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LEAD ADDITIVES ASSESSMENT REPORT

LEAD-SAFE PRODUCTS, HEALTHY LIVES

JULY 2024

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GLOSSARY

CDC – Centers for Disease Control and Prevention

COFEPRIS – Comisión Federal para la Protección contra Riesgos Sanitarios (Federal Commission for Protection against Sanitary Risks, Mexico)

DALY – Disability-Adjusted Life Years

ECHA – European Chemical Agency

ENSANUT – Encuesta Nacional de Salud y Nutrición (National Health and Nutrition Survey, Mexico)

EYCCSA – Esmaltes y Colorantes Cerámicos

FONART – Fondo Nacional para el Fomento de las Artesanías (National Fund for the Promotion of Handicrafts, Mexico)

FSO – Food Safety Officers

FSSAI – Food Safety and Standards Authority of India

GAELP – Global Alliance to Eliminate Lead Paint

GDP – Gross Domestic Product

IARC – International Agency for Research on Cancer

IDMC – Impulsora Dolorense de Materiales Cerámicos

INEGI – Instituto Nacional de Estadística y Geografía (National Institute of Statistics and Geography, Mexico)

InSLAR – Indian Society for Lead Awareness and Research

INSP – Instituto Nacional de Salud Pública (National Institute of Public Health, Mexico)

IPEN – International Pollutants Elimination Project

ISO – International Organization for Standardization

LEEP – Lead Exposure Elimination Project

LMICs – Low- and Middle-Income Countries

NECPR – National Environmental Chemicals and Pesticides Regulations

NESREA – National Environmental Standards and Regulations Enforcement Agency

NLLAP – National Lead Laboratory Accreditation Program

NGO – Non-Governmental Organization

NOM – Norma Oficial Mexicana (Official Mexican Standard)

PMA – Paint Manufacturers Association

PPM – Parts Per Million

REACH – Registration, Evaluation, Authorization, and restriction of Chemicals

R&D – Research and Development

RMS – Rapid Market Screening

SON – Standards Organization of Nigeria

SRADev – Sustainable Research and Action for Environmental Development (Nigeria)

UNEP – United Nations Environment Programme

USAID – United States Agency for International Development

$ – United States Dollar

EXECUTIVE SUMMARY

Lead poisoning accounts for ~1 percent of the global disease burden, affecting one-third of the world's children, mostly in low- and middle-income countries (LMICs). It is responsible for 5.5 million annual deaths, causes cognitive underdevelopment and increases risks of cardiovascular diseases and kidney failure, among other health issues. The economic costs of lead poisoning amount to annual GDP losses of $1 trillion in LMICs and a purchasing power parity loss of $5,000-$9,000 per capita.

Lead additives are found in many consumer goods, especially in LMICs. For instance, lead chromate is used as a coloring additive in paints, inks, printing, plastics, and even in spices. Additionally, it can be found in toys, foodware, cosmetics, and furniture. Lead bisilicates, made with lead oxides, are used in ceramics to create durable, glossy finishes. These lead additives are widespread in LMICs. Pure Earth conducted a Rapid Market Screening (RMS) of over 5,000 samples of consumer goods and foods from 25 low- and middle-income countries, and found 18 percent exceeded safe lead levels. Notable contamination was found in metallic foodware (52 percent), ceramic foodware (45 percent), and paints (41 percent), with additional high lead levels detected in toys (13 percent), cosmetics (12 percent), and spices (2 percent in general, 12 percent in Uttar Pradesh).

While each supply chain is unique, some common lessons apply to producers, consumers, the public sector, and civil society. Affordable lead-free alternatives exist, but interventions must be culturally sensitive and context-specific to ensure producer adoption, especially as no major technological innovations were identified to improve alternatives. Clear labeling of consumer products can help shift demand, but ensuring trustworthy labelling can be expensive. Effective monitoring requires strong testing and laboratory capacity, as enforcement gaps are often more constraining than regulatory gaps. Local civil society organizations are already addressing some of these barriers, but these efforts are small compared to the scale of the problem.

Barriers to lead-free consumer goods change by supply chain, but the following ones are recurrent:

- Transitioning away from lead in consumer goods may require **technical support**, as production processes often need to be reengineered.
- Producers face transition **costs** to shift to lead-free alternatives, even if operating costs afterwards are not necessarily higher. For instance, extensive testing and experimentation (through trial and error) is needed in ceramics to transition away from lead glazes and achieve satisfactory products. Reformulation costs are also a limiting factor for paint manufacturers.

- Lack of **awareness** is often a limitation, not only among consumers, but also among producers and public sector actors. For instance, spice sellers rarely know the severity of the health impacts of lead poisoning.
- Producers, especially in isolated areas, do not always have **access to lead-free alternatives**. For instance, boron-based glazes are hard to source in parts of rural Mexico where many artisans produce their products.

Interventions to increase adoption of lead-safe goods can focus on [a] supporting the adoption of lead-free alternatives or [b] disincentivizing the use of lead additives. Interventions to increase the adoption of alternatives may increase the availability and affordability of lead-free alternatives and equip producers with the technical capacity to produce lead-safe goods. Interventions to disincentivize the use of lead additives may involve more restrictive regulations or enable better enforcement.

We studied Ceramics in Mexico, Spices in India, and paint in Nigeria, as case studies in this report:

Glazed ceramics in Mexico: Traditional Mexican pottery often uses lead-based glazes, exposing millions to potential lead poisoning through the daily use of these crafts for food and beverage. This practice significantly contributes to elevated blood lead levels (BLLs) in the population, with 43 percent of Mexican children aged 0-14 exceeding 5 µg/dL. Progress towards lead-free ceramics is hindered by lenient regulations and enforcement gaps, significant transition risks for artisans, and deep cultural ties to traditional ceramics. Interventions should focus on increasing the market penetration of lead-free glazes, supporting kiln improvements, offering culturally sensitive technical assistance, incorporating performance-based incentives in artisanal loans, boosting demand through partnerships with large volume purchasers, implementing controls on lead oxidizers, and supporting a robust lead surveillance system.

Spices in India: Lead chromate is added to spices like turmeric and chili powder by distributors and sellers to enhance and maintain spice color. India is the second largest pigment producer and exporter globally, making lead chromate cheap and available for spice adulteration. ~65 percent of spices are sold loose making testing and tracking of point of addition highly challenging. This widespread use of chromate, along with low monitoring and consumer awareness, poses severe public health risks. Interventions should focus on improving the traceability of lead chromate production and distribution; raising awareness among consumers, sellers and regulators; improving testing; and building regulators' capacity and enhance accountability.

Paint in Nigeria: Lead-containing paints are widespread used, with 74% of sampled solvent-based home paints and 100% of sampled oil-based industrial paints containing lead. This persists due to inadequate regulatory enforcement, limited technical capacity for reformulation, lack of alternatives, and low consumer awareness. Solutions include facilitating annual paint exhibitions, providing in-house reformulation support, financial incentives for lead-free additives, and rewarding manufacturers who switch to lead-safe paint. Additionally, investing in testing capacity, enhancing regulatory monitoring and enforcement, listing lead chromates under the Rotterdam Convention, and improving lead additive traceability are crucial steps toward a safer industry.

THE PATH FORWARD

In addition to country- and supply chain-specific interventions, transversal interventions can help reduce lead exposure in LMICs. These include measuring blood lead levels and conducting forensic research to pinpoint sources of exposure, funding local and international organizations already active in LMICs, building technical testing capacity for effective monitoring and enforcement of regulations, enhancing awareness of lead poisoning as a public health concern, and shaping incentives for the private sector to switch practices. Each type of stakeholder may explore the following interventions.

Private Sector Actors

- **Businesses may drive demand for lead-free consumer goods**. For instance, large hotels and restaurants may purchase lead-free ceramics from artisans transitioning away from lead-glazed ceramics.
- **Lead-free alternative providers can invest in distribution in LMICs**, to ensure their products are available for producers to transition away from lead additives in their consumer goods.

Governments in LMICs

- **Develop regulatory standards** to eliminate lead additives in consumer goods. For instance, roughly half of the word’s countries are yet to introduce legally binding controls on the production, import, sale and use of lead paints.
- Invest in **enforcement** through testing and technical capacity for civil servants.

Institutional Donors & Philanthropies

- Support governments in achieving **regulatory changes**, adapted to national priorities.
- Build **lead testing capacity**, either nationally or regionally, to enable appropriate monitoring and surveillance.
- Fund **local civil society organizations** conducting research, awareness and capacity building efforts. Estimated funding for lead exposure reduction is only ~$15 million, less than 0.01% of lead poisoning's impact on LMICs' economies. Greater funding for locally grounded organizations is thus likely to generate high social return.
- Fund **research** to measure blood lead levels and conduct forensic research to pinpoint sources of exposure.
- **Support the listing of lead chromate in the Rotterdam Convention** as **a** hazardous chemical. Under the Convention's Prior Informed Consent (PIC) Procedure, lead chromates or paints that contain them can only be shipped to a country that has consented to receiving them.

1. INTRODUCTION

Lead poisoning affects one in three of the world's children, 90 percent of which are in low- and middle-income countries (LMICs) (UNICEF 2022) (Pure Earth n.d.), **and has significant health impacts on adults.** Lead has no biological role in the body, and any detectable lead level is unhealthy. Children are at higher risk of lead poisoning because they absorb 40 percent to 50 percent of ingested lead, while adults absorb only 10 percent to 15 percent (Jennifer Sample 2024). Lead poisoning in children results in numerous cognitive, social, and health issues. High levels of lead exposure can severely damage the brain and central nervous system of children, causing coma, convulsions, and even death. Although low levels of lead exposure show no obvious symptoms, they can impair brain development and cause behavioral changes such as reduced attention span and increased antisocial behavior in children (World Health Organization (WHO) 2023). Adults also suffer from lead poisoning, facing higher risks of high blood pressure, cardiovascular issues, and kidney failure (Pure Earth Mexico n.d.). Lead poisoning is now a major cause of cardiovascular disease in adults, leading to 5.5 million deaths annually (Larsen & Sánchez-Triana, 2023). Women with elevated lead levels during pregnancy may experience miscarriages, stillbirth, premature birth, and low birth weight in their babies (Children's Environmental Health Collaborative, UNICEF 2024). For instance, a study by Pure Earth and UNICEF found that over 900,000 premature deaths per year are attributed to lead exposure (UNICEF and Pure Earth 2020). Lead exposure is also responsible for 21.7 million disability-adjusted life years (DALYs) globally due to its long-term health effects. This includes 30 percent of the global burden of unexplained intellectual disability, 4.6 percent of cardiovascular disease, and 3 percent of chronic kidney diseases (World Health Organization (WHO) 2023).

The health impacts of lead exposure cause significant productivity and prosperity losses resulting in annual GDP loss of ~ $1 trillion in LMICs. Lead exposure results in productivity and prosperity losses by reducing physical well-being, cognitive capacity, and attention span, among other factors. These effects impact educational attainment and workforce productivity, ultimately causing significant economic losses. For instance, children with blood lead levels above 5 µg/dL may score 3-5+ points lower on intelligence tests than healthy peers due to brain development and behavioral changes impacts of lead poisoning (UNICEF and Pure Earth 2020). The economic burden is profound, with lead poisoning contributing to ~$1 trillion in annual GDP loss in LMICs alone and over $2 trillion globally (Champion, Khaliq y Mihelcic 2022). Additionally, lead poisoning causes significant purchasing power parity losses, estimated at $5,000-$9,000 per capita, due to the cumulative effect of lead exposure on communities (Champion, Khaliq y Mihelcic 2022). Pure Earth estimates the global cost of lead exposure between US$ 977 billion (2013) and US$ 6 trillion (2019) (Champion, Khaliq y Mihelcic 2022) (Pure Earth n.d.).

Lead additives are found in various consumer goods, setting a risky pathway for lead exposure, both for children and adults. The Centers for Disease Control and Prevention (CDC) has reported that no level of lead exposure is safe, highlighting the chronic and cumulative nature of these health impacts. However, children and adults are being exposed to lead through different consumer goods, sometimes without even knowing. Lead chromate, a bright yellow-to-orange pigment, serves as a pigment in paints, inks, printing, plastics, and is even found in spices and other foods due to its bright color, affordability, and availability. More specifically, lead chromate in paints can be found in toys, foodware, and furniture. Despite existing alternatives, transitioning away from lead chromate remains challenging due to cost and capability gaps. Lead bisilicates, found in ceramics, are used for their ability to create durable, glossy finishes. These additives are produced through processes that combine lead oxide with other elements, such as alumina and silica. When ceramics with lead glazes are used for cooking or storing food, lead can leach into the food, especially when the glaze is improperly fired or damaged.

Lower-middle-income countries (LMICs) are particularly affected by the widespread use of lead additives in consumer goods. Pure Earth's Rapid Market Screening (RMS) program conducted a global assessment of lead concentrations in over 5,000 samples of consumer goods and foods from markets across 25 low- and middle-income countries. This study aimed to improve understanding of lead exposure sources and inform strategies to mitigate lead poisoning. Key findings revealed that 18 percent of all samples exceeded relevant reference levels for lead. The study highlighted significant contamination in products such as metallic foodware (52 percent of samples), ceramic foodware (45 percent), and paints (41 percent for large surfaces). Additional results showed high lead levels in toys (13 percent), cosmetics (12 percent), spices (2 percent in general, 12 percent in Uttar Pradesh), and other consumer goods (Pure Earth 2024).

This report examines lead exposure from consumer goods in Mexico, India, and Nigeria. These countries were selected for their size and influence in different regions, as well as high prevalence of children with blood lead levels (BLL) above the CDC's reference value of 3.5 micrograms per deciliter (µg/dL). According to Our World in Data, Mexico has approximately 43 percent of children aged 0-14 exceeding 5 µg/dL, India around 52 percent and Nigeria 54 percent (Our World in Data 2021). These elevated levels contribute to more than 320,000 premature deaths annually across these countries (Our World in Data 2021). By focusing on different consumer goods in each country, the report aims to gather diverse insights and identify targeted interventions that can be replicated in other countries facing similar issues. The report focuses on ceramics in Mexico, spices in India, and paint in Nigeria due to their roles as sources of lead exposure: traditional use of lead-glazed ceramics in food preparation in Mexico, contamination of spices with lead chromate in India, and the use of leaded paints in residential and industrial settings in Nigeria. Additionally, a separate report analyzes used lead-acid battery (ULAB) recycling in each country, providing a comprehensive view of lead exposure issues.

Ceramics in Mexico: Traditional Mexican pottery often uses lead-based glazes, exposing millions of households to lead poisoning. Despite existing regulations, enforcement gaps and cultural ties to traditional methods hinder progress towards a lead-free ceramic industry. The Instituto Nacional de Salud Pública (INSP) reported that in 2018, 17.4 percent of children aged 1-4 in ceramic-producing states had blood lead levels above 5 µg/dL (ENSANUT 2022) (Téllez-Rojo et al. 2020).

Spices in India: Lead chromate is added to spices like turmeric and chili powder to enhance color. This poses severe public health risks. According to research by Pure Earth, nearly half of the turmeric, chili, coriander and mixed curry powders samples tested in Bihar contained lead levels that exceeded the Indian standard of 10 ppm. Moreover, Pure Earth's Rapid Market Screening (RMS) found that 12 percent of spices in Uttar Pradesh exceeded lead reference levels, while those in Tamil Nadu and Maharashtra did not (Pure Earth 2024).

Paint in Nigeria: Lead-containing paints remain in use due to inadequate regulatory enforcement and limited consumer awareness. A 2017 survey of 54 solvent-based paints from 18 brands revealed that 74 percent contained lead concentrations above 90 ppm, and 54 percent contained levels above 10,000 ppm (Sustainable Research and Action for Environmental Development (SRADev Nigeria) 2017). Moreover, an academic study published in 2024 found that 100 percent of 34 samples of oil-based paints (predominantly used in industrial settings and rarely inside homes) contained lead levels exceeding 90 ppm (Osibanjo and Akindele 2024). Pure Earth's Rapid Market Screening (RMS) also found that 76 percent of paint (large surface) samples exceeded reference levels for lead (Pure Earth 2024).

Each supply chain is unique and complex, requiring tailored interventions to effectively reduce lead exposure. Understanding the specific contexts and challenges of these supply chains must be considered when designing interventions for them to be effective. For example, in Mexico, addressing cultural ties to traditional pottery methods is highly recommended for the community to embrace and adopt proposed alternatives.

Strategies for reducing lead additives will change per consumer good. However, some common lessons may apply across these supply chains.

- **Producers:** Alternatives to lead additives exist and are not prohibitively expensive, but adapting these alternatives rarely unlocks large economic gains, and private actors do not anticipate major technological innovations for these alternatives. Additionally, interventions must be culturally sensitive and adapted to local contexts. Advocating for the addition of lead additives to Annex III of the Rotterdam Convention can support countries in their efforts to reduce the availability of lead additives on their markets consequently nudging markets towards the adoption of lead-free alternatives.

The Rotterdam Convention

This international treaty enforces a legally binding Prior Informed Consent (PIC) procedure for international trade in the hazardous chemicals listed in its Annex III. Adding lead chromates to the hazardous chemicals list will require exporting countries to prevent exports of lead chromates and related paints to countries that do not consent to receiving them. Importing countries can refuse such imports or allow them under specific conditions and must also impose corresponding prohibitions on the domestic manufacture of lead chromates and of paints that contain them (IPEN n.d.).

- **Consumers:** There is a lack of consumers awareness, but campaigns are costly. Clear labeling can help consumers choose lead-free options, though appropriate testing and monitoring should ensure labelling remains trustworthy.
- **Public Sector:** Enforcement gaps are a major barrier, more so than regulatory gaps. Improved testing and laboratory capacity, along with increased awareness in the sector, are necessary for effective monitoring.
- **Civil Society:** Local organizations are already working to reduce lead additives but often operate on a small scale. Partnerships with the private sector can enhance access and funding but may lead to conflicts of interest.

Beyond consumer goods, we have identified five key transversal lessons to reduce lead exposure in LMICs. First, there is lack of clear attribution of different sources of lead exposure. Various sources, such as leaded paints, contaminated spices, and lead-glazed ceramics, contribute to the problem, but pinpointing their relative impact remains challenging. Second, civil society organizations are actively working in LMICs to combat lead exposure, providing grassroots support and advocacy. Third, missing testing capabilities constrain monitoring and enforcement of lead regulations. Fourth, there is uneven awareness of the scale of lead poisoning as a public health issue. Lastly, the health and economic externalities of lead poisoning far exceed the private costs of production. The table below summarizes the implications of these general findings.

Figure 1: Transversal lessons to reduce lead exposure in LMICs

Findings	Implications
Limited data on the relative contribution of different sources of lead exposure	Systematically **measure blood lead levels** in the population and conduct "**forensic research**"[I]
Civil society organizations already working in LMICs	Fund local organizations, in line with the **localization agenda of USAID** and other bi- and multilaterals
Missing testing capabilities constraining monitoring and enforcement	**Build technical testing** capacity in LMICs in collaboration with existing institutions
Uneven awareness of the **scale** of lead poisoning as a public health issue	**Communicate** impacts of lead poisoning in language that resonates with top decision-makers
Health and economic **externalities** far exceeding private costs of production	**Shape** private sector **incentives**: pure market incentives will not naturally produce a lead-safe future

Interventions to reduce lead in consumer goods necessitate a dual focus on both the private and public sectors to ensure effective outcomes. Incentives for manufacturers to transition to lead-free alternatives should be paired with support for robust enforcement mechanisms to ensure compliance. This integrated approach ensures that manufacturers meet the high standards of product quality incentivized to adopt, ultimately protecting public health.

To reduce lead in consumer goods, interventions should either support lead-free alternatives or disincentivize the use of lead additives. Supporting lead-free alternatives involves improving their availability and affordability through subsidies, innovations, and enhanced distribution channels. Supporting the transition to alternatives also includes increasing the capacity of producers to transition to lead-free practices by investing in infrastructure and providing technical support. Additionally, raising awareness among producers and boosting demand for lead-free goods through targeted campaigns can support this transition. Disincentivizing lead additives includes changing laws and regulations to ban or discourage their use and improving enforcement through public sector capacity development and civil society monitoring.

Figure 2: Interventions framework

2. COUNTRY CASE STUDIES

2.1 CERAMICS IN MEXICO

Lead-based glazes are widely used in traditional Mexican pottery, exposing thousands of artisans millions of households to lead poisoning, especially in Central and Southern Mexico.

Barriers to lead-free ceramics include the widespread ability and easy use of lead-based glazes, the need for substantial trial and error to perfect the use of lead-free alternatives, deep cultural ties to traditional lead-based crafts limiting consumer awareness, lax regulations that fail to explicitly prohibit lead in ceramics and do not control the flow of lead oxides into the ceramics ecosystem, and the limited support for culturally sensitive and locally driven transition efforts.

Going forward, interventions should increase market penetration of lead-free glazes, support kiln improvements and artisan experimentation, provide culturally sensitive and locally driven technical assistance, incorporate lead-free incentives in productive loans, boost demand for lead-free ceramics through partnerships with large-volume buyers, implement industry controls on lead oxidizers, and reinvigorate existing multistakeholder efforts such as the Immediate Action Program for Lead Exposure Control in Mexico.

2.1.1. MARKET OVERVIEW AND REGULATORY FRAMEWORK

The widespread use of lead-based glazes in traditional Mexican pottery is a significant public health concern, exposing millions of households to lead. Of the estimated 70,000 potters and ceramists in Mexico, about 50,000 specialize in crafting glazed pieces with a characteristic shiny, glossy finish (Secretaría de Economía 2024) (Pure Earth 2021).[1] Over 90 percent of these artisans utilize lead oxide-based glazes, subjecting themselves and their families to direct lead exposure during the ceramic crafting process. This exposure risk extends beyond artisan communities, with an estimated 4 to 16 million households exposed to lead leaching when using these ceramics for cooking, serving, and storing food and beverages (Pure Earth 2021) (INEGI 2020). This extensive use of ceramics among the Mexican population is one of the main drivers of Mexico's high prevalence of lead poisoning[2] in children between the ages of 1 and 4 (Pure Earth 2019), currently standing at 17.4 percent nationwide (ENSANUT 2022) (Téllez-Rojo et al. 2020).

The prevalence of lead poisoning is strongly correlated with the production and use of lead-glazed ceramics. Four of the five states where lead poisoning is most prevalent–Puebla, Tlaxcala, the State of Mexico, and Oaxaca–are also the largest producers of lead-glazed ceramics. In these states, child lead poisoning rates between the ages 1 and 4 exceed 30 percent (ENSANUT 2022) (Téllez-Rojo et al. 2020). While other lead sources should not be minimized,[3] there is a clear correlation between the production and use of glazed ceramics and elevated lead exposure.

Lead-based glazes persist as an input for over 90 percent of glazed ceramics due to their availability and ease of application. Artisans often have ready access to these glazes or can easily prepare them by combining locally sourced lead oxide, silica, and water. Lead-based glazes also possess a wide firing temperature range. They vitrify[4] at low temperatures (~700°C) but can withstand temperatures exceeding 1,000°C.[5] This not only makes lead-based glazes versatile for

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[1] Official censuses from INEGI and FONART estimate between 10,000 and 25,000 artisans. However, the Ministry of Economy suggests that these figures are undercounted, with a more realistic estimate ranging from 50,000 to 75,000 artisans nationwide. Given the family-based nature of ceramic making, often involving children, underreporting is common making it difficult to determine exact population estimates.

[2] Defined as blood lead level concentrations of 5 µg/dL or higher (WHO, 2020). Notably, the CDC has recently lowered its reference value to 3.5 µg/dL, and the current WHO criterion is based on the previous CDC reference value.

[3] Other important drivers of lead poisoning in Mexico include lead-acid battery recycling, paint, make-up, and toys. See (Casa Cem 2024)

[4] Vitrification is the process through which a glaze reaches a high enough temperature for it to melt and form a smooth, non-porous, glassy surface on the piece, making it durable and water resistant. A vitrified glaze is not necessarily free form the risk of leaching.

[5] Experts shared that when fired above ~1,050°C, lead glaze can "seal" onto a ceramic piece and become a structural part of it, which can reduce (but not entirely eliminate) the risk of lead leaching.

various types of kilns and artisanal methods but make them easy to use as they do not require neither high temperatures nor extreme technical temperature precision to use. Moreover, lead-glazed ceramic pieces are sought after by consumers to prepare traditional dishes including beans, mole, salsas, and coffee. The earthy ceramic and the sweetness from the lead yield a specific, hard-to-replicate flavor profile, deepening cultural and identity-based ties to traditional methods of crafting ceramics with lead.

This widespread availability of lead oxides and glazes is facilitated through both formal and informal channels facilitating distribution to artisan communities. These distribution channels range from regional, formal supply stores in mid-sized towns, intermediaries colloquially known as *coyotes*, and even illicit networks involving organized crime groups. These distribution networks have a long-standing presence in artisan communities, where artisans often organize themselves through trade guilds and local unions. One or two guild or union members often act as liaisons with these networks, managing the sourcing and distribution of lead oxide and other ceramic supplies to their communities. These liaisons then sell oxides through home-based sales or through further intermediation via local stores or markets where fruits, vegetables, and other produce are also sold.

Once ceramic pieces are crafted, they are sold to stores, households, and businesses such as hotels and restaurants. This distribution is largely informal, typically handled by artisans themselves or through personal networks of intermediaries, which help extend their reach to other states. Sales are majorly conducted through direct purchases at workshops by request, local markets and stores, door-to-door sales, roadside stalls, and fairs. This demand is further supported by state-sponsored distribution and promotion at expos and bazaars.

Lead-glazed pieces are largely demanded due to their glossy finish, their unique aesthetics[6], and their distinctive flavor profile for food preparation. These pieces are sought after by consumers to prepare traditional dishes such as beans, mole, salsas, coffee, among others. The earthy ceramic and the sweetness from the lead yield a specific, hard-to-replicate flavor profile, deepening cultural and identity-based ties to traditional, lead-containing crafting ceramics. For instance, these pieces are a staple of traditional Mexican restaurants and diners. Furthermore, knowledge and risk perception of the health risks associated with lead exposure from these pieces remains limited among consumers. The lack of clear visual signals for consumers to distinguish lead-containing from lead-free pieces exacerbates this; pieces are virtually indistinguishable for a regular buyer.

[6] Mexico has a rich diversity of ceramic techniques, with regional variations in color, shape, and intended use. Large ceramic-making communities (400+ workshops) frequently have a distinct ceramic style. Even within the same community, workshops often use unique clay combinations, shapes, and pigments, creative distinctive staples that vary from workshop to workshop.

Lead-free glazes exist in the market but come with tradeoffs that have limited their widespread adoption. These alternatives predominantly come in the form of mineral-based frits, which are powdered glass materials that have been melted at high temperatures to create stable, insoluble compounds. They are available in various formulations, primarily differing in their melting agent or *flux*, the substance that lowers a glaze's melting point and promotes the fusion of materials during firing. Lead oxides serve as the flux for lead-based glazes, whereas lead-free alternatives utilize fluxes such as boron, alkali oxides, and alkaline earth oxides. These alternatives vary in cost, temperature requirements, and shine and color effects.

While less hazardous, most artisans have been hesitant to embrace these alternatives, citing concerns over differences in finish quality and aesthetics. They have also expressed skepticism towards transition efforts, often perceiving them as external impositions to displace them from the market. Additionally, there is a general aversion to modifying productive processes due to the risk of jeopardizing their primary income source. However, artisans who have successfully transitioned to lead-free practices report that high-quality, lead-free glazed ceramics are achievable.

Successfully transitioning to a lead-free glaze requires extensive experimentation to adapt inputs and productive processes. This includes modifying clay compositions, adjusting pigments, incorporating additives to the glaze, and experiment with firing times and temperatures. Such experimentation often results in the loss of entire firing rounds, imposing a substantial burden on low-income artisans in terms of time and resources. Moreover, lead-free glazes often require higher temperatures and more precise temperature control than traditional lead glazes compatible with wood-fired kilns with sometimes uneven temperature distributions.[7]

Mexico's Health Ministry and its sanitary regulator COFEPRIS have established regulations for lead in ceramics. This regulatory framework is largely comprised of NOMs, *Normas Oficiales Mexicanas*, which are mandatory technical regulations on products, processes, and services when these may constitute a risk to people, animals, and the environment in general. As of July 2024, the key NOMs relevant to lead exposure through traditional ceramics include:

- NOM-199-SSA1-2000 (NOM-199) prompts public intervention and control measures if blood lead level concentrations exceed 5.0 µg/dl for pregnant women and children under 15 years old, and 25.0 µg/dl for the rest of non-occupationally exposed population. Health care providers and laboratories conducting blood lead level analyses are mandated to notify health authorities when lead levels exceed these criteria (DOF 2002).

[7] Although boron-based glazes do not require higher firing temperatures. See relevant section under Supply Chain Analysis for additional details.

- NOM-231-SSA1-2016 (NOM-231) outlines permissible soluble lead limits in ceramic crafts, requiring pieces exceeding these limits bear a legend reading "Do not use with food or beverages, contains lead" (DOF 2016).
- NOM-004-SSA1-2013 (NOM-004) establishes sanitary limitations and specifications for the permissible use of lead compounds, including lead oxide. It states that "lead use should be avoided as an ingredient for glaze, glazed pottery, or glazed ceramics" (DOF, NORMA Oficial Mexicana NOM-004-SSA1-2013, Salud ambiental. Limitaciones y especificaciones sanitarias para el uso de los compuestos de plomo. 2014).
- NOM-047-SSA1-2011 (NOM-047) establishes maximum blood lead limits for occupationally exposed workers (30 µg/dl for men and 10 µg/dl for women) (DOF 2012).

Despite these regulatory mandates and the potential for fines and business closures due to non-compliance, effective monitoring and enforcement have proven challenging.

- While NOM-199 sets blood lead limits, its impact is limited by the absence of a comprehensive national lead surveillance system. Additionally, these limits cannot be interpreted as safe maximum blood lead level concentrations, as experts emphasize that there is no safe concentration of lead in blood. While clinics, labs, and hospitals should notify authorities about high blood lead concentrations, there is minimal enforcement.
- The informal and fragmented distribution channels through which traditional ceramics are circulated complicate lead testing to monitor NOM-231 compliance, placing the responsibility of labeling compliance on artisans, resulting in limited adherence.
- NOM-004 is lenient in language, as it does not strictly prohibit the use of lead compounds in ceramics but merely recommends against its use.
- Since ceramic making is largely conducted informally, NOM-047 has low practical effectiveness, leaving virtually no provisions for a comprehensive surveillance of blood lead levels among artisan households.

A review is mandated for these regulations every five years. This requirement has not been consistently met, rendering some stipulations outdated according to experts.

Recent regulatory developments have brought further challenges and uncertainty with the potential cancellation of lead-related NOMs. In 2023, the National Program for Quality Infrastructure[8] began a cancellation process for NOM-004 and of modification projects of NOM-047 and NOM-199, which faced significant criticism from civil society and researchers, who described them as lacking robust, evidence-based justification (Cossío Díaz 2023) (Contreras 2023).

[8] Programa Nacional de Infraestructura de la Calidad

As of July 2024, all mentioned NOMs remain active and have not been officially cancelled nor substituted. The CCNNSP, a committee in charge of reviewing NOM-related updates, began a formal analysis in July 2023 to determine which NOMs would change or be eliminated. After four sessions, the outcome for these specific NOMs remains inconclusive (CCNNSP, Acta de la Primera Sesión Extraordinaria 01/2023 2023) (2023) (2023) (2024). Additionally, the official NOM catalogue from COFEPRIS displays these NOMs as "active" (COFEPRIS 2024), there have been no official cancellations emitted by the Secretariat of Health nor from the National Commission of Regulatory Improvement (CONAMER 2024). The table below summarizes these this information.

Table 1: Mexican regulations governing lead in ceramics

NOM	Description	Challenges/Gaps
NOM-199-SSA1-2000	Sets blood lead level thresholds for public intervention: 5.0 µg/dl for pregnant women and children under 15, 25.0 µg/dl for non-occupationally exposed adults	• Lack of comprehensive national lead surveillance system • Minimal enforcement of notification requirements • Thresholds not considered "safe" levels by experts
NOM-231-SSA1-2016	Outlines permissible soluble lead limits in ceramic crafts	• Informal distribution channels complicate testing and monitoring • Labeling compliance relies heavily on artisans • Limited adherence due to informal nature of industry
NOM-004-SSA1-2013	Establishes limitations for lead compound use, including in glazes	• Lenient language ("should be avoided" rather than explicit prohibition)
NOM-047-SSA1-2011	Sets maximum blood lead limits for occupationally exposed workers: 30 µg/dl for men, 10 µg/dl for women	• Low practical effectiveness for informal, household-based ceramic production • No provisions for surveillance of artisan households
All NOMs		• Inconsistent five-year review process • Potential outdated stipulations • Proposed cancellations/modifications creating uncertainty • Ongoing review by CCNSP with inconclusive outcomes

Efforts around encouraging the adoption of safer practices have seen early success but require scaling and implementation support. The Fondo Nacional para el Fomento de las Artesanías (FONART), a public agency under the Mexican Ministry of Culture has promoted the transition to lead-free ceramics since the 1990s. Over the past thirty years, FONART has organized recurrent lead-free ceramic expos, established a permanent lead-free ceramics shop in Mexico City, and delivered workshops and lead-free technical assistance to artisans in collaboration with international entities such as UNESCO and Pure Earth. FONART has also developed transition manuals for artisans, organized lead-free ceramics contests, and most recently, introduced a "Lead-Free Certification" for NOM-compliant pieces (Blacksmith Institute n.d.). These efforts have been instrumental in reaching and transitioning initial groups of artisans to lead-free practices, but they have struggled to penetrate the highly fragmented and largely informal artisan production ecosystem, as currently 90-99 percent of pieces do not comply with NOM lead standards (Pure Earth 2021) (Instituto Nacional de Salud Pública 2021). Additionally, FONART is largely reliant on federal budgetary changes and the political will of public decision makers.

More about FONART

FONART is the leading agency dedicated to supporting and promoting traditional Mexican artisans and their crafts. Established to preserve and enhance Mexico's artisanal heritage, the agency operates through eight operational branches known as *vertientes*, through which the agency supports artisans' livelihoods while promoting cultural heritage and craftmanship:

[1] Trainings and technical assistance programs	[5] Popular arts contests
[2] Production subsidies	[6] Occupational health support
[3] Crafts purchases	[7] Creation of artisanal corridors
[4] Promotion in artisanal fairs and expos	[8] Support for strategic artisanal projects

FONART's operational rules* govern these operational branches. Within them, two lead-related facts stand out:

(i) The only explicit mention of lead occurs under *vertiente* [4], stating that FONART *can* provide financial support for artisans to obtain the lead-free certification to comply with the relevant NOM to facilitate their participation in fairs and expos. **

(ii) To apply as beneficiaries to programs, artisans must subject their crafts to compliance with FONART's DAM matrix, a criteria framework for determining if crafts are eligible for benefits. As of 2023, the DAM matrix evaluates a craft's characteristics, including the origin of raw materials and artisanal processes, but does not include considerations about the use of lead oxides or lead derivatives.

These points suggest that artisans using lead-glaze can still access many of FONART's program benefits, according to their operational rules. Despite potential normative improvements, FONART has key individuals who are actively leading efforts to reduce lead use in ceramic glazes. For instance:

- FONART Director Emma Yanez, who has advocated from her leadership role for stricter regulations on lead oxide and lead glaze manufacturers, arguing that regulatory burdens should be borne by manufacturers rather than by artisans (FONART 2022).
- Mario Covarrubias, Director of *vertiente* [1] has led the agency's on-the-ground efforts to deliver transition programs and support artisanal communities in facilitating this change for over 20 years.

** Original version in Spanish available at: ACUERDO por el que se emiten las Reglas de Operación de Programas del FONART para el ejercicio fiscal 2023*
*** It is unclear through these operational norms if all fairs and expos require lead-free compliance. There are multiple lead-free expos occurring yearly in Mexico City, which do require the certification.*

Additional public policy efforts were prompted by first-time evidence of widespread lead poisoning among children in 2018. The Instituto Nacional de Salud Pública (INSP), Mexico's scientific and policy research institute for health, integrated blood lead measurements into the ENSANUT national health and nutrition survey in 2018. The survey revealed a widespread prevalence of lead poisoning, with 17.4 percent of children aged 1-4 nationwide exceeding the 5 µg/dl threshold for blood lead concentrations, with rates surpassing 30 percent in some ceramic-producing states[9]. These findings prompted a national action program[10] to address lead exposure, developed jointly by public health agencies and a civil society association[11]. The program and its implementation were approved by the General Health Council through an official agreement in 2019.[12] Five action lines are emphasized through the program:

1. **Regulatory framework reviews, especially to NOM-199**
2. **Assurance of a sound clinical management of lead exposure and lead poisoning**
3. **Reduction of lead exposure from lead-glazed pottery production and use**
4. **The establishment of an epidemiological blood lead surveillance system**
5. **Promotion of health awareness and communication strategies**

Civil society organizations and health experts have elevated the robustness of the action program and urged its reinvigoration. The program has been praised by public, private, and civil

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[9] Including Puebla at 46.6 percent, San Luis Potosí at 37.4 percent, Tlaxcala at 35.6 percent, and Oaxaca at 29.4 percent (Tellez Rojo 2020). A notable exception is Michoacán, where despite being a large ceramic producing state, lead poisoning rates are below national average.
[10] The Immediate Action Program for Lead Exposure Control In Mexico (*Programa de acción de aplicación inmediata para el control de la exposición a plomo*)
[11] Collaborative Living in a Chemical World
[12] Acuerdo del Consejo de Salubridad General (CSG 83/27.11.2019), published in the Diario Oficial de la Federación, the Mexican equivalent to the Federal Registry in the US.

society actors, given its comprehensive action lines. However, the program's implementation has stalled upon leadership changes in the General Health Council. Regulatory revisions to NOM-199 have been approved but remain as drafts, and epidemiological lead measurement pilot programs were designed but none have been conducted yet. Civil society stakeholders signaled a limited political will and lack of resources to scale programs as key barriers to fully implement this plan.

Multiple civil society organizations, collectives, and nonprofits have advanced efforts towards transitioning to lead-free ceramics.

Organizations conducting research, advocacy, awareness, training and support for lead-free ceramics in Mexico (non-exhaustive)

- **Casa Cem** *is a civil society association dedicated to fostering an informed and engaged society to promote sustainable living and community resilience. They conduct research on the life cycles of natural resources and their interactions with human societies. Through their findings, they advance public policy advocacy, training programs, communication projects, and foster synergies for environmental education and health with the public, private, and social sectors. As thought leaders on lead exposure, Casa Cem has conducted research and awareness campaigns on its exposure risks in Mexico through ceramics, lead-acid battery recycling, children playgrounds, among others.*
- **Colaborativo Viviendo en un Mundo Químico** *is a group of environmental public health experts and researchers focusing on the integration of environmental health and public policy analysis. The collective, grouping scholars, thought leaders, and public health officials emphasizes collaborative efforts to address chemical management and environmental health issues. Notably, Mundo Químico was instrumental in the development of the multi-stakeholder Action Program to address lead exposure in Mexico.*
- **Pure Earth** *is a global non-profit organization dedicated to addressing pollution-related health problems in LMICs. Through their* **Barro Aprobado Program,** *they have targeted lead poisoning in Mexico caused by traditional lead-glazed pottery. The program focuses on consumer education, artisan training and support, and promotion. It has successfully supported over 100 artisans and dozens of restaurants in their transition to lead-free practices.*

Additionally, while a public dependency from the Ministry of Health, the **Instituto Nacional de Salud Pública (INSP)** has advanced the most significant blood lead surveillance efforts through the inclusion of blood lead monitoring in the ENSANUT national health survey. With continuous data on lead exposure, intervention strategies on target populations can be informed. However, their efforts require recuring additional financial and political support from federal agencies.

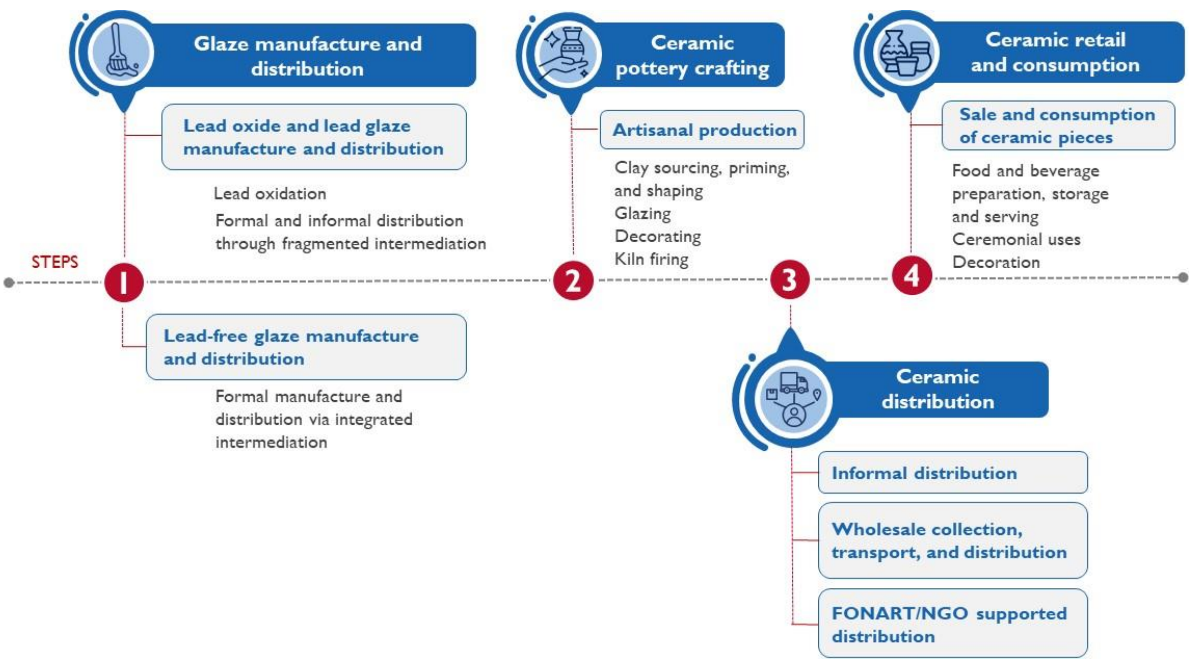
2.1.2. SUPPLY CHAIN ANALYSIS[13]

The production of lead-glazed ceramics in Mexico involves thousands of formal and informal stakeholders across four broad stages:

a) **Glaze manufacture and distribution**
b) **Ceramic pottery crafting**
c) **Ceramic distribution**
d) **Ceramic retail and consumption**

Multiple sub-processes are active at each stage. For instance, lead-based and lead-free glazes are manufactured and distributed through different processes under stage (a). The visual below summarizes these stages:

Figure 3: Traditional glazed ceramics supply chain



[13] Information in this section was collected through publicly available information from the Ministries of Culture, Health, and Economy and through field work conducted in Mexico City, Atzompa, Oaxaca, and Dolores Hidalgo, Guanajuato. Conversations with dozens of artisans and advocates for lead-free ceramics, including artisan Doña Socorro from Cerámica Coronilla workshop, artisan Doña Raziel from María Dolores workshop, artisans Doña Graciela and Don Angel, artisans Doña Isabel Martínez Maldonado and Don Selso Enríquez from Tradiciones workshop, Diego Mier y Terán from Innovando la Tradición, staff from Cooperativa 1050°, Impulsora Dolorense de Materiales Cerámicos, Don David Zimbrón, and Dr. Ramona Pérez from the SDSU Center for Latin American Studies, proved invaluable to inform this chapter, which does not necessarily reflect their opinions. We remain deeply grateful for their time and openness.

Preamble: key terms and definitions around glazes

Glazes are thin, glass-like coatings applied to surfaces to enhance their appearance and functionality. They can vary in several key characteristics. Their **transparency** determines whether the glaze is see-through (transparent) or not (opaque). **Finish** can be brilliant (light-reflecting) or matte (non-reflective). Glazes can also be categorized by the **temperature range** they require for proper firing: low (below 1,000°C), medium (1,000 – 1,100°C), or high (above 1,1000°C). Their **flux**, or melting agent, is the substance used to lower their melting point and promotes material fusion during firing. Common fluxes include lead oxides, boron, alkali oxides like sodium and potassium, and alkaline earth oxides like calcium or magnesium oxide.

Table 2: Characteristics of glazes

Characteristic	Options	Description or examples
Transparency	Transparent	Allows light to pass through
	Opaque	Does not allow light to pass through
Finish	Brilliant	Reflects light, glossy appearance
	Matte	Does not reflect light, non-glossy appearance
Firing temperature	Low temperature (<1,000°C)	Suitable for lower temperature kilns (e.g., regular wood-fired kilns)
	Medium temperature (1,000 – 1,100°C)	Suitable for medium-temperature kilns (e.g., gas kilns, specialized wood-fired kilns)
	High temperature (>1,000°C)	Suitable for industrial kilns
Flux	Lead oxides	Low melting point
	Boron	Low melting point
	Alkali oxides	Melting point depends on composition (e.g., sodium or potassium oxides)
	Alkaline earth oxides	Melting point depends on composition (calcium or magnesium oxide)

Table elaborated with data shared by FONART, 2024

Understanding glaze preparation methods and glaze-clay compatibility are key to understanding how to successfully substitute one glaze for another in ceramic making:

- Preparation: Lead-based glazes can be easily prepared “manually” by artisans by combining lead oxide, silica, and water, forming a milky, viscous mixture. In contrast, most lead-free alternatives require the use of **frits**, which are pre-made power compounds that have been subjected to high temperatures to eliminate impurities and render compounds insoluble. These frits are necessarily produced by manufacturers.

- Glaze-clay compatibility: A successful glaze application depends heavily on its compatibility with the ceramic body[14]. The coefficient of thermal expansion (CTE) of both the glaze and the clay determine this compatibility. For optimal results, these CTEs should be similar. When differing significantly, the glaze may crack or craze as the piece cools after firing, affecting both its durability and aesthetic appeal. Variables such as the type(s) of clay used and their density and mineral composition, the type of glaze used and its thickness, firing temperatures, and pigments used for coloring influence CTE.

A) Glaze manufacture and distribution

A1) Lead oxide and lead glaze manufacture and distribution

Lead oxide powders are the primary component of lead-based glazes and are produced by four major oxidizers in Mexico. PENOX, a large German oxidizer, and Dynakrom, a leading national supplier, both operate in Monterrey. *Óxidos y pigmentos*, based in Tijuana near the US border, and *Weico Químicos (Grupo Kalidad)*, with operations in six states, share the remaining oxide production market. *Weico* Químicos is unique in being the only oxidizer with a ceramics division and direct sales outlets for artisans, supplying various materials for ceramic making. The remaining oxidizers primarily supply the lead-acid battery and pigment industries, with minimal additional sales to glass and PVC manufacturing industries. Outside of the direct sales conducted through *Weico Químicos*, oxides reach the ceramic ecosystem indirectly through intermediaries.

Lead oxide is distributed to the ceramics ecosystem through either formal frit manufacturers or via fragmented intermediary networks. Six manufacturers lead most of the production of frits in Mexico: Cerámicos San José, Ferro, and Procerama, Esmaltes y Colorantes Cerámicos (EYCCSA), Daltile Mexico (aka. Macesa). These manufacturers source supplies from oxidizers and can produce both lead-containing and lead-free frits, which serve as the base for glazes. They supply various industries, including glass, enamel, paints, medical products, and notably, artisanal glazed ceramics. Informal distribution also facilitates raw lead oxides to hundreds of small and medium-scale chemical materials distributors, operating at the margin of informality across the country.

Level of isolation and organizational capacity determine how oxides and glaze reach an artisan community. In highly isolated communities, intermediaries colloquially known as *coyotes* bridge the gap between chemical distributors and remote areas. Civil society and experts have reported that organized crime is occasionally also involved in this distribution. These intermediaries sell oxides in a range of sizes, from 25kg sacks to a ton, typically to community members or local artisan unions, who act as liaisons with these intermediary networks. These liaisons then sell

[14] The base clay or mixture of clays and other substances that forms the main structure of a ceramic piece prior to its glazing and firing.

oxides through home-based sales or through further intermediation via local stores or markets, where fruits, vegetables, and other produce are also sold. Larger artisan communities can access regional supply centers that provide oxides, glazes, and other inputs for ceramic crafting, which have the capability to ship orders nationwide. Intermediaries across this supply process, including *coyotes*, unions, and organized crime, frequently take advantage of their supply power over artisan households, exacerbating their reliance on them.

Artisans either acquire pre-made lead glaze or source oxides to prepare it themselves. If pre-made glaze is locally available, it is often supplied through the local artisan union. Alternatively, artisans source their own lead oxide supplies and prepare homemade glazes by mixing the oxide with silica and water in buckets or containers, forming a milky mixture that is applied to the shaped clay or ceramic paste. Lead glazes require low-temperature kilns to be fired, as they can vitrify at temperatures as low as 700°C, while still being able to withstand high-temperatures above 1,100°C. This large range of withstood temperatures is another attractive feature of lead-based glazes, as they don't require high or precise temperature management, enabling artisans with lower quality kilns that might have more uneven temperature distributions to remain productive.

A2) Lead-free glaze manufacture and distribution

Frits, pre-made chemical compounds, are the main presentation of lead-free glazes. They have more complex chemical compositions and must therefore be pre-made by frit manufacturers. These frits come in a variety of formulations, and were developed to provide a source of fluxes for low and mid-temperature glazes. Artisans combine them with water and viscosity modifiers (like bentonite, which enhances adherence to the clay body) to form a glaze slurry, which is similar to lead-glaze in terms of application and viscosity.

The most common and adaptable lead-free glazes are based of boron frits. These frits are cost-competitive with lead-oxides, frequently costing *less*, and require low firing temperatures to vitrify onto ceramic pieces (depending on the specific glaze, ranging from 780°C to 1,080°C). This lead-free alternative is heavily promoted by FONART through their lead-free transition program[15]. When transition efforts began in the early 1990s, artisans reported significant differences in shine, fragility, and color-matching capacity of boron-based glaze. However, artisans that have successfully transitioned and civil society experts shared that matching the quality of a lead-glazed piece is achievable, and rather requires extensive trial and error in formulation and adaptation of their productive processes. Formally speaking, this experimentation involves adjusting inputs and processes to allow the glazes' and ceramic bodies' coefficients of thermal expansion to match.

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[15] *Programa Nacional para la Conservación de los Recursos No Renovables y la Sustitución del Plomo en la Alfarería Vidriada*

Four specific boron-based glazes have most of the lead-free market. **ECOTT-300** is the most frequent variety among lead-free artisans. It yields a transparent glaze and requires firing temperatures ranging from 850 to 1,080°C. **ECOTT-301** requires lower temperatures, from 780 to 1,000°C, and is mostly used to achieve green, red, and copper finishes, providing variable tonalities if mixed with ECOTT-300.[16] Achieving the right viscosity has been reported as challenging with this glaze. Daltile provides two transparent lead-free glazes: **MC-097** AND **MC-03A**. Both are transparent and require firing temperatures of 850 to 1,080°C.

Relevant temperature tradeoffs must be considered when using these glazes. While these alternatives *can* vitrify at low temperatures below 1,000°C, the specific clays and pigments used may demand higher temperatures to fix properly onto the ceramic body—temperatures that are not achievable with traditional wood-fired kilns used by most artisan communities. As a result, alternative kilns like gas- or electricity-powered ones are frequently necessary to use these glazes. Furthermore, lead-free glazes demand much stricter temperature control to vitrify properly. If subjected to excessive temperatures, the glaze can melt and yield a low-quality piece, whereas lead glaze is very flexible in terms of temperatures withstood. Artisans that have successfully transitioned have reported high-quality finished pieces when using these glazes, notwithstanding the extensive experimentation needed to adapt their other inputs and processes.

Lead-free artisans source their glazes through shipped orders from distributors. A handful of glaze distributors operate nationwide, with a major distribution hub located in Dolores Hidalgo, Guanajuato, where two large distributors operate: *Impulsora Dolorense de Materiales Cerámicos* (IDMC), and *Materiales Cerámicos Salazar*. These suppliers provide both lead-based and lead-free glazes, pigments, and other materials for artisans. Sourcing lead-free glaze is straightforward; for example, lead-free artisans in Atzompa, Oaxaca, source their glaze from IDMC by placing orders over the phone, paying via virtual bank transfer (which requires owning a smartphone), and receiving shipments by van or truck, typically within three days. Suppliers like IDMC can cater to small-scale orders, starting at 25kg sacks.

Despite their availability and cost-competitiveness, boron-based glazes are rarely used by artisans. The extensive experimentation required to adapt inputs and processes to produce high-quality outputs with lead-free glazes is a significant barrier as it involves risking time and income from failed firing rounds. Additionally, ceramic material sourcing is often part of the social fabric of artisan communities, involving local leaders, guilds, and unions. Deviating from an established social equilibrium is perceived as disruptive and can be conducive to social costs such as ostracization from neighboring artisans.

[16] ECOTT-300 and ECOTT-301 are manufactured by Cerámicos San José

Skepticism towards the health effects of lead has also limited the adoption of lead-based glazes. Artisans in Atzompa, Oaxaca who made the switch reported only doing so after observing severe and notable health impacts on their families. The gradual, pervasive nature of lead-related harm often goes unrecognized in many communities, despite awareness campaigns from FONART and civil society organizations. Researchers have noted that such campaigns struggle to gain traction as some lead exposure symptoms mirror those of malnutrition—a common experience among low-income families.

B) Ceramic pottery crafting

Estimates from public institutions suggest between 50,000 and 70,000 artisans crafting glazed ceramics in Mexico. These artisans are distributed across 20 states, primarily in communities in central-southern states like Oaxaca, Puebla, State of Mexico, Hidalgo, Guanajuato, and Michoacán. Most artisans are concentrated in artisan hubs or clusters, medium-sized towns where most families are dedicated to ceramic making, each one with between 400 and 800 workshops. While their production is predominantly informal, artisan communities have strong organizational capacity to manage their processes collectively and remain connected with authorities and support-providing agencies. Common organizational structures include family workshops, cooperatives, unions, civil associations, and local committees, often validated by local authorities.

Throughout the ceramic making process, male and female artisans divide various tasks, starting with sourcing their clay from local deposits. Clay types vary in color, consistency, and mineral composition based on geographical region. To minimize cracks during firing, male artisans clean, refine, and knead the clay to remove impurities. Some workshops combine multiple clay types to achieve specific densities and colors, leading to clay variation within the same artisan community. The prepared clay is then shaped by hand, using potter's wheels, or with molds to create specific shapes and patterns, a task shared by both male and female artisans. Most frequent lead-glazed ceramic pieces include *ollas* (cooking pots), *cazuelas* (cassoles), mugs, plates, and decorative pieces. The molded clay is then left to dry.

Shaped pieces are then glazed before being decorated and fired in kilns.[17] This process is mostly conducted by female artisans, who apply the glaze individually on each piece by hand, by dipping, brushing, or pouring the prepared glaze mixture, aiming to achieve an even coat for a high-quality finish. Artisans often use bare hands to dip pieces into the mixture, covering their arms elbow-deep with the glaze, which is prepared in buckets. Once glaze dries onto each piece, they are decorated by using a variety of pigment formulations. Color is integral to a workshop's identity, as the patterns and tonalities achieved serve as distinguishing features across workshops. Each

[17] Several types of Mexican ceramics require a first, low-temperature firing round (500°C~800°C) prior to being glazed, known colloquially as *sancochado*.

pigment has a specific formulation that is integral to the artisanal process and may react differently on the ceramic pieces depending on the types of clay and glazes used. Once artisans decorate the pieces, they are placed in kilns for firing.

Over 80 percent of glazed ceramic workshops use wood-powered kilns. These kilns are inexpensive and relatively easy to build with easy-to-source materials like brick and adobe. An average wood-powered kiln costs about $100 and can fire between 200-400 pieces per round.[18] However, variations in kiln construction quality affect the temperatures they can withstand, ranging from very low (below 500°C) to medium temperatures (up to 900°C). Poorly constructed kilns can also have significant temperature variations *within* the same firing round, with pieces closer to heat sources being experiencing temperatures hundreds of °C higher than those further away.[19] Each firing round requires burning dried wood, which is a significant cost driver and exposes artisans to harmful fumes. Furthermore, deforestation in some regions has led to the use of lower-quality substitutes including less dense woods, car tires, or plastics, which constrain firing temperatures and produce more toxic fumes, creating polluting externalities for nearby neighbors. Substituting these kilns is a focus of diverse philanthropic programs addressing climate change.

Most remaining workshops use gas kilns for their crafts.[20] They offer a larger capacity range, from small gas kilns handling around 200 pieces to large ones handling over 1,000 pieces per round. These kilns are considerably more expensive, costing between $4,000 and $15,000 to install,[21] depending on size, and can reach medium to medium-high temperatures (900 – 1,100°C). Operating one of these kilns involves managing gas supply logistics, using different heat measurement instruments, and understanding the rates at which temperature changes to control firing quality.

Once an artisan fires lead-containing pieces in their kiln, lead residues become a potential long-term contamination source in the kiln. Consequently, any subsequent firing, even of lead-free pieces, is at risk of lead contamination.

Lead-free glazes generally require higher temperatures to vitrify and properly fix into ceramic crafts. Lead-based glazes vitrify at medium-low temperatures, between 800 and 900°C, forming a glossy, glass-like surface. Lead-containing pieces that are fired at lower temperatures have a

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[18] While larger and smaller wood-fired kilns do exist, they are rare.

[19] This is not an issue when using lead glaze, which is very flexible in terms of temperatures withstood. However, lead-free glazes require a much stricter temperature control to properly vitrify.

[20] A minimal percentage (< 0.5 percent) of kilns used in glazed ceramic production are powered with diesel or electricity.

[21] Installation includes the kiln, an internal fiber glass coating that acts as insulator, the plaques where ceramic pieces are placed during firing, gas pipes, valves and regulators, and a stationary gas tank. Some artisans have also adopted the use of pyrometers to measuring and monitoring temperature.

significantly higher risk of lead leaching when pieces are used for food consumption. Boron-based glazes, the most cost-competitive lead-free alternatives, require similar temperatures to vitrify but require significant experimentation to match their finish quality, fragility, and color to original, glazed pieces. Most lead-free frits, which offer high-quality glaze finishes, require firing temperatures above 1,000°C to vitrify properly, which are high enough to minimize the risk of leaching, but also require experimentation to properly match end results.

C) Ceramic distribution

The distribution channels used by artisans depend on their community's location, organizational capacity, and the types of pieces crafted. Finished ceramics are mostly distributed by artisans themselves or through their own personal networks of informal intermediaries who distribute the pieces to selling points in other communities. They sell to consumers through stores, markets, door-to-door sales, roadside stalls, fairs, and through bartering with other artisan communities. Artisans frequently have their own storage sites for excess inventory. Lead-free ceramic sales are primarily driven by orders from consumers and large-volume buyers like hotels and restaurants.

Artisan-led distribution is also intertwined with communal social norms and values. Artisan communities maintain strong cultural and identity-based ties to their crafts, taking pride in the intricacies of the unique colors and shapes of their finished products. Furthermore, community members adhere to horizontal and communal values. Each artisan family, frequently spanning multiple workshops, has a role to play in maintaining the social equilibrium of ceramic production, from supporting material sourcing, production, and sales. Consequently, artisans who unilaterally shift to lead-free practices have reported experiencing ostracization from their neighbors and local leaders. This has resulted in their occasional exclusion from local selling points and unions restricting their access to materials, forcing them to develop their own sourcing strategies.

FONART complements the distribution and sales of traditional ceramics. Their ceramic promotion programs aim to connect artisans with regulated expos and fairs, stores in tourist destinations, arts and crafts contests, museums, and shops. FONART also provides digital commerce support, offering technical assistance to open and manage virtual shops and promoting ceramic pieces through their own digital platforms. The Fund's activities have connected artisans with the national and international markets, which were particularly relevant during the pandemic when potters' incomes were at risk. However, their capacity is limited and insufficient to absorb a significant share of the overall aggregate production.

Ceramic retail and consumption

Regardless of their selling point, ceramic pieces are predominantly purchased by households, tourists, hotels, and restaurants across the country, who use them for cooking, storing, and serving food. Multiple dishes are purposefully prepared in lead-glazed pieces to achieve a unique flavor profile–earthiness from the clay and a distinctive sweetness from the lead glaze. Beans, *mole*, certain salsas, and drinks like *pozol* and *café de olla* are all traditionally prepared in lead-glazed ceramics, given that their flavors are hard to replicate without lead glaze. In addition to food ware, some types of glazed ceramic pieces hold ceremonial significance in special festivities and celebrations. For instance, candlesticks and smokers (*sahumerios*) usually have very specific colors and glossy finishes, which are hard to replicate when changing glaze.

Hotels and restaurants are increasingly complying with lead-free requirements. Increased lead monitoring and testing in large establishments has prompted increased demand for lead-free ware to serve their food and beverages. However, there is no clear data on the proportion of establishments that purchase lead-free ware.

2.1.3. BARRIERS TO LEAD-SAFE CERAMICS

There are five main barriers to reducing lead exposure through glazed ceramics:

(i) **The widespread availability of unregulated and easy-to-use lead oxide supplies for lead glaze.** Despite being a fraction of the lead oxide market, the ceramic ecosystem benefits from well-established distribution networks that make lead oxide and pre-made lead glazes readily available to artisans. These networks, ranging from formal shops, informal intermediaries, and local unions, ensure a steady supply of lead oxide even in isolated communities. The simplicity of preparing and applying lead glazes, combined with the low firing temperatures required (700°C+), makes them an attractive option for artisans using traditional wood-fired kilns. However, the use of lead glazes comes at a significant health cost, as the entire process, from preparation, application, and firing, exposes artisans, their households, and communities to dangerous levels of lead. Additionally, since most lead-glazed pieces are fired at low temperatures, below 900°C, these ceramic pieces leach high concentration of lead over time when used for food and beverage preparation and storage.

> *"Lead oxide is extremely noble. You can buy it in the corner store, take the powder, add some water, some silica, and add it to practically anything for a lovely glow"*
> *- Clay ceramist from Dolores Hidalgo, Guanajuato -*

(ii) **Limitations of lead-free alternatives, including their lower market penetration in artisan communities and different temperature requirements, force artisans to adapt their productive processes and engage in substantial trial and error to use these glazes.** Outside of semi-urban communities, lead-free glazes are not locally available and must be shipped by order to workshops. While this is feasible, artisans are generally disconnected from distributors, as local leaders and unions are usually in charge of material sourcing. Furthermore, lead-free glazes *can* require higher temperatures to properly vitrify and demand stricter temperature compared to lead-based glaze. Transitioning to lead-free glazes also demands adjustments in other inputs such as clay and pigments, to achieve the desired final product. Clays, for instance, are locally sourced and their color and density vary by region, leading to subtle differences in how they react to different glazes. Although these limitations do not make the adoption of lead-free alternatives impossible, they require significant experimentation. Artisans must invest considerable time and resources in adapting their techniques, from glaze and pigment application to firing, to ensure that pieces glazed with these alternatives maintain the distinctive characteristics of their workshop's traditional output. This trial-and-error process poses a substantial barrier, especially for artisans with limited economic margins and deeply ingrained production methods. Workshops that have transitioned to lead-free glazes report losing between three and five rounds of firing during this adaptation process. For small and medium-scale artisans, who typically conduct one firing per week, this translates to about a month's worth of income loss. Artisans, often living on low incomes and working day-to-day, face challenges in affording the costs of experimentation needed to perfect new glazes.

(iii) **Regulations do not ban or restrict the sale of lead oxide nor the production and distribution of traditional ceramics with lead, compounded by significant enforcement gaps.** NOM-004 does not explicitly ban the use of lead oxide in ceramics and sets permissible levels. NOM-231 requires lead-containing crafts to carry the warning "Do not use with food or beverages, contains lead," but enforcement is limited because artisans, who mostly operate informally, are unlikely to apply these labeling guidelines. Aside from compliance with export-grade quality standards, there are no mandatory requirements for artisans' crafts to be certified as "lead-free". NOM-047 outlines occupational blood lead limits but lacks provisions and surveillance strategies for blood lead levels among artisan communities, their households, and surrounding areas.

"(Regulatory) language is very lenient; it states that "lead use should be avoided" (…) the language is clearly not a prohibition."

- Expert advisor from Civil Society Organization -

(iv) **No labelling, stamps or visual cues for consumer differentiation between lead-glazed and lead-free pieces.** Consumers cannot visually distinguish lead-containing ceramics from lead-free ones once they reach the selling point. Despite reported differences in finish (shine, fragility), it is nearly impossible to differentiate pieces by appearance alone, as variations can be attributed to factors like burning temperature, pigmentation, and clay density/porosity. The only reliable indicator is the official "lead-free certification/label" provided by FONART and COFEPRIS. However, less than 1 percent of ceramic pieces nationwide carry this certification, primarily to meet export requirements. While NOM-231 mandates that lead-glazed ceramics must bear a warning stating "Do not use with food or beverages, contains lead," enforcement is hindered by the informal nature of most ceramic sales, with artisans rarely label products in ways that might deter buyers or might even include a false "lead-free stamp". Outside of large department stores that supply industrial, lead-free ware, consumers lack reliable visual cues to distinguish between lead-containing and lead-free ceramics.

"As a consumer, how can you tell if one piece has lead and another doesn't? Well, you really can't"
- NGO -

(v) **Need for culturally sensitive interventions for lead-free transitions.** Transitioning to lead-free glazes has been challenging for artisan communities. Despite government-backed programs, less than 1percent of glazed ceramic workshops have adopted lead-free practices. According to artisans and civil society stakeholders, the focal messages of transition efforts have emphasized the negative health impacts of lead exposure and the market benefits of adopting lead-free practices, with mixed reception among artisan households. Further, the facilitation of technical assistance has often been led and conducted by *outsiders*, frequently experts from the Health or Culture Ministry, who lack the local validation needed to resonate with artisans (although actors from FONART have been vocal and explicit in recognizing the cultural significance of pottery, and have led successful transition programs). Effective interventions should recognize the generational and cultural significance of traditional practices and the unique needs and experiences of artisans, and ideally, be locally led. When not artisan-centered, transition efforts can have the unintended effect of generating resistance to lead-free practices and reducing the risk perception of the impacts of lead exposure. While there have been notable efforts by FONART and civil society organizations on lead-free transitions, their impact and scale remain limited with a lack of a comprehensive program, continuity, and sufficient budget.

2.1.4. INTERVENTIONS

Supporting a successful transition to lead-free traditional glazed ceramics requires promoting lead-free glazes while disincentivizing the use of lead-based ones. To support lead-free practices, efforts should enhance the market penetration of lead-free glazes in artisan hubs and support a comprehensive transition for artisans by subsidizing kiln improvements, de-risking experimentation, and facilitating efforts through culturally sensitive assistance. Innovative finance mechanisms can further support this transition. Addressing the issue at its root by limiting lead oxide supplies is equally important and may be achieved by restricting the sales of lead oxide to glaze manufacturers and the ceramic ecosystem at large and promoting testing for lead-containing ceramics in large consumption hubs. A final, **cross-cutting recommendation** is to reinvigorate the General Health Council's Action Program to address lead exposure, which aims for the widespread transition to lead-free practices in ceramics and proposes surveillance and clinical management practices to better control lead exposure and treatment nationwide.

▪ Promoting lead-free glazes

Four relevant and additive ways to promote lead-free practices in ceramic glazes are the following:

INCREASE THE MARKET PENETRATION OF LEAD-FREE GLAZES IN ARTISAN COMMUNITIES

Mexico's existing infrastructure and distribution networks can bridge artisans and lead-free glaze suppliers. While many artisan communities are in remote areas, making local production of lead-free glazes difficult, these glazes can be shipped nationally. Their market penetration can be supported through direct connections between individual artisan households and lead-free glaze suppliers, reducing dependence on intermediaries. This can be supported with informational manuals on how to contact suppliers and establishing non-digital payment methods for artisans without digital bank transfer capabilities. Further research is required to determine whether to support the expansion of existing lead-free glaze distributors or establish new distribution hubs in under-supplied and high-exposure regions. Strengthening established distributors would leverage their existing networks and expertise to maximize their reach and benefit from economies of scale. However, expanding into more remote communities could increase distribution costs, potentially requiring more localized franchises or centers. An important consideration is the diversity of ceramic styles within and across communities, which will imply variations in the types of lead-free glazes demanded from region to region. Flexibility in distribution methods is important to meet these localized demands effectively.

SUPPORT LEAD-FREE GLAZE TRANSITION BY SUBSIDIZING KILN IMPROVEMENTS, DE-RISKING ARTISAN EXPERIMENTATION, AND FACILITATING CULTURALLY SENSITIVE TECHNICAL ASSISTANCE

A three-component approach can support artisans in their transition to lead-free glazes: (1) Sponsor gas kiln improvements to increase firing temperatures and facilitate lead residue remediation[22], (2) promote risk-taking and experimentation, as adapting a new glaze demands substantial trial and error, and (3) provide continuous, culturally sensitive, and locally grounded technical assistance throughout the full transition process.

COMPONENT 1: Sponsor gas kiln improvements for artisans

Enhancing kiln capabilities is a necessary step to adopting lead-free glazes, as these substitutes require increased temperatures and more precise temperature control. Gas kilns withstand medium to medium-high temperatures (above 1,050°C), enabling the use of most lead-free glazes. Their higher temperatures also significantly reduce the risk of lead leaching if lead-oxide glazes are still used. This makes gas-fired pieces considerably safer for consumers, though artisans and their households would remain exposed unless they entirely avoid lead glazes. Sponsoring gas kilns installation directly addresses lead remediation, by offering a substitute from wood-fired kilns contaminated with lead residues. However, a relevant consideration is that shifting to a gas kiln can be disruptive to artisans' traditional methods, as it requires managing gas supply logistics, operating new heat measurement instruments, and understanding how clay bodies react at different temperatures.[23] Considering the capital investment required for fully installing a gas kiln, ranging from $4,000 to $15,000 depending on size,[24] an ambitious transition program aimed at supporting the installation of gas kilns in 90 percent of workshops firing glazed ceramics nationwide would cost between $72 and $270 million[25]. An alternative approach could be explored through communal gas kilns in large ceramic making communities, where artisans would share the firing stage and bring their work to be fired at a local kiln. While also viable, consulted experts elevated concerns of artisanal micropolitics potentially influencing the success of this approach, worrying that access to firing could be withheld discretely by influential local actors.

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[22] Process of identifying, reducing, and eliminating lead contamination

[23] See component 3 of this recommendation for findings on how culturally-sensitive technical assistance can alleviate these disruptions.

[24] Gas kiln installation includes the kiln itself, an internal fiber glass coating that acts as insulator, the plaques where ceramic pieces are placed during firing, gas pipes, valves and regulators, and a stationary gas tank. Some artisans have also adopted the use of pyrometers to measuring and monitoring temperature.

[25] Considering the estimated 20,000 workshops of glazed ceramics nationwide.

A final consideration on a gas kiln transition is the limited accessibility of gas supplies in some artisan communities, particularly in most isolated areas. Although experts don't have a consensus on the number of communities too disconnected for gas kilns to be viable, the size of most ceramic-making hubs, which typically host over 200 workshops, suggests that gas kiln substitution is feasible in most communities.

A note on wood-fired kilns

Wood-fired kilns can be reconstructed and retrofitted to handle higher temperatures and achieve more uniform temperature distributions. While more cost-effective and less disruptive to the artisanal production process, given artisans' familiarity with these kilns, civil society stakeholders and researchers emphasized the additional health and environmental hazards associated with wood-fired kilns. Wood burning poses significant health hazards to artisans and their neighbors, while deforestation has increased production costs for artisans and forced them to use poor-quality substitutes like less dense woods, car tires, or plastics, which offer lower firing temperatures. These practices not only heighten the risk of lead leaching (if lead-based glazes were continued to be used), but also emit more harmful fumes that endanger artisan and community health.

Various stakeholders elevated the potential of gas kiln sponsorship programs to qualify for climate credits and attract green financing opportunities.

COMPONENT II: Promote and de-risk trial and error by reducing costs for artisan experimentation

Implementing a technical assistance program for artisans to experiment with and perfect the use of new glazes can mitigate the financial risks associated with transitioning. Achieving the desired finish, sturdiness, and color in differently glazed pieces involves extensive trial and error.[26] A comprehensive technical assistance program that offers locally available inputs, supports the adaptation of inputs to achieve desired outcomes, and facilitates multiple firing rounds can enable artisans to experiment and refine their techniques without jeopardizing their incomes. Ideally, such a program would include guaranteed purchases, potentially from entities like FONART or bulk-buyers, to provide artisans with a steady income stream during the experimentation process.

[26] Workshops that have transitioned to lead-free glazes reported losing between three and five rounds worth of fired pieces during their adaptation process

COMPONENT III: Engage local leadership to facilitate the transition with cultural sensitivity and localized buy in

A successful transition requires local leadership and facilitation to truly resonate with artisans. This requires the involvement of local leadership, realistic adaptation timelines, and recognition of locally available resources and constraints. Interviewees in ceramics producing communities reported that if not done correctly, lead-transition programs can unintentionally generate resistance to lead-free practices. Cultural sensitivity must be a focal point throughout all transition support: from engaging artisan households in deciding what kilns, glazes, and techniques best adapt to their identities and productive processes, to the provision of technical assistance to use new materials and technologies. Grounding this support in communal health and ensuring trainings are provided by local, trusted champions and experts, can be significant difference-makers. Embedding cultural sensitivity into transition support not only respects the values and identity-based ties of communities to their pieces, but ensures a genuine resonance with artisans, facilitating a successful transition. Local respect and validation are key in communities where external knowledge is often met with skepticism.

INCORPORATE PERFORMANCE-BASED INCENTIVES IN PRODUCTIVE LOANS FOR ARTISANAL PRODUCTION

Performance-based incentives in productive loans can drive the transition to lead-free glazes. Artisans frequently use productive loans, offered by public entities like FONART and private banks. These existing financial offerings can be leveraged to develop an artisan-centered loan program, adapting repayment schedules to artisans' productive cycles and offering financial incentives for adopting lead-free practices. These incentives might include interest rate reductions or lump sum discounts for artisans who fully transition to lead-free glazes by the end of their repayment periods. Collaboration with private sector laboratories would be necessary to verify compliance. Additionally, to mitigate moral hazard, requirements such as documenting the full transition process or conducting multiple tests throughout the repayment period could be implemented.

BOOST LEAD-FREE CERAMIC DEMAND THROUGH JOINT PROMOTION PROGRAMS WITH HOTEL AND RESTAURANT ASSOCIATIONS

Develop joint promotion programs with large-volume buyers to ensure a ready demand for lead-free ceramics. Restaurants and hotels are large-volume buyers that could be engaged for purchasing campaigns in coordination with their respective industry associations. Exploring the possibility of supplying the "salvageable" pieces from the subsidized first test rounds of firing, suggested in the previously described intervention regarding performance-based incentives, could also be beneficial. Recognitions from the Ministries of Culture and Health could be awarded to establishments using lead-free ceramics, acknowledging their support for tradition and Mexico's cultural heritage while benefiting public health.

▪ Disincentivizing the use of lead oxides in ceramic glaze

Two channels can address the extensive use of lead oxides in glazed ceramics:

PURSUE INDUSTRY CONTROLS ON LEAD OXIDIZERS TO RESTRICT THE SALES AND DISTRIBUTION OF LEAD OXIDES INTO THE CERAMICS ECOSYSTEM

Implementing stricter regulations on the production, sale, and distribution of lead oxide will curb its supply into the ceramic ecosystem. This requires revising NOM-004, which regulates permissible uses of lead oxide, to explicitly prohibit its commercialization for glazes in ceramic making and restrict sales of small quantities. Enhanced penalties for non-compliance, mandatory transaction record-keeping by manufacturers and distributors, and mandatory audits can enhance enforcement of this regulatory revision. Successful regulatory updates will also require private sector collaboration. For instance, lead oxide sales to the ceramic ecosystem are marginal compared to other industries,[27] so engaging the four main oxidizers in the countries as allies in the process can help address the issue at its source without risking their revenue sources. Additionally, major lead-acid battery manufacturers, who have pledged commitments to reduce nationwide lead exposure, can be encouraged pressure suppliers to enforce these restrictions and exclusively source lead oxides from certified manufacturers that do not supply the ceramics sector. Collaboration with industry associations of chemical manufacturers to develop best practices and guidelines for the correct distribution of lead oxides would further support these efforts. These supply limitations of lead oxides must be supported by the promotion of lead-free alternatives, as addressed in the first four interventions above. Without this balance, merely restricting lead oxide supplies could create perverse incentives for informal lead oxidizing and the emergence of black markets.

[27] Lead oxides are mostly supplies for manufacturing of lead-acid battery, glass, pigment, and PVC. A relevant exception is *Weico Químicos*, which does directly supply artisans.

PROMOTE RAPID LEAD-TESTING CAMPAIGNS IN LARGE CONSUMPTION HUBS OF LEAD GLAZED CERAMICS

Lead-testing campaigns can be pursued in municipalities where ceramic use for food is prevalent. Since these campaigns can face local government and union resistance in tourist-dependent areas, where ceramics are sold, testing can be prioritized in consumption hotspots. This could involve door-to-door testing in municipalities with the highest lead exposure prevalence, conducting on-the-spot demonstrations, providing informative pamphlets about lead risks, and offering immediate advice on safe ceramic use based on test results. These tests can vary in cost, from slow but inexpensive homemade tests using vinegar and chemical indicators (<$1 per test), to rhodizonate tests, the most common type, costing between $3~5 per test and are quicker and only require a swab and a solution, making them practical for widespread use. Lab tests are the most accurate but are too expensive for a widespread campaign. By focusing on consumption areas rather than production or tourist zones, these campaigns can raise awareness and identify at-risk populations without affecting tourism flows in sensitive areas.

▪ Cross-cutting recommendation

REINVIGORATE THE GENERAL HEALTH COUNCIL'S ACTION PROGRAM ON LEAD EXPOSURE

USAID's convening power could engage a diverse range of stakeholders in the ceramics ecosystem to reinvigorate and renew commitments to the Program. Public agencies, ministries, the private sector, and civil society should all be engaged as the program is implemented.

Focus should be placed on the following action lines from the program:

a) **Conducting regulatory reviews, including the already-approved draft changes to NOM-199 on blood lead levels, promoting additional reviews of lead- and ceramic-related NOMs, and pursuing relevant updates within FONART (e.g., updating their "DAM" matrix, which artisans must fill to access loans and subsidies, to include lead oxide considerations and differentiating subsidy amounts between lead oxide users and lead-free artisans)**

b) **Supporting the sound clinical management of lead exposure and enhancing the reporting of lead poisoning**

c) **Establishing a national blood lead level surveillance system, prioritizing states and subpopulations with highest prevalence of lead poisoning and conduct targeted**

screenings in communities with a high concentration of pottery workshops, to inform individual and population-level risk management of lead poisoning

d) Conducting health promotion strategies for different target groups, including (a) the general population, (2) frequent lead glazed pottery users, (3) glazed ceramic artisans, (4) medical professionals, and (4) policy makers and local and federal authorities

Funding national convenings with key stakeholders to encourage the adoption of these recommendations would be a substantial next step in this process.

Table 3: Summary of proposed interventions for the glazed ceramics supply chain, with corresponding actors and funding

	Intervention	Actors involved	Illustrative funding needs
Promotion of lead-free glazes	**Support the market penetration of lead-free glazes in artisanal communities**	• Artisan communities and workshops • Lead-free glaze manufacturers • Ceramic material distributors	**Low**. Lead-free glaze manufacture and distribution already exists and existing distribution infrastructure can be leveraged. Investments would need to be made to develop informational guidance for artisans on how to source these glazes, and on creating payment mechanisms for artisans without access to digital payment methods.
	Provide comprehensive transition support through kiln improvements, reducing experimentation costs, and facilitating culturally sensitive technical assistance	• Artisan communities and workshops • FONART • Local experts, organizations, and artisan associations • Funders / green capital provides	**80~285 million**: Between \$72 and \$270 million for gas kiln improvements, \$5 million for reducing experimentation costs[28], additional investments for delivering continuous and culturally sensitive technical assistance.[29]
	Develop artisan-centered financial	• Artisan communities and workshops • FONART	**Medium-Low**. Existing financial offerings from FONART and financial institutions can be leveraged.

[28] Contemplating fully sponsoring and supplying materials (assuming 250 pieces per firing round per workshop at a mean production cost of \$2.5 per piece) for four firing rounds for 90% of glazed ceramic workshops in large ceramic hubs (~8,000 workshops).

[29] Blended finance and/or collaboration with institutions and organizations providing green financing can be explored for kiln improvements given the environmental component.

	products with lead-free incentives	• Financial institutions	Investments need to be made in artisan-centered financial design and co-creation of new products with these entities. The rollout of these new financial products might require investments in operational upgrades within these entities.
	Engage hotel and restaurant associations to conduct promotion and purchase programs	• Artisan communities and workshops • Asociación Mexicana de Hoteles y Moteles • Asociación Mexicana de Restaurantes • Ministry of Culture • Ministry of Health	**Low**. Costs mostly lie in engagement and coordination with these entities and in developing the campaigns themselves. However, if purchase guarantees were explored for artisans, additional funds would be needed.
Eliminating use of lead oxides in ceramics	**Establish industry controls on lead oxidizers**	• SEMARNAT • Asociación Nacional de la Industria Química • Lead Oxidizers	**Low.** Costs mostly lie in coordination with authorities, regulation, and in engaging oxidizers in this process, which could be a substantial time and process investment.
	Promote rapid lead-testing campaigns in large consumption hubs of glazed ceramics	• Health Secretariat • Instituto Nacional de Salud Pública • Glazed Ceramics consumers (households, local eateries aka *fondas*, restaurants)	**$63,000 for a pilot testing campaign in the state of Puebla**. $40,000 in testing costs,[30] $13,000 in personnel costs[31], $10,000 in operational and logistical expenses[32]
Cross-cutting	**Reinvigorate the 2019 National Action Plan on Lead Exposure**	• General Health Council • Health Secretariat • Instituto Nacional de Salud Pública • FONART • Civil Society Organizations • General population	In addition to the large coordination and time costs behind reinvigorating this plan through multi-stakeholder engagement, the execution of specific actions through this plan might require significant investments. However, political commitments and action are the most crucial investment of resources in this intervention.

[30] Targeting two large cities and two smaller towns, assuming $4 per test, aiming for 2,500 rapid tests across all locations

[31] Assuming 10 field staff for testing and awareness raising and 1 project coordinator for 4 weeks of active testing, receiving above average salaries for temporary skilled work in Mexico.

[32] Such as transportation, communications and public awareness materials, and data management of test results

2.2 Spices & Lead Chromate Manufacturing in India

Lead chromate, a toxic pigment, is sometimes added to Indian spices, such as turmeric and chili powder. Distributers and sellers add it to enhance spice color and extend shelf life.

The barriers to a lead-free spice industry include extensive local manufacture of lead chromate, lack of traceability of unpackaged spices, insufficient routine monitoring and testing, and low consumer awareness.

The most promising interventions are to improve the traceability of lead chromate production and distribution; raise awareness among consumers, sellers and regulators; improve testing; build regulators' capacity and enhance accountability.

3.2.1. MARKET OVERVIEW AND REGULATORY FRAMEWORK

India is the largest producer, exporter, and consumer of spices in the world. India produces 75 of the 109 spices listed by the International Organization for Standardization (ISO). (Indian Trade Portal. n.d.) Due to the wide consumption of Indian spices, any systematic adulteration or contamination may create severe public health risks.

Lead chromate pigments are used to enhance the color of spices like turmeric and chili powder, but they are highly toxic due to the combination of lead and hexavalent chromium. Lead causes neurological damage, developmental delays, cognitive impairment, kidney damage, anemia, gastrointestinal issues, reproductive issues, and is causal for hypertension, cardiovascular disease and death. (US Environment Protection Agency n.d., ATSDR 2020, IPEN n.d.) Hexavalent chromium compounds are carcinogenic to humans as determined by the International Agency for Research on Cancer (IARC). (IARC Working Group 2009)

There is evidence of lead additives in Indian spices, though spices are one of the many contributing sources to lead poisoning in the Indian population. Studies have shown that spices grown in areas with industrial pollution can contain significant concentrations of lead and other hazardous metals. In addition to this and lead chromate additives, some spices have been shown to contain lead likely due to contamination from soil, air emissions and from lead introduced in processing/ grinding spices on nonfood grade metal equipment. (Angelon-Gaetz et al. 2022) In a Pure Earth study, nearly half of the household samples of turmeric, chili, coriander and mixed curry powders, collected across eight districts in Bihar between December 2022 and March 2023, were found to have lead levels above 2 ppm. (Sonal 2023) Studies based in other Indian states have also found prevalence of lead in spices, although not to the same extent as the Bihar-based study. For instance, according to an analysis of lead in consumer goods in 25 countries, 12 percent spice sample produced in Uttar Pradesh exceeded reference levels, though no lead traces were found in Tamil Nadu and Maharashtra. (Pure Earth 2023) A household sample investigation in the United States found that spice products from India had more than three times the lead levels of spices from the US. (Angelon-Gaetz et al. 2022)

Expert inputs suggest that spices containing low concentrations of lead, typically between 2-100 ppm, are usually not contaminated with lead chromate. The primary sources of lead in the majority of contaminated spices are soil, air emissions, and substandard processing or grinding equipment. While lead chromate may not always be the primary source of lead in spices with elevated lead levels, spices contribute to elevated blood lead levels among children at the same extent as soil, dust and other known environmental sources of lead exposure. (Brown et al. 2022) Broadly speaking, the Indian population has elevated blood lead levels. (Ericson et al. 2021) The addition of a hazardous compound like lead chromate can negatively impact the longevity and quality of life for consumers of spices containing this additive. This is particularly concerning because the extent of lead exposure through spices is comparable to that from other environmental sources.

Although lead contamination in spices does not only come from lead chromate, but in cases where spices are adulterated with this hazardous compound, the levels can be exceptionally high and lead to severe lead poisoning. (Naser et al. 2014) Research led by Stanford University between 2020-2021, which assessed more than 300 samples of turmeric across more than 20 locations in India, Nepal, Pakistan, Sri Lanka, and Bangladesh, identified the state of Bihar as a hotspot of lead chromate turmeric adulteration where 92% of samples exceeded the FSSAI limit compared to less than 25% elsewhere. Turmeric lead levels were more than 200 times higher than FSSAI limits and estimated to result in blood lead levels ten times the international blood lead reference value. Subsequent research led by Stanford University from 2021-present has further underscored the prevalence of lead chromate turmeric adulteration in Bihar and neighboring states. When lead chromate is added to spices for a visible change in color, the levels are typically in the thousands of parts per million. (Forsyth n.d.)

Evidence for lead chromate contamination has been found primarily in turmeric, cumin, and chili. However, expert inputs suggest that the spice to which lead chromate is added predominantly in India is turmeric, more specifically turmeric roots. While lead levels in samples of other spices like cumin and chili have been found to be high, they have been many times lower than turmeric. (Brown et al. 2022) Inputs from Stanford researchers, involved in researching lead levels in spices in India, indicate that the likely reason for lower lead levels in spices like cumin and spices compared to turmeric can be attributed to contamination occurring accidentally. These spices are contaminated with the lead chromate residue on grinding equipment from grinding turmeric.

The use of lead chromate as a coloring agent in spices is illegal in India according to The Food Safety and Standards regulation. This regulation established by the Food Safety and Standards Authority of India (FSSAI), states that a negative test for lead chromate is mandatory for turmeric – whether raw or processed. (Ministry of Health and Family Welfare 2011) The Food Safety and Standards (Contaminants, Toxins and Residues) regulation sets a permissible level of lead concentration of 0.1 – 10 ppm. (Ministry of Health and Family Welfare 2011) This pertains to all spices produced in India, including those that are likely to contain lead chromate, such as turmeric and chili powder. When lead chromate is added to spices lead concentrations typically reach thousands of parts per million.

The permissible lead levels in India as per the FSSAI regulation are not aligned to international standards. Drawing from EU standards, attempts were made (in 2015 and 2021) by FSSAI to introduce new permissible lead limits (0.05 – 0.1 ppm) for standardized foods, through the release of the drafts of proposed regulatory updates. (Ambwani 2021, PTI 2015) These attempts have not been successful in altering mandated levels as of mid-2024. Finally, the Food Safety and Standards Authority of India has the mandate to enforce standards through designated Food Safety Officers (FSOs).

Lead chromate enhances the color of spice products, maintaining brightness and extending shelf life, making them more appealing to consumers. (Kapley 2022) Adding pigments (lead chromates or non-toxic alternatives) to spices however is unnecessary, both from a taste and a nutrition point of view. Given that lead is also a preservative, spices with lead chromate will have a longer shelf life. Lead-based coloring agents like lead chromate are introduced to spice powders during processing – typically during polishing, grinding, sieving, or blending. Narrowing down the stakeholders responsible for this is challenging, owing to:

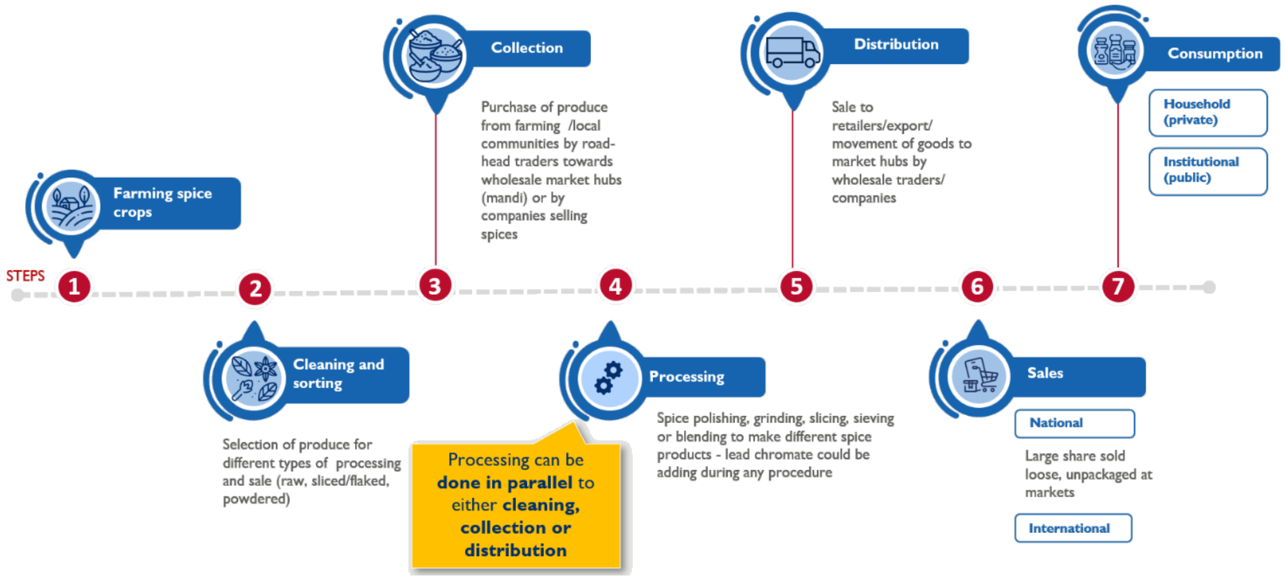
- The diversity and informality of actors involved in the spice supply chain
- The lack of traceability systems to trace the supply chain pathway of the end-product
- The technical challenges in detecting lead chromate presence in spices (especially in powdered products)

Penalties for regulatory violations are rare and inconsistent, and there is limited publicly available information on how violators are identified. Specific penalties and implications of distinct regulatory violations are also unclear. As per regulation, penalties apply to manufacturers and traders for failing to meet standards, such as the compulsory negative test for lead chromate. Although the consequences of such failures could include fines, product seizure, or license cancelation, it is not apparent what penalties apply for infringing upon the mandated negative test for lead chromate.

Public and social sector actors in India are working to eliminate lead exposure from various sources, including spices. These actors include ICMR-National Institute of Occupational Health, the Indian Society for Lead Awareness and Research (InSLAR), Toxics Link, the Center for Science and Environment, and Pure Earth. Pure Earth has undertaken research on the presence of lead in Indian spices, in addition to training pollution investigators and government officials to identify and map lead-contaminated sites and creating a global database to guide cleanup efforts. (Pure Earth n.d.) ICMR-National Institute of Occupational Health raises awareness about lead poisoning and its effects on health, particularly on children. (India Science, Technology & Innovation Portal n.d.) Toxics Link works to expose the dangers of lead poisoning, advocates for policy changes to reduce lead exposure in India and conducts research on lead in consumer products and lead-acid battery recycling. (Toxics Link 2023) The Center for Science and Environment conducts research and advocacy on environmental issues, including lead exposure, and runs initiatives focused on lead in spices, paint, toys, and other consumer goods. (Centre for Science and Environment n.d.)

3.2.2. SUPPLY CHAIN ANALYSIS

Figure 4: Summary of spices supply chain in India



The spice supply chain has seven main stages; lead chromate addition typically occurs during processing, the fourth stage. The stages are:

1) Farming

Spice crops are grown nationwide, mainly by smallholder farmers, accounting for around 85 percent of spice crop farmers (GIZ 2023), as well as by farms run by large corporations that also purchase produce from smallholder farmers. The types of spice crops grown in different geographies are specific to climatic and ecological conditions of the area – and the diverse physiography allows for the farming of a wide range of spice crops. As of 2022-2023, Maharashtra and Telangana were estimated to be the largest producers of turmeric, and Andhra Pradesh and Telangana the largest chili producers. (Spices Board of India n.d.)

2) Cleaning and sorting

This involves selecting produce for different types of processing and sale (raw, sliced/flaked, powdered).

3) Collection

The produce is purchased from farmers or local communities by:

- Road-head traders, who bring them to wholesale market hubs (referred to as *mandi* in some parts of India), or
- Large corporations who sell different types of spices or spice mixes

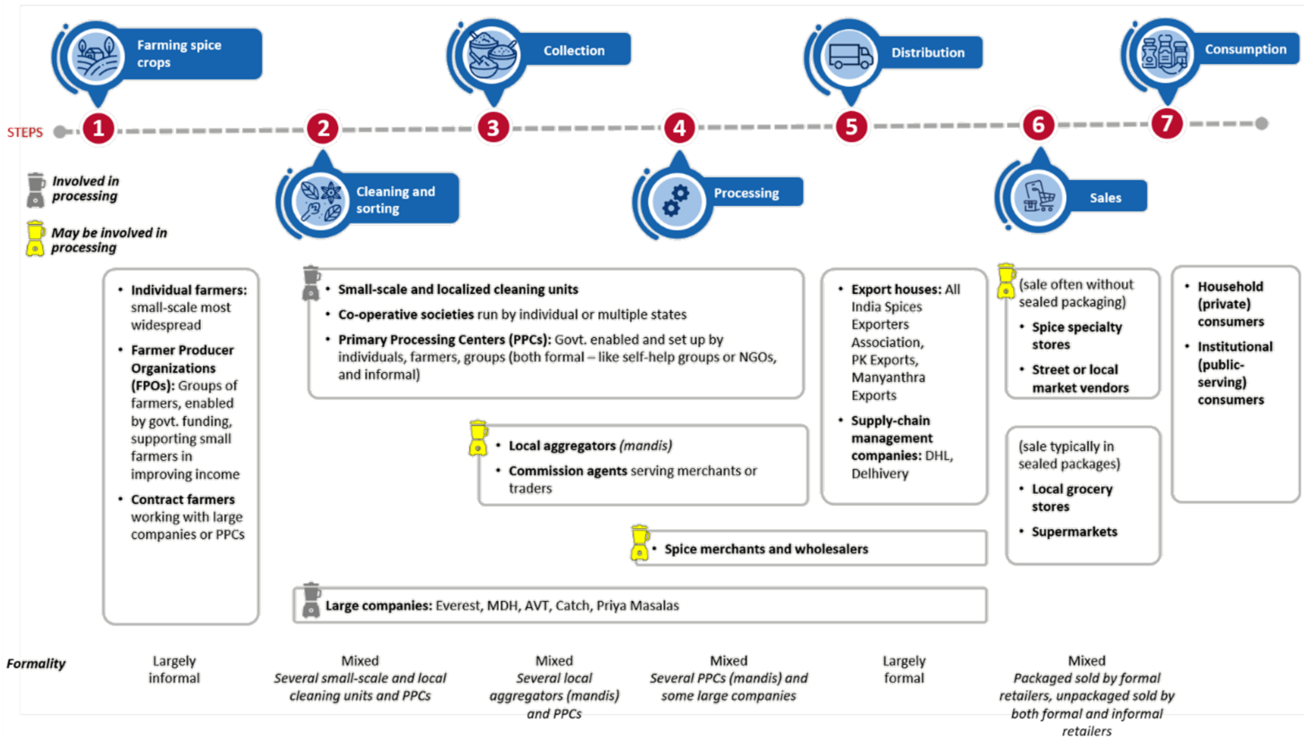
4) Processing

This stage involves spice polishing, grinding, slicing, sieving or blending to create various types of spice products, such as flaked spices, spice powders, and spice powder mixes. Since processing involves readying the farm produce for the market, coloring agents are typically added to enhance color and make the final product more attractive to consumers. Lead chromate is often added during these processes to any or all of these product types. Lead chromate is mainly added to turmeric, chili, and curry powder – or in spices that are popularly known to be of bright chrome-like color. To turmeric roots specifically, lead chromate is added during a cleaning process known as polishing. Processing occurs in different sites and stages and through varied stakeholders, mainly depending on whether spices are sold packaged or unpackaged.

- **The majority of branded, packaged spices – ~35 percent of the overall market (India Brand Equity Foundation. n.d.) – are sold by incorporated companies.** This market is dominated by less than ten legacy brands. These companies can clean and sort, collect, and distribute spices themselves. Processing of spices could be done in any of or across these stages and is contingent on the type of spice, spice product, and nature of processing required (i.e., how close to the point-of-sale does processing need to happen).

- **Spice products sold unpackaged or loose (by weight) are typically processed by local cleaning units, cooperative societies, primary processing centers (PPCs), or by spice traders/aggregators/retail stores.** While these could be done in any of or across supply chain stages, it is more likely this is done during the cleaning and sorting and collection stages, or just before the products are prepared for sale.

Figure 5: Deep-dive illustration of the spice processing stage



5) Distribution

Domestically, road-head traders sell loose spices to wholesale traders or retailers, while companies or wholesale traders distribute and sell packaged spice goods to retailers or other wholesale traders. Internationally, export houses primarily handle spice distribution facilitated through the Spices Board of India under the Ministry of Commerce and Industry, which oversees all spice exports.

6) Sales

Domestically, supermarkets and local grocery stores sell spices in branded packaged form, while spice specialty stores or local grocery stores/sellers sell them. Internationally, export houses sale dominate the sale of Indian spices, who largely sell packaged spice products, inclusive of both brands produced by large companies and organic spices produced (mainly, but not only) by smaller establishments. Companies (especially mid-sized companies) and brands producing packaged spices have seen a surge of interest from investors since 2020. (Tandon 2021)

7) Consumption

Spices are purchased and consumed by private or household level consumers and by public or institutional (hotels, restaurants, catering services) level consumers.

Both formal and informal actors, of various sizes, operate across stages of the spices supply chain. Large companies, primary processing centers (PPCs), and small-scale localized cleaning units (both formal and informal) are primarily involved in the cleaning and sorting stage. PPCs are run by both formal players—like women's cooperatives or NGOs—and informal players and need government approval. At the collection stage, spice merchants (or commission agents serving merchants or traders) and local aggregators (operating in market hubs or *mandi*s) dominate, but large companies are also involved. The distribution stage is the most formal stage; large companies have the operational wherewithal to distribute most widely, although export houses anchor international distribution. At the sales stage, spice retail stores including street markets stalls, spice specialty stores, and small local grocery stores (where products may be sold loose or without prepackaging) may also be potentially involved in processing.

3.2.3. BARRIERS TO LEAD-SAFE SPICES

There are five main barriers towards a lead-safe future in the context of Indian spices:

a) **Extensive manufacturing of lead chromate in India.** India manufactures all types of pigments in large quantities, making it the second largest pigment exporter globally. (World Integrated Trade Solution 2019) Local manufacturing makes lead chromate cheap and widely available, often in loose form with no labelling. Manufacturing of lead chromate does not involve significant costs or sophisticated processes. Under these conditions—without comprehensive regulation or its effective enforcement— the extent of lead chromate manufacturing in India enables spice processors to easily purchase and add lead chromate to their products. Lead chromate production will continue to exist given it has a thriving market due to its wide and legal application in products like industrial paints and inks.

b) **Lack of traceability systems to locate stakeholders responsible for lead chromate addition.** This is because diverse types of stakeholders process spices in different stages of the spices supply chain. In addition, fragmentation of processing across the supply chain is not the only challenge in identifying players responsible for lead chromate addition – spices are not always sold in packaged and branded form.

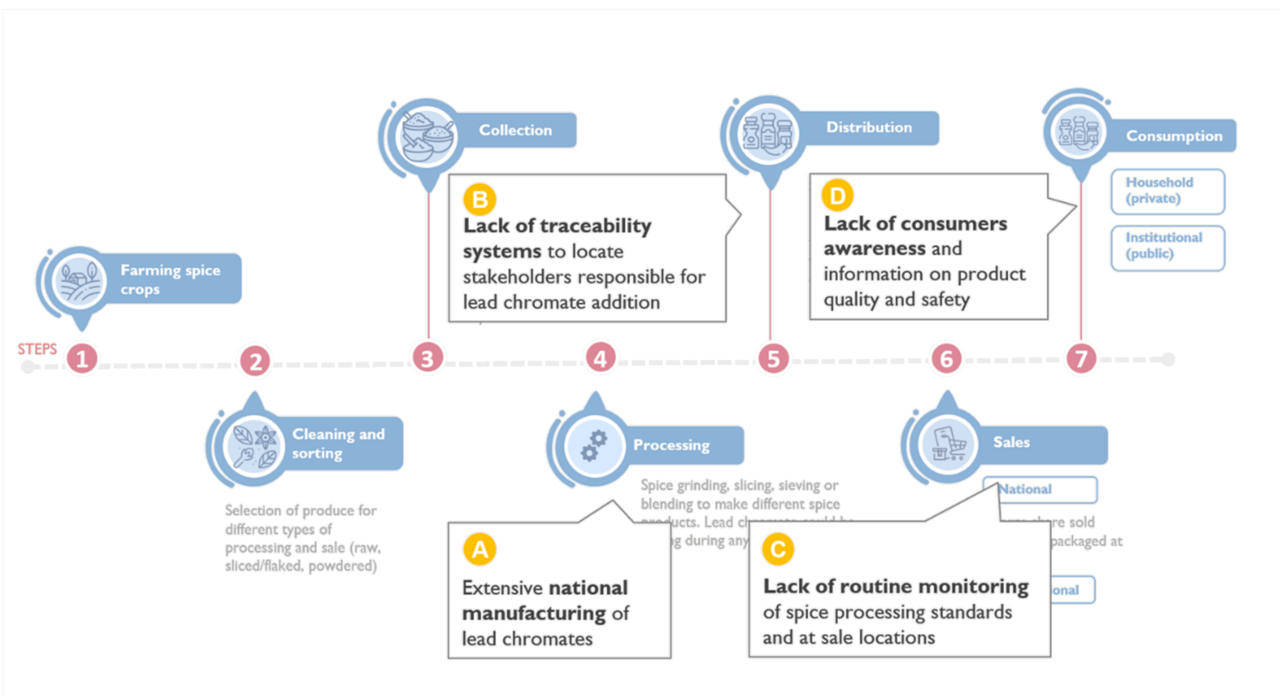
"Tracing players responsible for adding lead chromates to spices in India will be hard. Large sections of the population with low or middle socioeconomic status buy spices loose or unpackaged, at street-markets or local grocery stores."

- Large-scale pigment distributor -

c) **Lack of routine monitoring of spice processing standards and at selling points.** Although inspections and testing are required by regulation, they are either not conducted or, if conducted, not reported.

d) **Lack of consumer awareness and information on product quality and safety.** The extent to which food labels in India misrepresent ingredients is to be understood, but there is broad consensus that both labelling and marketing can be misleading. (Prasad 2024) The lack of awareness complemented by the long-term use of and trust in legacy brands, has resulted in limited know-how on food product quality assessment and minimal demand for quality certificates or accuracy in labeling.

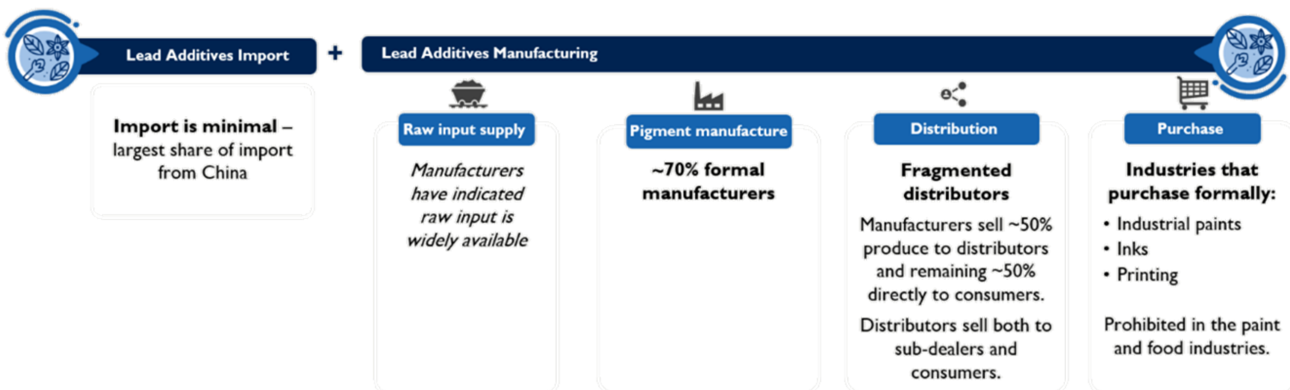
Figure 6: Summary of barriers to lead-free spices in India



3.2.3.1. SPOTLIGHT: MANUFACTURING OF LEAD CHROMATE IN INDIA

Lead chromate is produced by domestic pigment manufacturers, making it easily accessible and cheap for spice processors. The lead chromate supply chain involves chemical input suppliers, formal and informal pigment manufacturers, distributors, and buyers. Input suppliers provide the necessary raw materials, which manufacturers, both formal and informal, convert into lead chromate. Raw inputs for lead chromate production are easily available in India. Distributors handle the logistics of moving the lead chromate, ensuring the product reaches the end users, who are typically in sectors such as paints, inks, and printing.

Figure 7: Summary of lead chromate supply chain in India



India is one of the world's largest lead chromate manufacturers and exporters, along with China. Geographically, lead chromate production is heavily concentrated in the Indian states of Gujarat and Maharashtra. The majority of large-scale manufacturers operate out of Vapi, Gujarat, including companies like Raveshia Pigments, Anupam Colours Private Ltd., and Anupam Colours and Chemicals Ltd.

Approximately 70 percent of lead chromate production occurs in the formal sector, with the remaining ~30 percent produced informally, according to pigment manufacturers. A significant portion of lead chromate produced in India, up to 50 percent, is exported. Given the formal sector caters to exports, there is higher non-compliance risk involved, often addressed through more standardized processes. However, the absence of a reliable traceability system makes it difficult to produce precise data on its distribution and sale, both internationally and nationally. For instance, Indian traders use varying HS[33] codes for lead chromate, complicating the tracking of lead

[33] The Harmonized System (HS) is the international, standardized numerical method of classifying traded products (International Trade Administration n.d.)

chromate through the supply chain. Lead chromates should be assigned the HS code 28415091, for "Chromates except of zinc or lead and dichromates except of sodium or potassium; peroxochromates" but are frequently mislabeled with code pertaining to other pigments or chemicals (e.g., HS codes 28415091 for other chromates, 28413000 for sodium dichromates, or 28415010 for potassium chromate). (Alpha Chemika. n.d., Techno PharmChem. n.d.)

Most lead chromate producers also manufacture other pigments, as lead chromates typically account for less than 10 percent of their total sales, according to manufacturers. Despite its small share, lead chromate production is attractive because it is neither cost-intensive nor requires sophisticated infrastructure and technology. The persisting demand for lead chromate complements the low investment it requires, offering manufacturers the potential to increase profit margins.

Pigment manufacturers mentioned, however, that the production of lead chromate in India has declined in the past decade. International concerns about its high toxicity have resulted in European countries making its use illegal for all applications, causing the demand to decrease. The ECHA extensively studied the market and determined that there were substitutes available for all uses of these hazardous compounds. Therefore, the European Commission under REACH banned the production, import, export and use of lead chromate. In 2019 a ruling by the Court of Justice of the European Union upheld this regulation and nullified the temporary exemptions that were allowed for some applications. (IPEN 2019) These regulatory and subsequent market pressures have contributed to the overall decrease in production.

Lead chromate continues to be produced in India for paints, inks, and printing businesses. Lead chromate also finds its way into products where its use is illegal, such as turmeric (raw and processed), indicating gaps in regulatory enforcement. Research on alternatives for lead chromate have been ongoing since the introduction of the Registration, Evaluation, Authorization, and restriction of Chemicals (REACH) regulation in Europe in 2007 which has made less-toxic alternatives available. The pigment manufacturing industry in India insists on the economic and performance (brightness, opacity, and weatherability) advantages of lead chromate, despite the availability of alternatives that are less toxic. While regulations recommend reducing the production, sale, and use of lead chromate, manufacturers claim that the advantages it offers continue to sustain its demand.

While there are cost-advantages to continuing the production and use of lead chromate, performance advantages are no longer unique to lead chromate. New pigment chemistries are now available that have the chromaticity and brightness of organic pigments and the opacity and durability of inorganic pigments, making lead chromates expendable. (Ryan 2013) The European Chemical Agency (ECHA) has established that claims of the superior performance of lead chromates are no longer true and there are substitutes for all applications. However, industry players in India maintain that lead chromates offers the brightest chrome colors and retains brightness for the longest periods. The suspicions among Indian pigment manufacturers about alternatives and associated research efforts signal that producers are unaware of cost-effective, durable alternatives. The lack of awareness of viable and marketable substitutes suggests that enough demand for lead chromate continues to exist to continue production, even if overall on a downward trajectory. The decrease or halt in lead chromate production in several countries post-REACH can explain the expansion of international markets for Indian lead chromate manufacturers and persistence of demand. Inputs from manufacturing stakeholders in India indicate that EU countries continue to import lead chromates, although the demand has been decreasing consistently. This demand from abroad helps sustain production levels in India, despite national regulations that disincentivize its use in some industries. As long as there is demand for lead chromate and its production remains legal, the formal pigment manufacturing sector is likely to continue to cater to this demand.

Making lead chromate production illegal is, however, not necessarily an effective solution. Companies can shift production to other countries to cater to international markets, given it is still legal to produce in several countries. Banning production could potentially lead to an increase in informal production, given the ease of production. Informal manufacturers can cater to markets that formal manufacturers will no longer serve, in addition to capitalizing on the demand for the illegal use of lead chromate.

Atomized distribution and informal production are some reasons lead chromate sales and purchase is difficult to trace. Manufacturers sell approximately 50 percent of lead chromate directly to companies and the other 50 percent to distribution agents, who then sell to end users. The inconsistency in the application of HS codes (which is used for international and domestic distribution and is domestically relevant to applicable Goods and Services Tax (GST) rates) across the supply chain. The misrepresentation of the final use case by distributors and those purchasing further complicates traceability. This lack of traceability poses risks not only to spices, but also to paints and other consumer goods like cosmetics, toys, and plastics.

3.2.4. INTERVENTIONS

Interventions can focus on both "upstream" efforts to restrict the lead chromate supply and "downstream" on the spices supply chain. Upstream efforts aim to reduce or eliminate the production of lead chromate and improve the traceability of lead chromate distribution, while downstream efforts seek to eliminate the use of lead chromate in the spice industry by increasing testing and regulatory penalties along with capacity for enforcement, and raising awareness among consumers, regulators and spice sellers.

▪ Upstream interventions

Some potential ways to address lead chromate in spices at the level of lead chromate manufacturing and distribution are:

IMPROVE TRACEABILITY SYSTEMS

Increase traceability across the supply chain to disincentivize the distribution of lead chromate. Currently, India lacks adequate systems to trace the sale of lead chromate by pigment manufacturers and distributors. Initially, regulators should ensure HS codes are applied appropriately by conducting random audits. New regulations are needed to ensure all bags containing lead pigments are appropriately labeled, with visible warning signs. These efforts should be focused on lead chromate manufacturers in Gujarat and Maharashtra, importers, and distribution agents across the country.

STRENGTHEN REGULATORY STANDARDS

Update regulatory norms on lead chromate production, its import and export, and its sale. Efforts to update compliance parameters in alignment with standards set out in REACH have been underway through the release of the Chemical Management and Safety Rules drafts, with the latest and fifth draft being released in 2020. However, whether this will convert existing regulatory advisories to lead chromate manufacturers on declaring details on production and sale into regulatory mandates is unclear. Going forward, a system should be put in place to license purchasers of lead chromate and only permit sales to such entities. Lead chromates, and other lead pigments, should only be sold to end users in specified industries for specified uses to avoid leakage to the spice supply chain. Regulatory update to separate trade norms (and HS or other trade tracking codes) for hazardous and non-hazardous chemicals will help increase control over trade.

Downstream interventions

Some potential ways to eliminate the addition of lead chromate in spices are:

MAKE LEAD CHROMATE ILLEGAL IN ALL SPICE PRODUCTS

Update regulatory norms on lead chromate pigment use in spice products by mandating negative test for lead chromate for all spice products. Currently, turmeric is the only spice product that requires mandatory negative test for lead chromate before sale, for both raw and processed forms. Given the ubiquity of lead chromate pigments in India, it is imperative that the use of lead chromate as a coloring agent is made illegal across spice products. Such efforts by regulatory bodies like the Food Safety and Standards Authority and the Ministry of Health and Family Welfare can also serve to make consumers more aware about the criticality of lead chromate toxicity.

BUILD ENFORCEMENT CAPACITY

Build capacity among Food Safety Officers (FSOs) and equip them for regulatory enforcement, along with increased regulation on lead chromate sales and purchase. Regulators need to upgrade their technical infrastructure and capacity, which needs more funding. Regulators also need access to up-to-date knowledge, and a keen awareness of the criticality of lead toxicity, to enforce environmentally sound management of ULABs regulations. Offering training programs to FSOs and providing them with appropriate data sources and tools to strengthen the identification and penalization of spice manufacturers using lead chromate can enable stronger enforcement.

IMPROVE TESTING

Build testing capabilities, increase frequency, and combine different testing methods. Food Safety Officers (FSO) must have testing tools at their disposal, and lab analyses should be available at the state level. Testing should be done frequently and systematically, but at random intervals to prevent sellers from adding lead chromate to spices in periods when they do not expect testing. Monitoring and testing of spices at grinding facilities must be done to reduce potential for lead contamination from other sources. Different testing methods should be mixed. For instance, a trained inspector can visually detect very high lead concentrations, especially in roots. Rapid and affordable tests can be carried out with lead swabs, while tests can be done at scale in spice markets with a handheld XRF. Tests requiring a high degree of accuracy (for certifications, for instance) could be done using wet lab techniques. Furthermore, cheap, low-tech tests should be made available to consumers in households and restaurants. When tests reveal lead adulteration, penalties should be rapidly and publicly enforced, to deter other sellers.

RUN AWARENESS CAMPAIGNS

Educate lead chromate manufacturers, traders, and consumers on the harmful impacts of lead chromate ingestion. Running context and stakeholder-specific awareness campaigns is important. Indian consumers for instance have poor awareness of the prevalence and risks of lead in their food. Low levels of enforcement further decrease consumer awareness and make it difficult for consumers to gauge safety standards in spice markets. In addition to being made cognizant of the ingredients used in their food products, consumers also need to know how to identify safe products. At consumer level, these efforts need to focus on women who purchase spice products at the household level. Interventions to increase awareness such as the recent campaign in Bangladesh, which educated producers and consumers about the risks of lead chromate in spices have high potential.

PILOT CITIZEN REPORTING TOOLS

Explore mechanisms for citizens to report on spices suspected of containing lead. Mechanisms for reporting may include hotlines and online platforms. The intervention could leverage FSSAI's consumer complaint system, which is now mostly used for restaurant hygiene complaints. However, there are two opposite implementation risks: consumers may not know or distrust the reporting tool, or they may grow disappointed if action is not taken when they report a suspicious case. For this intervention to succeed, the reporting mechanism should be publicized in spice markets and through appropriate channels, and enforcement should follow swiftly. Considering the potential implementation challenges, citizen reporting interventions should probably be piloted at a city or town level before scaling to the full state.

Reducing Lead Chromate Addition to Turmeric in Bangladesh

Lead chromate presence exceeding the national limit by 500 times was detected in Bangladeshi turmeric by Stanford University based researchers. Evidence was found for adulteration in 7 of the 9 turmeric producing states of Bangladesh. This adulteration was being done to make the turmeric appear a bright yellow color. Blood lead levels among Bangladeshi turmeric mill workers were also high.

This issue of lead toxicity of turmeric was addressed by the Government of Bangladesh and International Centre for Diarrheal Disease Research, Bangladesh through a two-fold solution. First, a public awareness campaign was launched to educate people – including turmeric producers, sellers and consumers – about the dangers of lead chromate in turmeric. This was linked to the adulteration that was being done in Bangladesh. Second, X-ray fluorescence analyzers were introduced, which could detect lead in turmeric in markets. This helped regulators impose fines on shops and vendors selling adulterated products.

These interventions successfully reduced lead contamination in turmeric in Bangladesh. Research following the interventions found that the percentage of turmeric samples that contained lead chromate decreased from 47 percent in 2019 to 0 percent in 2021. Additionally, blood lead levels among turmeric mill workers in Bangladesh dropped by a median of 30 percent.

▪ Cross-cutting recommendation

PROMOTE COLLABORATION BETWEEN STAKEHOLDERS

USAID's convening power could bring stakeholders from lead chromate manufacturing and distribution, and spices production and trade to promote collective efforts and encourage commitments to increasing lead-safety in spices and other similar consumables. Public agencies, ministries, the private sector, and civil society need to be engaged collaboratively for the effectiveness of the specific upstream and downstream interventions stated above. Funding is imperative for national convenings that gather key stakeholders and encourage both the adoption of interventions and cooperation in their implementation.

STRENGTHEN CONTROL OVER LEAD CHROMATE USE IN OTHER INDUSTRIES

Establish and enforce stringent limits on lead additive purchase and usage across industries where the application of lead additives is prevalent. By fostering partnerships between public agencies, industry leaders, and civil society organizations, USAID can create a platform for dialogue and consensus-building around lead-safe practices that regulatory bodies can then enforce. The stringent enforcement of lower lead chromate purchase limits for paint manufacturers, for instance, can contribute to reducing demand for lead chromate. This in turn can help mitigate the risks associated with lead exposure across consumer products and the environment.

Table 4: Summary of proposed interventions for the lead chromates manufacturing and spices supply chains, with corresponding actors and funding

	Intervention	Actors involved	Illustrative funding needs
Upstream	**Improve traceability systems**	• Lead chromate manufacturers • Regulatory agencies o Ministry of Chemicals and Fertilizers o Ministry of Trade and Commerce	Cost to update traceability systems and train public sector professionals responsible for the implementation ~$12,000 USD. Cost for introduction of technology-based traceability systems – inclusive of software, hardware, and training – would range from ~$20,500 USD to ~$45,000 USD. Ongoing annual costs are likely to be ~ $1,200 USD to ~$2,400 USD (including software maintenance and minor upgrades cost).
	Strengthen regulatory standards	• Ministry of Chemicals and Fertilizers • Lead chromate manufacturers • Spices Board of India under Ministry of Commerce and Industry • Food Safety and Standards Authority under the Ministry of Health and Family Welfare	Estimates covering rigorous research, regulatory drafting, public consultations, and implementation support amount to ~ $14,000 USD to ~ $30,000 USD. Monitoring costs are contingent on the nature of the new regulations.
Downstream	**Make lead chromate illegal in all spice products**	• Food Safety and Standards Authority • Food Safety Officers • Administration trainers	This intervention would include training costs for public officers of around ~ $7,000 USD per year, and

			resource building expenses of ~ $5,000 USD.
	Improve testing	• Food Safety and Standards Authority • Accredited testing laboratories • Spice manufacturing companies and units • Markets	The investment for testing depends on the nature of equipment required. To introduce XRF analyzers across large markets across India (as done in Bangladesh) could cost from ~ 15 mil USD to ~ 35 mil USD. Such efforts can be made more cost-effective by focusing on areas with high spice trade volume or where blood lead levels are high. Setting up testing labs requires ~$15,000 USD to ~ $70,000 USD, inclusive of equipment and training. Running cost of labs range from ~ $2,500 USD to ~ $6,000 USD per year, covering personnel, sample collection, and equipment maintenance.
	Run awareness campaigns	• Food Safety and Standards Authority • Consumer advocacy groups • Spice industry traders and exporters associations • Media outlets • Public health institutions	The cost of the campaign launch can range from ~$25,000 USD to ~ $90,000 USD, encompassing the creation of print, digital, or broadcast media, placement in popular platforms, and community outreach. The type of media has a large impact on the estimate. Subsequent annual costs vary based on the strategy and can include costs for refreshing materials or for continued campaigns. Cost of the evaluation of campaign effectiveness is ~ 4,000 USD.
	Pilot citizen reporting tools	• Food Safety and Standards Authority • Consumer advocacy groups • Spice industry traders and exporters associations • Media outlets • Public health institutions	The cost for the reporting tool ranges from ~ $8,500 USD to ~ $25,000 USD, depending on the sophistication of the tool developed and extent of promotion. Annual expenses for data management, follow-up investigations, and platform maintenance, can range from ~ $4,000 USD to ~ $15,000 USD.

2.3. Paint in Nigeria

The Nigerian paint industry is fragmented, and paint products can include high levels of lead, due to the widespread use of lead additives which offer bright colors and weather resistance but pose significant health risks.

To promote the adoption of alternative formulas without added lead, efforts can include facilitating annual paint exhibitions, providing financial incentives to increase the availability of lead-free additives, and rewarding manufacturers who switch to lead-safe paint. Additionally, investing in testing capacity, enhancing regulatory agencies' monitoring and enforcement capabilities of the new regulations under review, improving the traceability of lead additive imports, and listing lead chromates under the Rotterdam Convention are essential steps toward a safer industry.

2.3.1. MARKET OVERVIEW AND REGULATORY FRAMEWORK

Lead paint is used extensively in Nigeria for both decorative (residential) and industrial applications; yet lead content information is rarely provided on containers. Lead paint is defined by the UNEP Model Law on Regulating Lead Paint as containing more than 90 parts per million (ppm) of lead. (UN Environment Programme 2017) A 2017 survey of 54 solvent-based paints for home use from 18 different brands in Nigeria revealed that 74 percent contained lead concentrations above 90 ppm and 54 percent contained lead concentrations above 10,000 ppm. (SRADev Nigeria, IPEN 2017) Moreover, just 6 percent of these paints included information about lead on their labels[34], while others were just labeled as solvents, pigments, and resins with no further details on the type of solvents and pigments used. (SRADev Nigeria, IPEN, UNEP, GEP 2020) Moreover, In addition to this study, other studies have also documented high levels of lead in paints used in both residential and industrial settings. For instance, an academic study published in 2024 found that 100 percent of 34 samples of oil-based paints (predominantly used in industrial settings and rarely inside homes) in Nigeria contained lead levels exceeding 90 ppm. The lead concentrations ranged from 4,490 ppm to 91,500 ppm, with an average of 31,800 ppm. (Ajoke Fehintola Idayat Akindele 2024) Moreover, Pure-Earth's 2021 Rapid Market Screening Program found that 76 percent of samples of paints in Nigeria exceeded the 90ppm limit.

Lead additives, including lead chromates, are commonly utilized in solvent-based decorative paints and industrial paints due to their favorable chemical properties and low cost. Lead additives, such as lead chromate, are used in paints both to enhance the color and as effective drying and anti-corrosive agents. Lead chromate, known for its exceptional weather resistance and long-lasting brightness, reduces the frequency of repainting compared to other pigment alternatives, while also offering cost-effectiveness due to its lower usage per square foot for achieving comparable brightness levels. Below is a list of key lead-containing additives used in the paint industry: (SRADev Nigeria, IPEN, UNEP, GEP 2020)

- **White pigment:** Lead carbonate
- **Yellow pigment:** Lead monoxide, lead chromate, lead molybdate, lead sulfochromate yellow, and lead sulfate
- **Red pigment:** Lead chromate molybdate sulfate red
- **Driers:** Lead octanoate, lead 2-ethylhexanoate, and lead naphthenate
- **Other additives:** lead chromate oxide, lead oxide, lead nitrate, lead peroxide, and tri-lead bis(carbonate) dihydroxide

[34] In over 100 studies across 59 countries, testing more than 4,000 solvent-based paints, IPEN found that labels often do not reflect true lead content. Some paints labeled as lead-free actually contained high levels of lead.

Although lead-free additives are available and can be imported into Nigeria, they are not widely used in Nigeria outside of major paint brands. Major paint brands such as Chemical and Allied Products (CAP) Plc, Paints and Coatings Manufacturing Nigeria (PCMN) Plc, Berger Paints Nigeria Plc, and Meyer Paints claim to only produce lead-safe paint due to having acquired this capacity from their parent international companies.[35] However, small-scale paint manufacturers that vastly outnumber these large brands have not adopted the use of lead-free additives (such as organic pigments, titanium dioxide, strontium, and zirconium) due to their perceived high cost, among other barriers. (SRADev Nigeria, IPEN, UNEP, GEP 2020)

Currently, one standard regulates lead paint in Nigeria—but it is largely voluntary in practice as there is limited regulatory enforcement in the country. The Nigerian Industrial Standards (2017), maintained by the Standards Organization of Nigeria (SON), encourages the certification of companies that comply with a lead limit in paint of 90 ppm, requests clear labeling on paint containers to indicate the lead content or specify lead-free status, and outlines procedures for manufacturers to comply with lead content regulations, including testing, certification, and monitoring requirements. However, there is no accompanying penalties or strategy for the monitoring and enforcement of the standard. As a result, compliance has largely been voluntary.

A second, more robust regulation for lead paint—the National Environmental (Chemicals and Pesticides) Regulations (NECPR, 2023)—is under review by the National Environmental Standards and Regulations Enforcement Agency (NESREA), but the monitoring procedures for this standard are unclear. NECPR limits lead concentration in paint to a maximum of 90 ppm and establishes sanctions and penalties for non-compliance (e.g., a fine of less than 5 million naira (~$3,900) for an individual, or less than 50 million naira (~$40,000) for a corporation). The regulations prohibit the production, distribution, import, and export of paint products exceeding the specified limit, and producers must provide standardized labels on all paints to inform consumers and workers of lead exposure hazards, with an indication of "no added lead" for paint with lead content below 90 ppm. Manufacturers must treat liquid waste to ensure that lead content stays below the national permissible limit of 0.1 µg/l. While regulations outline sanctions for non-compliance, there is limited clarity regarding monitoring procedures and the frequency of assessments. The regulations were recently amended in January 2024 and are still being socialized within the community of producers and other actors to ensure buy-in before they are signed. Implementation might not begin for another 1–2 years, according to regulatory agencies and NGOs operating in the ecosystem.

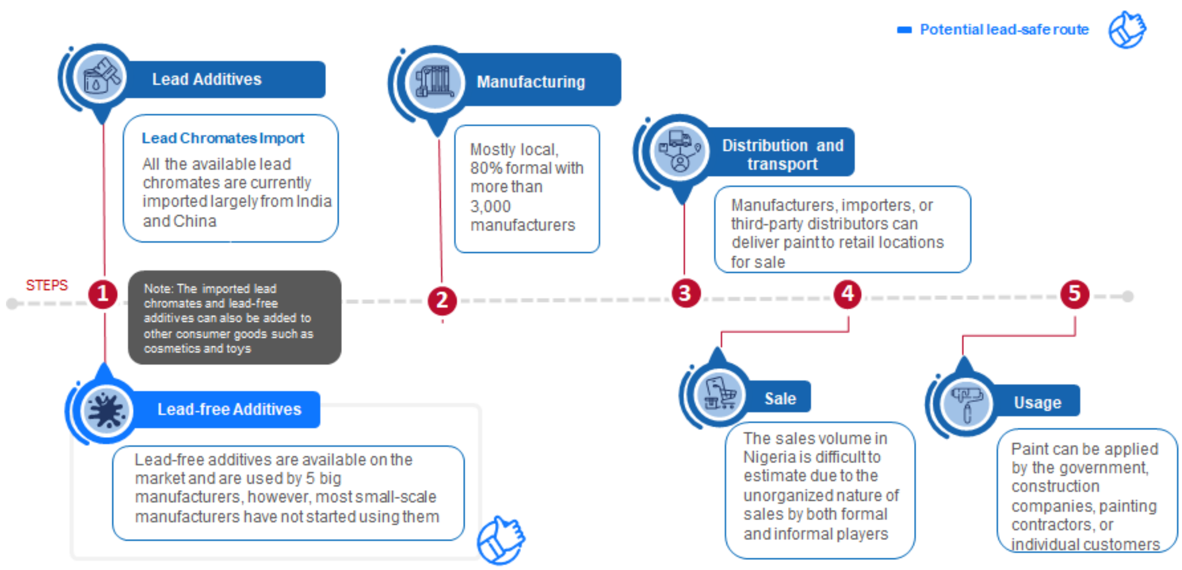
Several organizations are making efforts to build buy-in from manufacturers to eliminate lead paint in Nigeria through stricter regulations and data collection. Several national and

[35] Testing paint samples from these companies would help verify this, as some have recently registered for ongoing reformulation support efforts

multinational organizations and NGOs—such as the Paint Manufacturers Association of Nigeria, Sustainable Research and Action for Environmental Development (SRADev) Nigeria, Lead Exposure Elimination Project (LEEP), UNEP, and IPEN—are actively documenting the state of the country's lead paint industry, as well as building awareness and capacity around alternatives to lead additives and the paint reformulation process. (SAICM 2020)

2.3.2. SUPPLY CHAIN ANALYSIS

Figure 8: Simplified paint supply chain in Nigeria



Five main stages make up the paint supply chain: lead additives (lead chromates) importation (or lead-free additive acquisition), manufacturing, transport and distribution, sales, usage, and lead disposal and substitution. Currently, lead chromates available in Nigeria are largely imported from India and China (stage 1). The lead-free additives available on the market are mainly sourced from India and are used by five big players, while small-scale manufacturers have not begun using them. (SRADev Nigeria, IPEN, UNEP, GEP 2020) Manufacturing (stage 2) is predominantly local, with over 80 percent of paint manufacturing taking place within the formal sector. A small number of large formal manufacturers control ~10-15 percent of the market, while numerous small-scale players represent ~70 percent, with the remaining portion consisting of informal players. Manufacturers, importers, or third-party distributors can deliver paint to retail locations (stage 3) for sale (stage 4). Paint sales in Nigeria are estimated to be around 128 million liters per year, dominated by paint for decorative use (64 percent of the total share). (SRADev Nigeria, IPEN, UNEP, GEP 2020) The end-users of paint (stage 5) include the government, construction companies, painting contractors, and individual customers.

Figure 9: Players involved in different stages of the paint supply chain

Stage	Description	Illustrative players
Lead chromates import	• Imported by recognized players mainly from Asian countries	Chizzy, REDA,Cormart, Brenntag, Nagode Industries, Nycil
Lead-free additives import	• Mainly imported from India. Examples of additives include strontium and zirconium as drying agents, and titanium dioxide, and chromate as pigments	BASF, Clariant Corporation (through Parco Enterprise), Bruchsaler Farben, Papertex Limited
Paint manufacturing	• Highly fragmented as small-scale manufacturers (the majority in the market) represent ~70% of the market share	Small-scale manufacturers Berger, Dulux, Meyer, Portland Paints Nigeria, Caplux, IPWA,Trumpcoat, etc.
Transportation and distribution	• Fragmented with a lot of informal players in addition to formal manufacturers and transportation companies	Local manufacturers, formal transportation companies, and SMEs
Paint sales	• Fragmented with varying degrees of formality – some informal manufacturers sell paint in their backyards. However, recognized brands such as Meyer Paints, Berger Paints have points of sale in different states in Nigeria	Retailers, wholesalers, manufacturers
Paint usage	• Diverse usage based on the consumer types and purpose (residential, industrial, commercial, etc.)	Government, Construction companies, painting contractors, other individual consumers

Although there are many importers of lead additives on the Nigerian market, consulted researchers estimate that six large importers dominate most of the market. (SRADev Nigeria, IPEN, UNEP, GEP 2020) The main importers are Chizzy Limited, REDA Chemicals, Cormart Nigeria Limited, Brenntag Nigeria Limited, Nagode Industries Limited, and Nycil Limited. Data on shares of the market that each of these controls is not publicly available.

Four other firms are major importers of lead-free additives. Lead-free additives available on the market include the drying agents strontium and zirconium, as well as pigments titanium dioxide, chromate, chromium, and cadmium. BASF, Clariant Corporation (through Parco Enterprise Nigeria Limited), Bruchsaler Farben, and Papertex Limited are the main companies bringing lead-free additives into the market.

Nigeria's paint manufacturing industry is highly fragmented, with over 3,000 manufacturers, including a small number of major players accounting for 10-15 percent of the market, and numerous small-scale manufacturers comprising approximately 70 percent of the market, according to paint manufacturers. The major five brands - Chemical and Allied Products (CAP) Plc, Paints and Coatings Manufacturing Nigeria (PCMN) Plc, Berger Paints Nigeria Plc, Meyer Paints, and Chemstar Paint - represent 10-15 percent of the market by volume. On the other hand, registered small-scale manufacturers represent ~70 percent of the market, according to paint manufacturers. These figures do not, however, account for informal manufacturers, which typically produce lower cost, substandard paint. Low entry barriers allow informal manufacturers to easily obtain lead additives and produce paint in backyards and at construction sites.

Paint distribution and sales are highly fragmented. Transportation and distribution of paint is highly fragmented—a mix of informal players, formal manufacturers, and formal transportation companies bring paint to retail sites. Paint sales, too, are highly fragmented and informal—some informal manufacturers sell paint in their backyards or neighborhoods, making it difficult to trace their activities, according to paint manufacturers and NGOs in the country. However, recognized brands such as Meyer Paints and Berger Paints also maintain points of sale across the country.

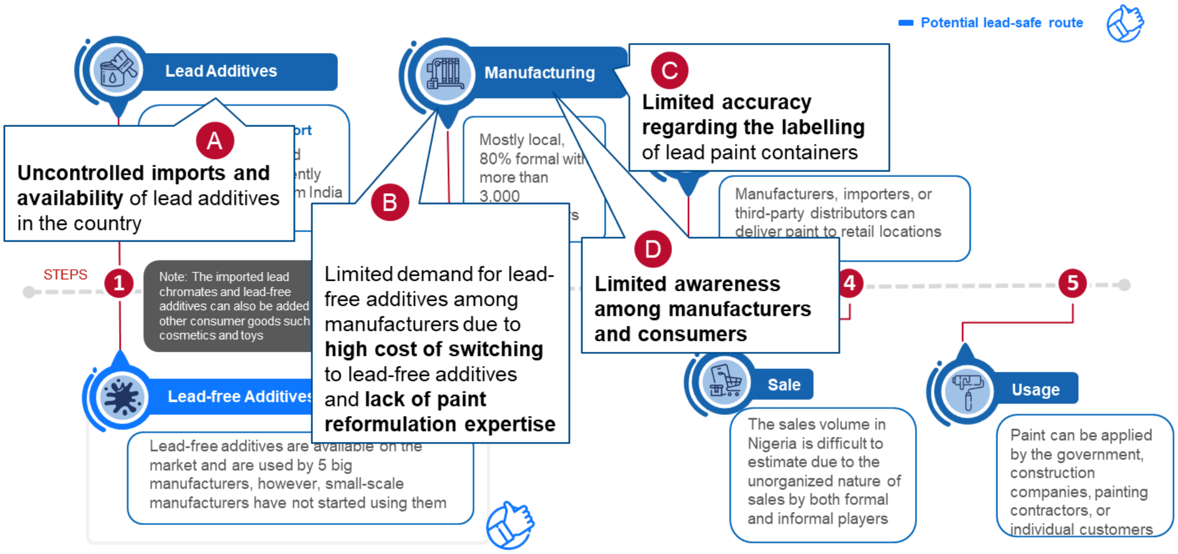
KEY PUBLIC AND SOCIAL SECTOR STAKEHOLDERS

Federal government regulators are responsible for creating, enforcing, and promoting awareness of regulations and standards for paint manufacturers. The National Environmental Standards and Regulations Enforcement Agency (NESREA) is Nigeria's federal regulatory agency responsible for setting and ensuring compliance with environmental related regulations at the federal level. The Standards Organization of Nigeria (SON) focuses on standardizing all consumer products in Nigeria, including paint. In addition to setting regulations and standards, these government agencies are active in strengthening awareness on lead paint elimination in Nigeria, through awareness and capacity-building sessions with paint manufacturers in collaboration with other actors.

Several organizations focus on awareness building, data collection, and training. Prominent social sector actors include Lead Exposure Elimination Project (LEEP), International Pollutants Elimination Project (IPEN), and Sustainable Research and Action for Environmental Development (SRADev) Nigeria. As a member of the Global Alliance to Eliminate Lead Paint (GAELP) since 2009, IPEN partners with country-specific organizations, such as SRADev Nigeria, to conduct lead paint studies, provide technical assistance to manufacturers, and support governments in implementing lead paint regulations. SRADev Nigeria has conducted various lead paint studies (with the support from IPEN and recently LEEP) to gather Nigeria-specific data on lead in solvent-based paints for home use. IPEN has also provided capacity building to help SRADev Nigeria implement on-the-ground activities—for instance, alongside NESREA, SRADev Nigeria is active in raising awareness among Nigerian paint manufacturers about lead paint elimination. In 2024, LEEP is working with SRADev Nigeria and NESREA to facilitate the implementation of the revised regulations through awareness building campaigns in three out of six geopolitical zones in Nigeria, focusing on communicating details about the regulations, and offering technical support for the paint reformulation process. Moreover, LEEP is working on identifying more suppliers of lead-free additives that paint manufacturers can engage in their reformulation process.

2.3.3. BARRIERS TO A LEAD-SAFE FUTURE

Figure 10: Key barriers to a lead-safe paint supply chain in Nigeria



The four main barriers to a lead-safe paint supply chain in Nigeria are:

(i) **Limited controls placed on the import of lead additives.** Nigeria does not have restrictions on the import of lead additives and does not have monitoring strategies in place to track where lead additives are sold. The lack of controls leads to wide availability of lead additives in the country and low barriers of entry into the paint industry.

(ii) **Limited controls placed on the import of lead additives.** Switching to lead-free alternatives incurs additional costs. Reformulating to achieve perfect colors and other paint qualities involves research and development expenses. Additionally, lead-free pigments and dryers are approximately 20 percent more expensive per kilogram of dry weight than their lead-based counterparts. Manufacturers have varied perspectives on how lead-free additives affect paint prices. Some argue that despite higher upfront costs, less quantity of lead-free additives is needed, resulting in no net increase in production costs and no effect on the final paint price. Others, however, report higher overall production costs after switching to lead-free additives, leading to an increase in the final paint price. In addition, small-scale manufacturers lack the technical expertise to conduct paint reformulation processes due to limited research and development (R&D) capabilities needed for paint reformulation. The switching costs and lack of reformulation expertise explain the limited demand for lead-free additives. As a result, lead-free additives are scarce in local markets because importers lack sufficient market demand to justify importing them.

“I am not going to stock lead-free additives that will sit in inventory for two years. Irregular demand is why we don't import them in large quantities. However, I currently import lead-free additives for big manufacturers who can forecast their demand for the next quarter or six months. Good forecasting is very important.”

- Lead-free additives importer -

(iii) **Limited accuracy regarding the labelling of paint containers.** A 2017 survey of 54 solvent-based paints found that only 6 percent included lead information on their labels, while the rest were vaguely labeled as containing solvents, pigments, and resins without details**.** (SRADev Nigeria, IPEN 2017) The absence of this information limits consumer awareness of the type of paint they are buying. Recently amended regulations mandate that companies include clear information about lead on their labels, but enforcement is lax due to limited testing capabilities of labs, and lack of monitoring and enforcement capacity of regulatory agencies.

“There is limited funding to support implementation. Because of this, there are no guidelines that are developed following the regulations to guide operators on how to implement suggested actions.”

- Regulatory agency -

(iv) **Limited awareness among small-scale manufacturers and consumers.** Awareness sessions are being conducted with manufacturers about the dangers of lead paint, the mandatory 90ppm regulations, and the reformulation process. However, these interventions only cover three out of six geopolitical zones in Nigeria – Abuja in the northeast, Ibadan in the southwest, and Onitsha in the southeast of the country, according to LEEP supporting these efforts.

“General awareness in the industry and among users has not taken up, despite efforts being put in. For most people, paint is just paint and the cheaper the better. They don’t concern themselves with its ingredients.

With rising fuel prices and devaluation of the Naira, people have bigger priorities, like putting food on the table for their families"

- Paint manufacturer -

2.3.4. INTERVENTIONS

To promote the transition to paints without added lead, interventions can focus on supporting lead-free alternatives and disincentivizing the use of lead additives. Supporting alternatives can involve improving information on the availability of alternatives, enhancing the capacity of manufacturers to transition, raising manufacturers awareness on dangers of lead paint, and boosting demand for lead-safe paint through awareness and preferred purchasing programs. Disincentivizing the use of lead additives can involve changing laws and regulations to restrict the import and production of lead additives used in paint, improving the enforcement of the 90ppm limit on lean in paint in revised regulations, and listing lead chromates under the Rotterdam Convention. These six key recommendations to promote a transition to lead-free additives fall in one of the two categories described, with a focus on capacity building, market linkages, investment promotion, awareness, and monitoring.

▪ Supporting lead-free alternatives

Three potential ways to promote the adoption of lead-free additives in paint in Nigeria are the following:

CONDUCT PAINT EXHIBITIONS AND OFFER IN-HOUSE SUPPORT FOCUSED ON AWARENESS, MARKET LINKAGES, AND CAPACITY BUILDING

Support efforts to eliminate lead in paint by facilitating annual paint exhibitions in each of the six geopolitical zones in Nigeria. These events would bring together manufacturers and suppliers of lead-free additives, boosting awareness and capacity for paint reformulation. Key organizations involved can include development partners, civil society organizations, and government agencies (e.g.: Lead Exposure Elimination Project (LEEP), IPEN, SRADev Nigeria, the Paint Manufacturers Association (PMA), the Federal Ministry of Environment (FMEV), the National Environmental Standards and Regulations Enforcement Agency (NESREA), and Standards Organization of Nigeria (SON). The exhibitions would feature awareness sessions on harmful effects of lead paint and revised regulations that mandate low legal limit on lead in paint (including regulations on adequate labeling of paint containers to include lead content) by government agencies and civil society actors. The exhibitions would also feature live reformulation demonstrations by lead-free additive suppliers and serve as a platform for market linkages between paint manufacturers and lead-free additives suppliers. In addition to exhibitions, interested companies can be offered in-house support by seconding technical staff to help them with the reformulation process. This initiative would address manufacturers' limited expertise and increase demand for lead-free additives.

INCREASE THE AVAILABILITY OF LEAD-FREE ADDITIVES ON THE MARKET

Collaborate with the government to explore financial incentives for lead-free additive suppliers to boost imports. Increasing the availability and use of lead-free additives by manufacturers necessitates the involvement of importers as they are key to determining what the market uses, given reliance on imports of lead additives. Lead-free pigments can still be more expensive- albeit a decreasing cost globally - which might discourage distributors. Giving incentives to reduce this cost difference could help attract more distributors. Potential incentives can include tax breaks and removal of import duties (supplemented by increased tariffs for lead additives) and buy-back guarantees for lead-free additives from the government or development partners. Additionally, to meet suppliers' need for forecasted demand over the next quarter or six months, collaboration with the civil society organizations to coordinate group purchasing from manufacturers to increase demand could prove impactful.

INCENTIVIZE MANUFACTURERS TO SWITCH TO LEAD-SAFE PAINT BY BOOSTING DEMAND

Offer preferential procurement contracts for certified lead safe paint producers to incentivize manufacturers to switch to lead-safe paint. The Lead Safe Paint™ certification program currently operating in the Philippines, Sri Lanka and Bangladesh can be a model for Nigeria to adopt. The program requires third party testing of paints for lead content to initially obtain certification and periodically to ensure compliance in paints sourced from these markets. Manufacturers can use the recognition from third party certification as a marketing tool to boost demand for their products. Additionally, preferential procurement contracts can require that paints have lead-safe paint certification. This can be done through engaging government agencies, embassies, schools and other large private sector purchasers to pilot this initiative by choosing lead-safe manufacturers for new construction and their building maintenance services. This approach, in addition to awareness and capacity building efforts, actively supports the transition to lead-safe paint.

▪ Disincentivizing the use of lead additives in paint

Three channels can address the extensive use of lead additives in paint in Nigeria:

PROMOTE INVESTMENT IN TESTING LABS CAPACITY AND BUILD REGULATORY AGENCIES' CAPACITY TO BOOST MONITORING AND ENFORCEMENT

Promote investment in testing laboratories capacity building to enhance regulatory agencies' capacity to enforce the 90ppm lead content limit. A few centrally located testing labs in Nigeria (~2) can be supported in participating in a proficiency analytical testing program such as the National Lead Laboratory Accreditation Program (NLLAP) to enhance their competence in conducting lead tests. This initiative will ensure that paint companies and agencies like NESREA and SON have access to these labs for testing their paint samples and better monitoring of compliance with the regulations. Additionally, provide training sessions for regulatory personnel on effective monitoring and enforcement strategies for the NECPR, 2024, including enforcing labelling requirements, to maximize the labs' impact.

ENHANCE TRACEABILITY AND IMPLEMENT RESTRICTIONS ON LEAD ADDITIVES IMPORTS

Restrict the import of lead additives to licensed companies only, requiring importers to obtain a license or permission to import lead chromate and other lead compounds. This intervention leverages testing capabilities developed through investments in testing labs capacity and regulatory capacity building, addressing the issue of uncontrolled importers of lead additives and providing visibility into their downstream supply chains. Enhanced visibility will inform monitoring of lead additives in paint and other consumer goods effectively.

LIST LEAD CHROMATES UNDER THE ROTTERDAM CONVENTION

Support the Government of Nigeria in submitting a notification to list lead chromates as hazardous chemicals under Annex III of the Rotterdam Convention. The government of Nigeria can be supported to prepare relevant documents needed to submit a notification to the Rotterdam Convention to ensure that they comply with all the criteria, especially the risk evaluation criterion that requires that the country's decision to take the notified regulatory action was justified by a Risk Evaluation that reviewed scientific data and information in the context of the Prevailing Conditions in the notifying country.

- ## Cross-cutting recommendation

PROMOTE COLLABORATION BETWEEN STAKEHOLDERS

USAID's convening power could bring stakeholders from the paint industry, including public, private, and civil society actors to promote collective efforts and encourage commitments to increasing lead-safety in paint and other similar consumables. Public agencies, ministries, the private sector, and civil society need to be engaged collaboratively for the effectiveness of the interventions stated above. Funding is imperative for national convenings that gather key stakeholders and encourage both the adoption of interventions and cooperation in their implementation.

Successfully implementing the suggested interventions requires identifying partners to engage and estimating funding needs for illustrative design, as summarized in the table below:

Table 5: Summary of proposed interventions for the paint supply chain and corresponding actors and funding for illustrative design

Intervention	Actors involved	Illustrative funding needs
Conduct paint exhibitions and in-house support focused on awareness, market linkages, and capacity building	• Development partners to offer funding to run these exhibitions • Civil society actors to conduct awareness building sessions on dangers of lead exposure and new regulations • Lead-free additive suppliers to conduct capacity building and live demonstration of capacity building sessions • Development partners to subsidize the cost of seconded staff to interested paint companies requiring direct reformulation support	\$100,000-\$160,000 annually to fund 12 exhibitions (2 per year in each of the 6 geopolitical zones) and in-house reformulation support for 10 manufacturers: • ~\$50,000 for seconded scientists in 10 manufacturing facilities • \$24,000-\$36,000 in overhead costs • \$12,000-\$30,000 in exhibition venue rental costs • \$12,000-\$24,000 in other miscellaneous costs such as logistics,

		- direct outreach to companies, and food catering costs, etc. $2,000-$14,000 in marketing costs
Increase the availability of lead-free additives on the market	- Development partners to convene partners to decide on suitable incentives - Development partners in collaboration with the government to provide financial incentives - Civil society organizations to coordinate group purchasing from manufacturers	$80,000-$205,000 annually to guarantee at least 60-250 tons of lead-free alternatives, corresponding to 10-40 percent of the market and organizing bulk purchases from manufacturers: $30,000-$130,000 in buy-back guarantees costs $36,000-$54,000 in lead-free additives bulk purchase coordination costs $12,000-$18,000 in overhead costs to convene key actors for decision making $2,000-$4,500 in venue rental cost and other miscellaneous costs for a decision-making meeting
Incentivize manufacturers to switch to lead-safe paint	- Development partners to provide financial support to promote third party certification for lead-safe paint - Government agencies, embassies, large private sector purchasers, and schools to offer preferential procurement contracts to lead-safe paint manufacturers	$40,000-$130,000 annually to bring together key actors for decision-making on preferential contracts and to support third party lead-safe paint certification for 5 manufacturers: $25,000-$100,000 to fully subsidize third party lead safe paint certifications for 5 companies $8,000-$12,000 in overhead costs to organize workshop with public, private,

		and social actors on procurement contracts • $3,000-$7,500 in recognition awards purchase costs • $4,000-$10,000 in venue rental costs for workshop and award ceremonies • $4,000-$6,000 in miscellaneous costs such as logistics and food catering costs
Promote investment in testing labs capacity and build regulatory agencies' capacity to boost monitoring and enforcement	• Development partners to provide financial support to 2 existing testing laboratories to participate in proficiency testing programs • Trained professionals to provide training sessions for regulatory personnel on effective monitoring and enforcement strategies	$60,000-$100,000 annually to finance participation in proficiency testing programs and capacity building sessions for regulatory agencies: • ~$8,000 for proficiency testing programs • $55,000-$90,000 to cover capacity building sessions for regulatory agencies personnel across 6 geopolitical zones in Nigeria
Enhance traceability and implement restrictions on lead additive imports	• Regulatory agencies to develop a specific license to be offered to importers of lead compounds • Regulatory agencies to conduct regular monitoring of the downstream buyers of the imported lead compounds to ensure they do not end up in paints	$55,000-$100,000 for one year to cover capacity building sessions for regulatory agencies personnel across 6 geopolitical zones in Nigeria.
List lead chromates under the Rotterdam Convention	• Government agencies to prepare all relevant documentations needed to submit a notification to the Rotterdam Convention	Cost can widely vary depending on availability of all data required, the need for additional research or testing, and resources required for

	• IPEN and country NGOs to provide relevant support to the government to collate all documents	stakeholder engagement and consultations

Future efforts should focus on promoting consumer awareness to increase demand for lead-safe paint. This strategy is considered for the future due to the high costs associated with running such campaigns and the current absence of necessary conditions for success. To effectively advance this intervention, it is essential to (i) increase the availability of affordable lead-safe paint options for all consumers, and (ii) enforce and monitor compliance with regulatory requirements for paint container labeling, ensuring that consumers can easily identify lead-safe products.

Beyond barriers to and efforts to promote a lead-safe paint supply chain in Nigeria already discussed at length in the following sections, future efforts should also address lead exposure from inhaling or ingesting dust from deteriorating lead paint. When lead paint on walls, windows, toys, and furniture deteriorates, it releases dust into the air and soil. Children living and playing in these areas can inhale or ingest this dust. Sometimes, children pick up paint chips and put them in their mouths, which is particularly dangerous due to the high lead content in the chips compared to dust and soil. Community awareness of the dangers of lead exposure, especially from old paint dust, is low. Additionally, regulatory agencies do not have testing capacity to determine lead content in paints in older buildings. Recently amended regulations in NECPR, 2024 require that the demolition of lead paint in buildings should be carried out with adequate safety procedures but enforcement is lacking. Moreover, the prohibitive costs of removal and repainting likely deter people and businesses from undertaking the process.

REFERENCES

Agency for Toxic Substances and Disease Registry (ATSDR). 2020. “Toxicological Profile for Lead.” United States Department of Health and Human Services. https://www.atsdr.cdc.gov/toxprofiles/tp13.pdf.

Alpha Chemika. n.d. “LEAD CHROMATE Extra Pure.” Accessed July 10, 2024. https://www.alphachemika.co/chemical/3550/LEAD_CHROMATE_Extra_Pure.html.

Ajoke Fehintola Idayat Akindele, O. O. (2024). A Revisit on Lead in Decorative and Industrial Paints in Nigeria. *ResearchGate*.

Ambwani, Meenakshi, Tomojit Basu. 2021 “Food Safety Regulator Tightens Screws, Fixes New Lead Levels.” BusinessLine, December 6, 2021. Accessed July 10, 2024. https://www.thehindubusinessline.com/news/food-safety-regulator-tightens-screws-fixes-new-lead-levels/article62326548.ece.

Angelon-Gaetz, Kim A., Marjorie N. Segule, and Molly Wilson. 2022. “Lead Levels in Spices From Market Basket and Home Lead Investigation Samples in North Carolina.” Public Health Reports 138 (1): 91–96. https://doi.org/10.1177/00333549211066152.

Brown, M. J., P. Patel, E. Nash, T. Dikid, C. Blanton, J. E. Forsyth, R. Fontaine, et al. 2022. “Prevalence of Elevated Blood Lead Levels and Risk Factors Among Children Living in Patna, Bihar, India 2020.” PLOS Global Public Health 2 (10): e0000743. https://doi.org/10.1371/journal.pgph.0000743.

Centre for Science and Environment. n.d. “Lead in Paints.” Accessed July 10, 2024. https://www.cseindia.org/lead-in-paints-521.

Champion, Wyatt M., Mahmooda Khaliq, and James R. Mihelcic. 2022. "Advancing Knowledge to Reduce Lead Exposure of Children in Data-Poor Low- and Middle-Income Countries." *ACS Publications.* October 12. Accessed June 2024. https://pubs.acs.org/doi/10.1021/acs.estlett.2c00656.

Children's Environmental Health Collaborative, UNICEF. 2024. "Towards a future free from lead exposure: A ministerial dialogue on preventing maternal and child exposure to toxic lead." Geneva.

Ericson, Bret, Howard Hu, Emily Nash, Greg Ferraro, Julia Sinitsky, and Mark Patrick Taylor. 2021. “Blood Lead Levels in Low-income and Middle-income Countries: A Systematic Review.”

The Lancet. Planetary Health 5 (3): e145–53. https://doi.org/10.1016/s2542-5196(20)30278-3.

Forsyth, J. E. et al. Evidence of turmeric adulteration with lead chromate across South Asia. Under Review at *The Science of the Total Environment.*

GIZ. 2023. "Enhancing the Capacities of Smallholder Spice Farmers in Sustainable Farming." Last updated July, 2023. Accessed July 10, 2024. https://www.giz.de/en/worldwide/129102.html.

IARC Working Group on the Evaluation of Carcinogenic Risks to Humans. 2009. "Arsenic, Metals, Fibres, and Dusts: Volume 100 C A Review of Human Carcinogens". International Agency for Research on Cancer. https://publications.iarc.fr/_publications/media/download/5224/5637a4f4ad9cfd4e81ab40a8fa057015a3e8911b.pdf.

India Brand Equity Foundation. n.d. "What are the latest trends in the spices market in India?" Accessed July 10, 2024. https://sites.google.com/view/ibefindia/article/what-are-the-latest-trends-in-the-spices-market-in-india.

India Science, Technology & Innovation Portal n.d. "National Institute of Occupational Health (NIOH), Ahmedabad." Accessed July 10, 2024. https://www.indiascienceandtechnology.gov.in/organisations/ministry-and-departments/indian-council-medical-research-icmr/national-institute-occupational-health-nioh-ahmedabad.

Indian Trade Portal. n.d. "Spices Industry." Accessed July 10, 2024. https://www.indiantradeportal.in/vs.jsp?lang=0&id=0,31,24100,24119.

International Trade Administration n.d. "Harmonized System (HS) Codes." Accessed July 10, 2024. https://www.trade.gov/harmonized-system-hs-codes.

IPEN. 2019. "EU Tribunal Deems Lead Chromates Authorisation Illegal." Accessed July 10, 2024. https://ipen.org/news/eu-tribunal-deems-lead-chromates-authorisation-illegal.

IPEN. n.d. "Lead Chromates and the Rotterdam Convention." https://ipen.org/sites/default/files/documents/1_what_are_lead_chromates_and_how_do_they_cause_harm.pdf.

IPEN. (n.d.). *Listing Lead Chromates Under the Rotterdam Convention.* Retrieved from IPEN: https://ipen.org/site/listing-lead-chromates-under-rotterdam-convention

Jennifer Sample, MD. 2024. "Lead Exposure in Children: Failure to Protect the Most Vulnerable." *The Journal of Pediatric Pharmacology and Therapeutics.* https://www.ncbi.nlm.nih.gov/pmc/articles/PMC11163901/.

Kapley, Atya, Ankit Gupta and Himanshu Kumbhare. 2022. "Assessment of Lead Impact on Human and India's Response." Council of Scientific and Industrial Research (CSIR) and NITI Aayog. https://www.pureearth.org/wp-content/uploads/2022/06/Lead-Report-India-CSIR-NITI-Ayog-June-2022.pdf.

Larsen, B., and Sánchez-Triana. 2023. "Global health burden and cost of lead exposure in children and adults: a health impact and economic modelling analysis." *The Lancet Planetary Health.*

Ministry of Health and Family Welfare. 2011. "Food Safety and Standards (Contaminants, Toxins and

Residues) Regulation, 2011." The Gazette of India. https://www.fssai.gov.in/upload/uploadfiles/files/Contaminants_Regulations.pdf.

Ministry of Health and Family Welfare. 2011. "Food Safety and Standards (Food Products Standards and Food Additives) Regulations, 2011." The Gazette of India. https://www.fssai.gov.in/upload/uploadfiles/files/Food_Additives_Regulations.pdf.

Naser, Hm, S Sultana, M Manjurul Haque, S Akhter, and Ra Begum. 2014. "Lead, Cadmium and Nickel Accumulation in Some Common Spices Grown in Industrial Areas of Bangladesh." The Agriculturists 12 (1): 122–30. https://doi.org/10.3329/agric.v12i1.19867.

Osibanjo, Oladele, and Ajoke Fehintola Idayat Akindele. 2024. *A Revisit on Lead in Decorative and Industrial Paints in Nigeria.* Department of Chemistry, University of Ibadan, Ibadan-Nigeria.

Our World in Data. 2021. *Our World in Data: Number of children with lead levels in blood greater than 5 µg/dL, 2019.* Accessed June 2024. https://ourworldindata.org/grapher/children-lead-5micrograms?tab=map.

Our World in Data. 2021. *Our World in Data: Number of premature deaths from lead exposure.* Accessed June 2024. https://ourworldindata.org/grapher/deaths-lead-exposure

Prasad, Seema. 2024. "Food Labels Misleading, India's New Dietary Guidelines Warn." Down to Earth, May 9, 2024. Accessed July 10, 2024. https://www.downtoearth.org.in/food/food-labels-misleading-india-s-new-dietary-guidelines-warn-96069.

Press Trust of India (PTI). 2015. "FSSAI for Fixing Lead Content Limit in Fruits, Pulses, Juices."

Business Today, June 25, 2015. Accessed July 10, 2024. https://www.businesstoday.in/latest/policy/story/fssai-for-fixing-lead-content-limit-in-fruits-pulses-juices-47899-2015-06-25.

Pure Earth. 2023. “Lead in Consumer Goods: A 25-country Analysis of Lead (Pb) Levels in 5,000+ Products and Foods.” https://www.pureearth.org/wp-content/uploads/2023/11/Pure-Earth-RMS-Final-Report.pdf.

Pure Earth. n.d. *Pure Earth.* Accessed June 2024. https://www.pureearth.org/global-lead-program/lead-poisoning/.

Pure Earth n.d. “Identification and Establishment of Spices Supply-Chains in North India.” Accessed July 10, 2024. https://www.pureearth.org/project/spices-supply-chains-in-north-india/.

Pure Earth Mexico. n.d. *Barro Aprobado.* Accessed June 2024. https://barroaprobado.org/wp-content/uploads/2023/05/back-225x225al25-3.pdf.

Ryan, Mark. 2013. “Lead is dead.” European Coatings Journal, 3: 74-78. https://www.unicoil.com.sa/wp-content/uploads/2017/04/Lead_is_Dead-ECJ_2013_03.pdf.

SAICM. (2020, October). *Eliminating Lead Paint: The Role of the Paint Industry.* Retrieved from SAICM Knowledge: https://saicmknowledge.org/sites/default/files/publications/Lead%20in%20Paint%20D6.pdf

Sonal, Shruti. 2023. “Trendy to Toxic: Is Turmeric Losing Its Golden Hue?” The Times of India, November 12, 2023. Accessed July 10, 2024. https://timesofindia.indiatimes.com/home/sunday-times/trendy-to-toxic-is-turmeric-losing-its-golden-hue/articleshow/105159206.cms.

SRADev Nigeria, IPEN. (2017, July). *Lead in Solvent-based Paints for Home Use in Nigeria.* Retrieved from IPEN: https://ipen.org/sites/default/files/documents/ipen-nigeria-lead-report-v1_1-en.pdf

SRADev Nigeria, IPEN, UNEP, GEP. (2020, March). *Baseline Information for the Lead Paint Country Situation in Nigeria.* Retrieved from SAICM Knowledge: https://saicmknowledge.org/sites/default/files/publications/Baseline-Nigeria.pdf

Spices Board of India. n.d. “Major spice/state wise area and production of spices.” https://indianspices.com/sites/default/files/Major%20spice%20state%20wise%20area%20production%202022-23.pdf.

Sustainable Research and Action for Environmental Development (SRADev Nigeria). 2017. *LEAD IN SOLVENT-BASED PAINTS FOR HOME USE IN NIGERIA.* IPEN.

Tandon, Suneera. 2021. "'Branded Spices Mkt May Double by 2025.'" Mint, August 10, 2021. Accessed July 10, 2024. https://www.livemint.com/industry/retail/branded-spices-market-set-to-double-to-rs50-000-crore-by-2025-11628584763525.html.

Techno PharmChem. n.d. "Lead (II) Chromate LR." Accessed July 10, 2024. https://www.technopharmchem.com/ProductList/productDetail/763.

Toxics Link. 2023. "Lead Chromate – Factsheet." https://toxicslink.org/wp-content/uploads/2023/08/Lead%20Chromates%20Factsheet.pdf.

UNICEF. 2022. September. Accessed June 2024. https://www.unicef.org/media/123161/file/Childhood_Lead_Exposure_Key_Messages_2022.pdf.

UNICEF and Pure Earth. 2020. "The Toxic Truth: Children's Exposure to Lead Pollution Undermines a Generation of Future Potential." https://www.unicef.org/reports/toxic-truth-childrens-exposure-to-lead-pollution-2020

USAID. 2024. *USAID and UNICEF Join Forces to Call for More Action to Prevent Maternal and Child Exposure to Toxic Lead.* May 29. Accessed June. https://www.usaid.gov/news-information/press-releases/may-29-2024-usaid-and-unicef-join-forces-call-more-action-prevent-maternal-and-child-exposure-toxic-lead.

US Environment Protection Agency. n.d. "Integrated Science Assessment (ISA) for Lead". Accessed July 10, 2024. https://www.epa.gov/isa/integrated-science-assessment-isa-lead.

World Health Organization (WHO). 2023. "Lead poisoning." *World Health Organization.* August 11. Accessed June 2024. https://www.who.int/news-room/fact-sheets/detail/lead-poisoning-and-health.

World Integrated Trade Solution. 2019. "Pigments and Preparations Based Thereon Exports by Country." World Bank. Accessed July 10, 2024. https://wits.worldbank.org/trade/comtrade/en/country/ALL/year/2019/tradeflow/Exports/partner/WLD/product/320417.