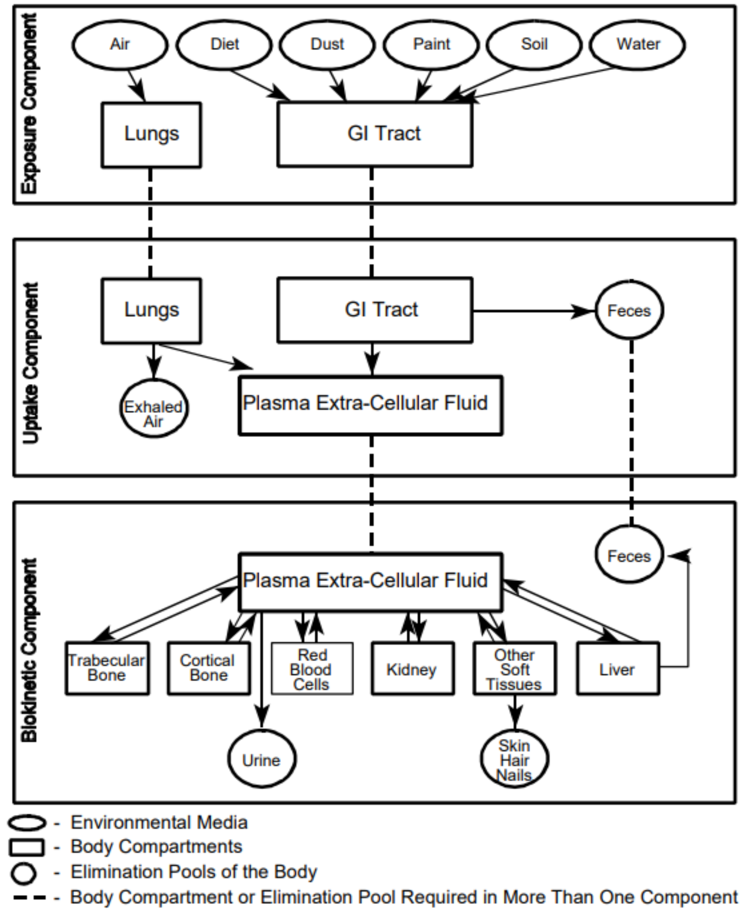
In addition to the household survey, enumerators were tasked with purchasing and testing paint that was available on local markets across the country. The largest paint store in the district/region center in each of Indonesia's provinces was selected to assess lead in paint currently available on the market. In each store, a survey enumerator collected details on the two most popular paint colors-brand combinations (as advised by store staff). Samples of both paints were then purchased and tested using the same protocol applied for home-based testing. Paint was purchased from a total of 68 paint shops, 136 tests were conducted, and of these, 105 tests were positive for lead.

Modeling

Developed by the United States, the Integrated Exposure Uptake Biokinetic Model for Lead in Children (IEUBK) model assesses the risk of lead exposure and blood lead levels from common sources. The model uses initially set default values that rely on empirical estimates of real-world lead uptake and biokinetics, contact and intake rates of children with contaminated sources, and data on the presence and behavior of environmental lead to predict a plausible distribution centered on the geometric mean (GM) of blood lead levels for a hypothetical child or population of children (EPA, 2020). The model provides a distribution of blood-lead levels, typically expressed as a geometric mean along with percentiles (e.g., 5th, 50th, and 95th percentiles). From this distribution, the IEUBK model is used to estimate the risk that a child's or a population of children's blood lead concentration will not exceed a certain threshold, in this case, 5 µg/dL. The model has been used extensively outside the United States, for instance in China, Australia, Belgium, among many others (Laidlaw et. al., 2017; Li et. al., 2016; Cornelis et. al., 2006). The details of the baseline IEUBK are described in EPA (1994).

The model consists of several components designed to estimate blood lead levels in children. The exposure component translates environmental lead concentrations from various media—air, water, soil, dust, and diet—into lead intake rates, using specific equations tailored for each medium and age group. The model also includes an uptake component, which calculates the fraction of lead absorbed into the bloodstream. This is done through both saturable and non-saturable uptake mechanisms, which varies depending on concentration due to the body's limited capacity to absorb lead at higher exposure levels. The biokinetic component models the distribution of absorbed lead within the body, including blood plasma, red blood cells, bones, and the liver, while also estimating the elimination of lead through urine and feces. Age-dependent equations are used to approximate the transfer of lead within the body and its elimination over time. Finally, the model's probability distribution component predicts the distribution of blood lead levels across a population of children, generating statistical estimates based on the provided exposure data.

Figure 3: Exposure sources and biological processes represented in the IEUBK model.



Source: Environmental Protection Agency (1994)

Most directly relevant for the applications in this study relate to the model parameter of indoor dust. The indoor dust parameter is typically estimated either as the background soil lead exposure (adjusted by a conversion factor), or, in the case of lead-based paint in the dwelling, as estimate of the exposure from lead dust in the home. The baseline dust parameter for exposure of lead paint in the home is 1200 µg/g (US EPA, 1986; US HUD 1995), with model calibration varying from 400 to 1600 µg/g depending on paint deterioration conditions. The lead-based paint in homes parameter is calibrated according to the following rule: (i) 64 µg/g used if no paint, or paint tested negative for lead (equivalent to background exposure as estimated by Sekarningsih et al., 2021), (ii) 400 µg/g used if lead paint reported in “very good” condition, (iii) 800 µg/g used if lead paint reported in “mostly good” condition, (iv) 1,200 µg/g used if lead paint reported in “mostly bad” condition, and (v) 1,600 µg/g used if lead paint reported in “very bad” condition. For each category (of lead paint exposure, and paint condition), the estimated geometric mean of blood levels and distributions are calculated via the standard IEUBK model and applied to the household survey data. Sensitivity analysis of model parameters is included in Annex D.

Results

Tests for lead in interior paint conducted in a nationally representative sample of households find that 44.8 percent of Indonesians live in homes with lead paint. Most (57.9 percent) households with any interior paint at all have lead paint. Indonesian children are more often at risk, with about 46 percent aged five or younger—about 10.2 million children—living in homes with lead paint. Figure (4) details the proportion of positive household lead tests conditional on the presence of any visible indoor paint across the six major regions in Indonesia—Maluku & Papua, Sumatera, Java-Bali, Kalimantan, Sulawesi, and Nusa Tenggara. Lead paint is most prevalent in Maluku & Papua, Indonesia's poorest island group, with 77 percent of household paint affected. Close behind is Sumatera, where 76 percent of households with paint are exposed to lead. In Kalimantan, 64 of household paint tests were positive for lead. Sulawesi shows a slightly lower prevalence at 61 percent, still slightly above the national average. About 51 percent of household paint tests were positive Java-Bali, the most populous region, below the national average. Finally, Nusa Tenggara had the lowest prevalence among the regions.

Figure 4: Positive test rate for interior lead paint.

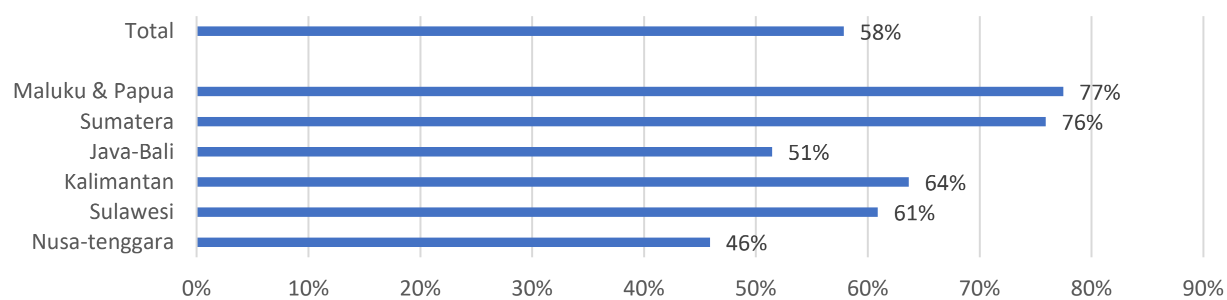
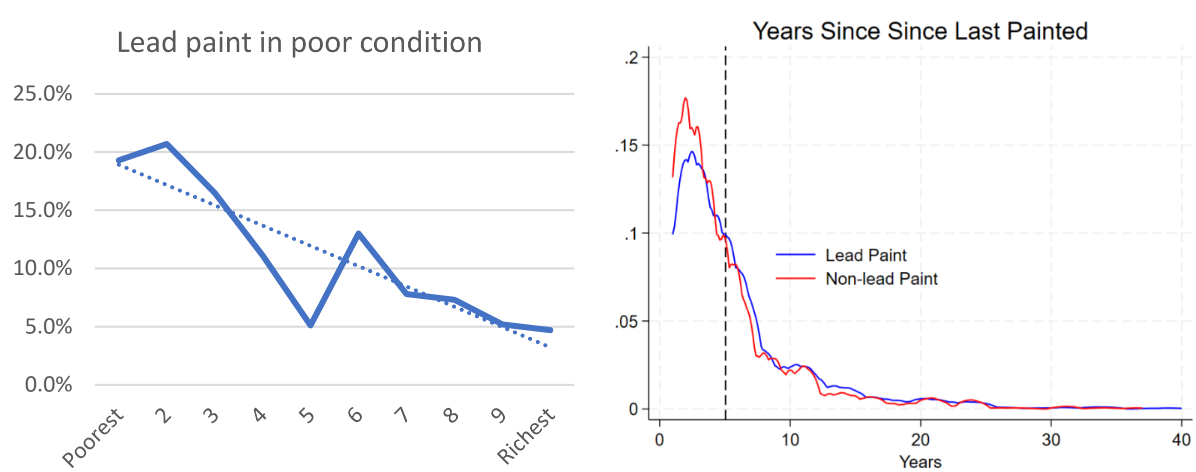


Figure 5: Lead test result of paint by income decile, and age of paint



Notes: Income is measured as per capita monthly income from all sources, including labor income and transfers. Income is spatially deflated for local cost of living.

The results show large socioeconomic disparities in exposure lead paint. Poorer households were more likely to live in homes where lead paint is in poor condition and suffer the greater exposure to toxic dust as a result. The proportion of households with no paint also varies by income, although less dramatically. Households in the poorest income deciles exhibit the highest prevalence of lead paint in poor condition, with 19.3 percent of the poorest decile and 20.7 percent of the second poorest decile reporting such conditions. Conversely, these households also have a substantial proportion of lead paint in good condition, particularly in the second decile where 47.1 percent of households report good-condition lead paint. The presence of homes with no paint decreases slightly in these deciles, with 29.8 percent in the poorest and 26.3 percent in the second poorest.

As income increases, the proportion of households with lead paint in poor condition generally declines. For example, the third decile reports 16.5 percent of households with lead paint in poor condition, while the fourth and fifth deciles show a marked reduction to 11.1 percent and 5.1 percent, respectively. However, a significant percentage of households across these middle deciles still report lead paint in good condition, ranging from 41.8 percent in the third decile to 48.1 percent in the fourth decile. The proportion of homes with no paint also tends to decline with rising income, from 24.8 percent in the third decile to 16.4 percent in the fifth decile. In the higher income deciles, the percentage of households with lead paint in poor condition continues to decrease, with 7.8 percent in the seventh decile, 7.3 percent in the eighth decile, and 5.2 percent in the ninth decile. However, the prevalence of lead paint in good condition remains high, peaking at 52.1 percent in the ninth decile. Households with no paint are less common in these deciles, with percentages ranging from 14.3 percent to 11.7 percent. The richest decile shows the lowest prevalence of lead paint in poor condition, at 4.7 percent, while maintaining a relatively high percentage of lead paint in good condition (47.6 percent). The proportion of households with no paint is slightly higher than in the higher middle deciles, at 13.2 percent. These findings suggest that while lead paint remains prevalent across all income groups, poorer households are disproportionately affected by lead paint in poor condition, exposing them to higher risks of lead poisoning. The data also indicate that wealthier households are more likely to maintain paint in better condition, reducing their exposure to lead hazards.