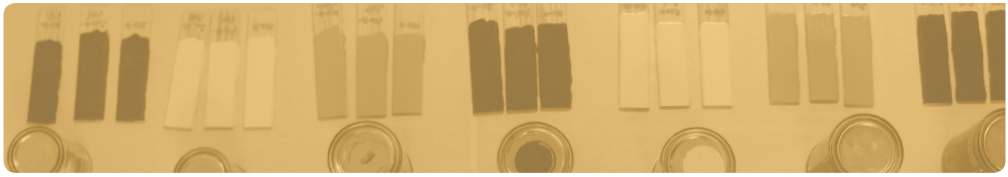
CHINA



SOLUBLE AND TOTAL LEAD CONTENT OF SOLVENT-BASED PAINTS FOR HOME USE IN CHINA

October 2017

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NATIONAL REPORT

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October 2017

ACKNOWLEDGMENTS

We take this opportunity to thank all those who were instrumental in compiling and shaping this paint study.

This study was undertaken as part of IPEN's Global Lead Paint Elimination Campaign. It was conducted in the People's Republic of China by Shenzhen Zero Waste Environmental Public Interest Development Center (Shenzhen Zero Waste) in partnership with IPEN.

The analytical study of soluble lead content of paints sold in China for home use, financed by the Government of Sweden, is a follow-up to an earlier study based on total lead content undertaken as part of the Asian Lead Paint Elimination Project. The Asian Lead Paint Elimination Project was established to eliminate lead in paint and raise widespread awareness among business entrepreneurs and consumers about the adverse human health impacts of lead-based household enamel paints, particularly on the health of children under six years old. The Asian Lead Paint Elimination Project was implemented by IPEN over a period of three years (2012-2015) in seven focus countries (Bangladesh, India, Indonesia, Nepal, Philippines, Sri Lanka, and Thailand) with funding from the European Union (EU) totaling 1.4 million euros. The provided funding also included means to conduct a study on the lead content of paints in China, to assess the need for similar activities in China.

While this study and report was published with the assistance of the European Union and the Government of Sweden, its contents are the sole responsibility of Shenzhen Zero Waste together with IPEN, and can in no way be taken to reflect the views of these funders.

Established in 1998, IPEN is currently comprised of over 500 Participating Organizations in 116 countries, primarily developing and transition countries. IPEN brings together leading environmental and public health groups around the world to establish and implement safe chemicals policies and practices that protect human health and the environment. IPEN's mission is a toxics-free future for all.

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The Shenzhen Zero Waste Environmental Public Interest Development Center is an organization working on chemical safety and environmental health (CSEH). It seeks to build a CSEH Information Center by developing independent testing techniques on hazardous chemical pollution, conducting research and investigation on environmental health cases, organizing international exchange activities, and by systematically communicating scientific knowledge and practical information. The CSEH Information Center hopes to develop into an important think tank providing high quality intellectual support for CSEH efforts in China. The group also envisions the launch of a relevant national network to promote cooperation among civil society groups on CSEH issues and concerns, upgrade national policies and contribute to global efforts in pursuit of a toxic free future.

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PREFACE

Lead paints for home use continue to be widely produced, sold, and used in developing countries despite the fact that most highly industrial countries banned lead paints for household use more than 40 years ago. IPEN and Participating Organizations are part of the global movement to eliminate lead paint by 2020 to protect children's health.

In 2007 and 2008, NGOs in the IPEN network collected and analyzed decorative (home use) paints on the market in 11 developing countries, and in countries with economies in transition. The results were startling. In every one of these countries, many of the paints contained dangerously high lead levels. In response, IPEN launched its Global Lead Paint Elimination Campaign, which seeks to eliminate lead in paint and raise widespread awareness among business entrepreneurs and consumers about the adverse human health impacts of lead paint, particularly on the health of children. Since then, IPEN-affiliated NGOs and others have sampled and analyzed paints on the market in approximately 50 low- and middle-income countries.

Almost all countries that regulate the lead content of paints do so either through a total lead content limit or through prohibitions on using lead-based paint raw materials. However, the People's Republic of China has chosen to restrict lead in paint through a so-called soluble lead content limit, measuring migration of lead from a paint film when subjected to a standard weak acid treatment. This method, unsupported by health data, is intended to simulate the amount of lead that is bioavailable for absorption when mouthing or swallowing a lead-containing object such as a toy. To assess its protectiveness, IPEN therefore analyzed 141 paints for both their total lead content and for their soluble lead content, using the method specified in the Chinese standard.

This report presents new data on the soluble lead content of solvent-based paints for home use available on the market in the People's Republic of China compared to their total lead content. It also presents background information on why the use of lead paint is a source of serious concern, especially to children's health; a review of national policy frameworks that are in place to ban or restrict the manufacture, import, export, distribution, sale and use of lead paint, and provides a strong justification to adopt and enforce further regulatory controls in the People's Republic of China. Finally, it proposes action steps by different stakeholders to protect children and others from lead paint.

This study was conducted by Shenzhen Zero Waste in partnership with IPEN.

IPEN is an international NGO network of health and environmental organizations from all regions of the world of which Shenzhen Zero Waste is a member. IPEN is a leading global organization working to establish and implement safe chemicals policies and practices to protect human health and the environment. Its mission is a toxics-free future for all. IPEN helps build the capacity of its member organizations to implement on-the-ground activities, learn from each other's work, and work at the international level to set priorities and achieve new policies.

EXECUTIVE SUMMARY

Lead is a toxic metal that causes adverse effects on both human health and the environment. While lead exposure is also harmful to adults, lead exposure harms children at much lower levels, and the health effects are generally irreversible and can have a lifelong impact.

The younger the child, the more harmful lead can be, and children with nutritional deficiencies absorb ingested lead at an increased rate. The human fetus is the most vulnerable, and a pregnant woman can transfer lead that has accumulated in her body to her developing child. Lead is also transferred through breast milk when lead is present in a nursing mother.

Evidence of reduced intelligence caused by childhood exposure to lead has led the World Health Organization (WHO) to list "lead-caused mental retardation" as a recognized disease. WHO also lists it as one of the top ten diseases whose health burden among children is due to modifiable environmental factors. WHO have concluded that there is no known blood lead level that can be considered safe.

Lead paint is a major source of childhood lead exposure. The primary exposure route is when lead-containing paint on walls, windows, doors or other painted surfaces begins to chip or deteriorate, since this causes lead to be released to dust and soil. Children playing indoors or outdoors get house dust or soil on their hands, and then ingest it through normal hand-to-mouth behavior. Most regulations restricting lead content of paint used in homes, schools and other environments where children spend time is based on a total lead limit or a prohibition of using lead-based raw materials to account for this exposure route.

In the People's Republic of China, a newly Recommended National Standard on Safety Requirements for Hazardous Chemicals in Consumer Products includes three provisions are in place limiting the soluble lead content of paint used for various interior surfaces to 90 ppm (GB 18582-2008, 18581-2009 and 24410-2009).

The concept of soluble lead content, technically referred to as migration of lead, was introduced for toy regulations in the 1980s. It is based on the scenario that a child sucks and/or swallows toy material that contain lead, with the underlying assumption that a certain daily intake of lead by children can be considered safe. The method measures the amount of lead that is released from the toy

when incubated in a weak hydrochloric acid and is assumed to, without evidence, simulate what happens when the toy material comes into contact with stomach acid. The validity of this method for assessing safety of toys is discussed elsewhere and not in this report, but its exposure scenario and underlying assumptions creates serious questions about its appropriateness for limiting lead content of paint.

IPEN therefore contracted with an accredited European laboratory to analyze 141 paints for total lead content and the Chinese subsidiary of an internationally recognized product testing company for analyzing soluble lead content of the same 141 paints. Both laboratories used internationally standardized methods for their analyses.

As shown by the results released in this report, measuring the soluble lead content of paint is not only methodologically questionable but in many cases severely underestimates the paint's lead content.

RESULTS

Of the 141 paints, 99 (70 percent of paints) contained a total lead content above 90 parts per million (ppm, dry weight of the paint) and would not be allowed for sale in e.g., India, Nepal, the Philippines or the United States of America.

The soluble lead content analysis showed that 52 of the 141 paints (37 percent of paints) contained a soluble lead content above 90 ppm (dry weight of the paint), ranging from 100 ppm up to 4,630 ppm. This means that more than a third of the 141 paints analyzed in this study would not be allowed for sale in China. In addition, the majority (87 percent) of these 52 paints contained a total amount of lead above 10,000 ppm constituting a severe health hazard.

Of the 89 paints with a soluble lead content below 90 ppm, 47 paints contained total lead levels above 90 ppm. Most alarming were two paints with non-detectable soluble lead content but with total lead content of 10,700 ppm and 13,500 ppm, and one paint with a soluble lead content of 41 ppm that contained total lead content of 17,400 ppm.

Of all 141 paints analyzed, 48 paints (34 percent of paints) contained dangerously high total lead levels above 10,000 ppm and would not be allowed for sale in any country restricting the use of lead in decorative paint. The highest total lead level detected was 116,000 ppm.

Seventy of 71 paints with total lead concentration less than 600 ppm contained soluble lead concentrations of less than 90 ppm. However, it was not possible to

even approximately predict total lead levels of the paints based on their soluble lead content, since total lead levels in the 89 paints with soluble lead levels below 90 ppm ranged from below 4 ppm up to 17,400 ppm.

Brands

Of the 47 brands included in the study, all paints included from nine of the brands and at least one or more paint from 46 of the brands contained a soluble lead content less than 90 ppm. For four of the brands all samples contained less than 90 ppm total lead and soluble lead. This clearly shows that the technology exists in China to produce paint within the current regulatory limit.

In addition, all paints included from four of the brands and at least one or more paint from 28 of the brands contained a total lead content less than 90 ppm. This shows that it is technologically feasible to comply with a 90 ppm total lead limit for paints in the People's Republic of China.

On the other hand, one or more paint from 39 of the brands (83 percent of brands) contained lead at dangerously high levels above 10,000 ppm total lead.

Colors

Of the 141 paints included in the study, 45 were white and 96 colored. Yellow and green paints contained the highest concentrations of both total and soluble lead. A majority of the colored paints were red (41 paints) and yellow (42 paints). Almost all yellow paints (88 percent) exceeded the 90 ppm soluble lead limit and 95 percent exceeded 90 ppm total lead. Ninety-five percent of the yellow paints had an exceedingly high total lead content above 10,000 ppm. All five green paints contained a soluble lead content above 90 ppm, as well as a total lead content above 10,000 ppm. A fifth of the red paints contained a soluble lead content above 90 ppm and almost four-fifths had a total lead content above 90 ppm. Ten percent of the red paints contained an exceedingly high total lead content above 10,000 ppm.

White paints generally contained the least amount of lead. No white paints contained a soluble lead content above 90 ppm or above 10,000 ppm total lead content. Seventeen (38 percent) of the white paints contained total lead content above 90 ppm.

The average lead content per color showed the same trends, where green and yellow paints had total lead content averages of 54,100 ppm and 43,800 ppm and soluble lead content averages of 1,530 and 1,390 ppm, respectively.

Comparison with Earlier Studies

Two previous studies of the lead content of enamel paints intended for household use were published in 2009. One assessed both total and soluble lead content of 58 paints and the second only the total lead content of 64 paints. Results of the first study showed that 55 percent of the paints contained a soluble lead content above 90 ppm compared to 37 percent in the current study. Fifty percent of the samples in the first contained total lead concentrations greater than 600 ppm, the same percentage as in the current study. The second showed that 44 percent of the paints contained a total lead content above 90 ppm, compared to 70 percent in this study.

RECOMMENDATIONS

This study shows that lead paint is still widely available on the market in China irrespective of what method is used to assess the lead levels. To address the problem IPEN proposes the following:

For the government and relevant agencies:

- Review the procedures for ensuring compliance and enforcement of current national regulatory controls on lead in paint through a multi-stakeholders process involving representatives of relevant government agencies, the paint industry, civil society and other relevant sectors.
- Establish effective procedures for monitoring and enforcing full compliance with existing regulatory controls on the lead content of paints manufactured and/or sold in China.
- Consider possible revisions to existing regulatory controls on the lead content of paints to be based on the paint's total lead content instead of its soluble lead content and require manufacturers to include a dust lead hazard warning on the labels.

For the paint industry:

- Discontinue using lead-based pigments and lead-based drying catalysts as paint ingredients.
- Participate in an independent, third-party certification program which verifies that your paints do not contain added lead compounds.
- Provide information on product label indicating the lead content of the paint.

- Provide label warnings of possible lead dust hazards when old painted surfaces are disturbed.
- Seek assistance from paint industry associations, suppliers of raw materials and manufacturers of brands who eliminated lead from their paint to facilitate a cost-effective transition to lead-free paint production.

For individual, household and institutional consumers:

- Ask for unleaded paints and only purchase paint from businesses that sell unleaded paints.
- Be aware of lead paint and dust hazards, and precautions to take to minimize exposure.

For public health organizations:

- Support efforts to end the manufacture, sale and use of leaded paints.
- Support policy measures that will eliminate childhood lead exposure from all sources.
- Inform the public about childhood health and occupational health risks linked with lead paints and lead in dust.
- Promote efforts to make blood lead testing and analysis of dust lead levels in homes, schools and other places where children spend time available.
- Promote efforts to analyze dust samples in housing and day care centers to help assess the health risks from legacy use of leaded paints and from preparation of previously painted surfaces for re-painting.
- Encourage specifications of total lead levels below 90 ppm on purchase orders of paint consumers such as schools, day-care centers and housing property owners or managers.
- Support efforts to assess health risks from lead paint previously used in housing and other areas where children can be exposed.

For all stakeholders:

- Support efforts to end the manufacture, sale and use of leaded paints.
- Support policy measures that will eliminate childhood lead exposure from all sources.
- Join in efforts to inform the public about childhood health and occupational health risks linked with lead paints and lead in dust. Support efforts to analyze dust samples in housing and day care centers to help assess the current health hazards from leaded paints previously used.

- Support an independent, third-party certification and labeling program that will help consumer choose paint with no added lead.

1. BACKGROUND

1.1 HEALTH AND ECONOMIC IMPACTS OF LEAD EXPOSURE

Children are exposed to lead from paint when lead-containing paint on walls, windows, doors or other painted surfaces begins to chip or deteriorate, since this causes lead to be released to dust and soil. When a surface previously painted with lead paint is sanded or scraped in preparation for repainting, very large amounts of lead-contaminated dust is produced, which when spread can constitute a severe health hazard.[1]

Children playing indoors or outdoors get house dust or soil on their hands, and then ingest it through normal hand-to-mouth behavior. If the dust or the soil is contaminated with lead, the children will ingest lead. Hand-to-mouth behavior is especially prevalent in children aged six years and under, the age group most easily harmed by exposure to lead. A typical one- to six-year-old child ingests between 100 and 400 milligrams of house dust and soil each day.[2]

In some cases, children pick up paint chips and put them directly into their mouths. This can be especially harmful because the lead content of paint chips is typically much higher than what is found in dust and soils. When toys, household furniture, or other articles are painted with lead paint, children may directly ingest the lead-contaminated, dried paint when chewing on them. Nonetheless, the most common way that children ingest lead is through lead-contaminated dust and soil that gets onto their hands.[3]

While lead exposure is also harmful to adults, lead exposure harms children at much lower levels. In addition, children absorb up to five times as much of ingested lead than adults. Children with nutritional deficiencies absorb ingested lead at an even increased rate.[2]

The younger the child, the more harmful lead can be and the health effects are generally irreversible and can have a lifelong impact. The human fetus is the most vulnerable, and a pregnant woman can transfer lead that has accumulated in her body to her developing child.[4] Lead is also transferred through breast milk when lead is present in a nursing mother.[5]

Once lead enters a child's body through ingestion, inhalation, or across the placenta, it has the potential to damage a number of biological systems and pathways. The primary target is the central nervous system and the brain, but

Lead Paint Terminology

As used in this booklet:

- "Paint" includes varnishes, lacquers, stains, enamels, glazes, primers, or coatings used for any purpose. Paint is typically a mixture of resins, pigments, fillers, solvents, and other additives.
- "Lead paint" is paint to which one or more lead compounds have been added.
- "Lead pigments" are lead compounds used to give a paint product its color.
- "Lead anti-corrosive agents" are lead compounds used to protect a metal surface from rusting or other forms of corrosion.
- "Lead driers" are lead compounds used to make paint dry more quickly and evenly.
- "Decorative paint" refers to paints that are produced for use on inside or outside walls, and surfaces of homes, schools, commercial buildings, and similar structures. Decorative paints are frequently used on doors, gates, and windows, and to repaint household furniture such as cribs, playpens, tables, and chairs.
- "Solvent-based, enamel decorative paint" or "enamel decorative paint" refers to oil-based paints.
- "ppm" means parts per million total lead content by weight in a dried paint sample. All lead concentrations in the report are total lead levels, unless otherwise specified.

lead can also affect the blood system, the kidneys, and the skeleton.[6] Lead is also categorized as an endocrine-disrupting chemical (EDC).[7]

It is generally agreed that one key element in lead toxicity is its capacity to replace calcium in neurotransmitter systems, proteins, and bone structure, altering function and structure and thereby leading to severe health impacts. Lead is also known to affect and damage cell structure.[8]

According to the World Health Organization (WHO): "Lead has no essential role in the human body, and lead poisoning accounts for about 0.6 percent of the global burden of disease."[2] Evidence of reduced intelligence caused by childhood exposure to lead has led WHO to list "lead-caused mental retardation" as a recognized disease. WHO also lists it as one of the top ten diseases whose health burden among children is due to modifiable environmental factors.[9]

In recent years, medical researchers have been documenting significant health impacts in children from lower and lower levels of lead exposure.[2, 6] According to the factsheet on Lead Poisoning and Health from WHO: "There is no known level of lead exposure that is considered safe."[10]

When a young child is exposed to lead, the harm to her or his nervous system makes it more likely that the child will have difficulties in school and engage in impulsive and violent behavior.[11] Lead exposure in young children is also linked to increased rates of hyperactivity, inattentiveness, failure to graduate from high school, conduct disorder, juvenile delinquency, drug use, and incarceration.[2] Lead exposure impacts on children continue throughout life and have a long-term impact on a child's work performance, and—on average—are related to decreased economic success.

A recent study investigating the economic impact of childhood lead exposure on national economies in all low- and middle-income countries estimated a total cumulative cost burden of $977 billion international dollars* per year.[12] The study considered the neurodevelopmental effects on lead-exposed children, as measured by reduced IQ points, and it correlated lead exposure-related reductions in children's IQ scores to reductions in lifetime economic productivity, as expressed in lifelong earning power. The study identified many different sources of lead exposure in children, with lead paint as one major source. Broken down by region, the economic burden of childhood lead exposure as estimated by this study was:

Africa: $134.7 billion of economic loss, or 4.03 percent of Gross Domestic Product (GDP);

Latin America and the Caribbean: $142.3 billion of economic loss, or 2.04 percent of GDP; and

Asia: $699.9 billion of economic loss, or 1.88 percent of GDP.

Country estimates used in this study can be accessed at a publicly available website, **http://www.med.nyu.edu/pediatrics/research/environmentalpediatrics/leadexposure**, and shows that ***economic loss in China is economic loss in China is estimated at $227 billion, or 2 percent of Gross Domestic Product (GDP).***

* An International dollar is a currency unit used by economists and international organizations to compare the values of different currencies. It adjusts the value of the U.S. dollar to reflect currency exchange rates, purchasing power parity (PPP), and average commodity prices within each country. According to the World Bank, "An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States." The international dollar values in this report were calculated from a World Bank table that lists GDP per capita by country based on purchasing power parity and expressed in international dollars.

1.2 THE USE OF LEAD IN PAINT

Paints contain high levels of lead when the paint manufacturer intentionally adds one or more leaded compounds to the paint for some purpose. A paint product may also contain some amount of lead when paint ingredients contaminated with lead are used, or when there is cross-contamination from other product lines in the same factory. Leaded paint ingredients are most commonly intentionally used in solvent-based paint due to their chemical properties, and solvent-based enamel paints have been found to have high lead content in many countries.[13-15]

The leaded compounds most commonly added to paints are pigments. Pigments are used to give the paint its color, make the paint opaque (so it covers well), and protect the paint and the underlying surface from degradation caused by exposure to sunlight. Lead-based pigments are sometimes used alone, and sometimes used in combination with other pigments.

Leaded compounds may also be added to enamel paints for use as driers (sometimes called drying agents or drying catalysts). Leaded compounds are also sometimes added to paints used on metal surfaces to inhibit rust or corrosion. The most common of these is lead tetroxide, sometimes called red lead or minium.

Non-leaded pigments, driers, and anti-corrosive agents have been widely available for decades, and are used by manufacturers producing the highest quality paints. When a paint manufacturer does not intentionally add lead compounds in the formulation of its paints, and takes care to avoid the use of paint ingredients that are contaminated with lead, the lead content of the paint will be very low—less than 90 parts per million (ppm) total lead by dry weight, and frequently down to 10 ppm or less.

Most highly industrial countries adopted laws or regulations to control the lead content of decorative paints beginning in the 1970s and 1980s. Many also imposed controls on the lead content of paints used on toys and for other applications likely to contribute to lead exposure in children. These regulatory actions were taken based on scientific and medical findings that lead paint is a major source of lead exposure in children, and that lead exposure in children causes serious harm, especially to children aged six years and under.

1.3 INTERNATIONAL REGULATORY APPROACHES TO LEAD CONTENT OF PAINT

Lead content of newly produced paint is typically calculated as the weight fraction of lead in the dry paint expressed e.g. as parts per million (ppm), irrespective of which analytical method is used. It is however very important to know what method has been used to determine the lead concentration to be able to assess potential health hazards.

Lead content of paint is typically regulated either through prohibition on the use of lead-based paint raw materials or through a total maximum permissible lead concentration. The former is mainly used in the European Union (EU) whereas the second approach is common in other regions and countries, e.g. in the United States, Canada, Argentina, India, the Philippines and many others.[16] The most restrictive total lead limit in place today is 90 ppm, enacted e.g. in the United States, India, the Philippines and Nepal.

Both these types of regulatory controls are based on a precautionary approach, i.e. taking into account all lead in the paint that could potentially contribute to lead exposure. They also take the most common exposure scenario into account, where lead-containing paint starts to deteriorate and release lead into the surrounding environment leading to lead exposure in children (See section 1.1). There is also solid scientific evidence of the risk reduction provided by a total lead limit.[17]

The total lead content approach is straightforward and cost-efficient when it comes to compliance monitoring for government agencies and for paint manufacturers in their internal controls. Several internationally standardized high-throughput methods are available as well as at least one international laboratory proficiency testing program for analyzing total lead content of paint ensuring reliability of the data. Many accredited laboratories are available today to perform these analyses, which has led to competitive prices. Also, with the increasing sensitivity of x-ray fluorescence (XRF) techniques, utilization of High Definition XRF devices can become an effective compliance monitoring tool that after an initial high purchase cost becomes more cost effective than laboratory analyses.

Also, a total lead content approach with a 90 ppm limit enables paint manufacturers to sell their paint anywhere in the world, since it will meet all regulatory controls for lead in paint in place today.

1.4 PAINT MARKET AND REGULATORY FRAMEWORK IN CHINA

Regulatory limits on paint coatings for toys have been in place in China since 1986. Originally set to 250 ppm soluble lead content and 2,500 ppm total lead content, these are now adjusted to 90 ppm soluble lead and 600 ppm total lead.

Standards restricting the use of lead in paint for interior uses were introduced in China in 2001 and updated in 2008 and 2009. These standards include:

- GB 18582-2008. (2008) Indoor decorating and refurbishing materials - Limit of harmful substances of interior architectural coatings;
- GB 18581-2009. (2009) Indoor decorating and refurbishing materials - Limit of harmful substances of solvent based coatings for woodenware; and
- GB 24410-2009. (2009) Indoor decorating and refurbishing materials - Limit of harmful substances of water-based woodenware coatings.

These standards all specify a 90 ppm lead limit based on the migration of lead from the paint film, a so-called soluble lead limit. The concept of soluble lead content was first introduced in regulatory controls in the late 1980s when the Council of the European Communities issued its Directive on the Safety of Toys.[18] The method measures the amount of lead that can be extracted by a standard weak acid treatment to supposedly simulate the amount of lead that becomes bioavailable when e.g. a child sucks or swallows a toy that contains lead. The underlying assumption is that there is a certain daily intake of lead by children that can be considered safe, a so-called "tolerable daily intake." However, in response to the conclusion by the European Food Safety Agency (EFSA) that there is no threshold below which the exposure to lead has no critical health effects,[19] the permissible level in the current Toy Directive is in the process of being drastically reduced to 23 ppm soluble lead content for paint coatings on toys.

The People's Republic of China is the only country in the world today regulating lead content of paint for indoor use through a soluble lead content limit. This regulatory approach is problematic for both scientific and practical reasons:

1) It does not prevent exposure or provide health protection.

The most common route of lead exposure is through dust and soil from deteriorating paint. However, the soluble lead content approach assumes exposure through mouthing of objects with an intact paint coating and that there are safe levels of lead exposure. In addition, various factors affect the leach ability and bioavailability of lead from sources such as paint, dust and soil, making the analytical results very variable.[15] For example, leach ability of lead from

dried paint films was in a study shown to vary between four percent to 100 percent.[16] Also, the correlation between a total lead content limit and lower blood lead levels is clearly established through a wealth of scientific studies, but no such evidence exists for a soluble lead limit.

2) The soluble lead approach is more costly for government agencies.

Since the method measures how much lead leaches from a paint film over a certain time span, it is inherently more time consuming and has a much lower throughput. As such, it becomes more expensive for government agencies when monitoring compliance and no technical alternatives providing quantitative measurements such as XRF devices are available.

3) The soluble lead approach increase costs for paint manufacturers.

Since no other country regulates lead content of paint through its soluble lead content, it also imposes a trade barrier to export paint from, and import paint to China. The inability to accurately predict total lead content from soluble lead content adds an additional element of verification, since a paint manufacturer that wants to export paint will need to analyze its paints twice to show compliance both to the standard in China and that in countries to which the paint will be exported.

1.5 PAINT MARKET IN CHINA

China is one of the world's largest producer and consumer of coatings with nearly one-third of the global market,† and there may be as many 8,000 paint producers in China according to the industry magazine Coatings World.‡ The biggest players are global companies such as PPG, Akzo Nobel, Nippon Paint and Kansai Paint, but there is also a multitude of smaller manufacturers of regional and local importance. The water-based paint market is growing rapidly in China, partly due to a new four percent consumption tax on paint with a volatile organic compound (VOCs) content above 420 grams per liter that came into force in February 2015.§ The government has also listed water-based paint as a major supporting area for its "Made in China 2025" strategy.¶ The large global paint manufacturers are now primarily selling water-based paints in China and were therefore not included in this study. Still, solvent-based paint will

† http://www.prnewswire.com/news-releases/world-paint—coatings-market—demand-continues-to-boost-in-india-and-china-300322561.html
‡ http://www.coatingsworld.com/issues/2011-01/view_china-report/the-chinese-coatings-market-/
§ https://chemicalwatch.com/asiahub/23117/china-raises-tax-on-high-voc-paintschina/
¶ http://www.prnewswire.co.uk/news-releases/chinese-companies-prepare-for-a-blowout-in-waterborne-paint-market-610360385.html

continue to be a major component and the total output of the coatings production in 2020 is predicted to be 22 million tons, with so-called environmental friendly coatings constituting 57 percent.[**]

The demand for paint for newly constructed buildings has recently started to decrease with the slowing of the real estate market, but the demand for paint to repaint existing buildings and homes is increasing.[††]

** http://www.coatingsworld.com/issues/2016-10-01/view_china-report/china-coatings-market-enters-stable-growth-period/

†† http://www.coatingsworld.com/issues/2015-04-01/view_china-report/china-architectural-coatings-market-enters-a-new-era/

2. MATERIALS AND METHODS

From September to November 2014, 141 cans of decorative, enamel, solvent-based paint were purchased by Non-Governmental Organization Shenzhen Zero Waste from various stores in eight cities in China (Shenyang, Beijing, Nanchang, Zhengzhou, Guangzhou, Kunming, Xiamen and Shanghai). The paints represented 47 different brands produced by 36 named manufacturers and three manufacturers whose names were unclear.

One-hundred twenty-eight of the 141 paints sampled (91 percent of paints) were red, white and yellow. The four black, four blue and five green samples were collected from a total of six brands. The availability of all the paints in retail establishments suggested that they were intended to be used within home environments.

During the paint sample preparation, information such as color, brand, country where manufactured, and other details as provided on the label of the paint can was recorded. Generic paint colors were recorded, e.g., "yellow" instead of "sunflower." For all colored paints, the protocol called for obtaining "bright" or "strong" red and yellow paints when available.

Paint sampling preparation kits containing individually numbered, untreated wood pieces, single-use paintbrushes and stirring utensils made from untreated wood sticks were assembled and shipped to Shenzhen Zero Waste by the staff of the IPEN partner NGO, Arnika, in The Czech Republic.

Each can of paint was thoroughly stirred and was subsequently applied onto individually numbered triplicates of untreated wood pieces using different unused single-use paintbrushes by the staff of Shenzhen Zero Waste.

Each stirring utensil and paintbrush was used only once, and extra caution was taken to avoid cross contamination. All samples were then allowed to dry at room temperature for five to six days. After drying, one of the painted wood pieces were placed in individually labeled, resealable plastic bags and shipped to the lab of Certottica Scarl in Italy. The laboratory participated in the Environmental Lead Proficiency Analytical Testing (ELPAT) Program operated by the American Industrial Hygiene Association. In addition, earlier quality assurance using paint samples with known lead content have shown that the lab gives reliable analytical results. The samples were analyzed for total lead

content using method CPSC-CH-E1003-09.1: Standard Operating Procedure for Determining Lead (Pb) in Paint and Other Similar Surface Coatings.

One set of duplicates were sent to Intertek Testing Services Shenzhen Ltd in Shenzhen, China. These were analyzed for soluble lead content as detailed in the Chinese Standard GB 18582-2008: Indoor Decorating and Refurbishing Materials – Limit of Harmful Substances of Interior Architectural Coatings on soluble heavy metal content. This standard follows the international ISO 8124-3:2010 Safety of toys — Part 3: Migration of certain elements.

Figure 1. Preparation of paint samples for testing.

3. RESULTS

From September to November 2014, a total of 141 cans of solvent-based, enamel decorative paints were purchased in eight cities in China and analyzed for their total lead content and their soluble lead content. The details of the paints are provided in Appendix A, Table A1. Results are given in parts per million (ppm) total lead, based on dry weight of the paint. Please see Appendix Table A2 for detailed results of the analysis.

Of the 141 paints, 99 (70 percent of paints) contained a total lead content above 90 parts per million (ppm, dry weight of the paint) (Table A4, Appendix A) and would not be allowed for sale in e.g., India, Nepal, the Philippines or the United States of America.

The soluble lead content analysis showed that 52 of the 141 paints (37 percent of paints) contained a soluble lead content above 90 ppm (dry weight of the paint), ranging from 100 ppm up to 4,630 ppm. This means that almost half of the 141 paints analyzed for this study would not be allowed for sale in China. More importantly, the majority (87 percent) of these 52 paints contained a total lead concentration above 10,000 ppm, i.e., more than 1 percent of the dry weight of the paint consisted of lead, constituting a severe health hazard.

Of the 89 paints with a soluble lead content below 90 ppm, 47 paints contained total lead levels above 90 ppm. Most alarming are two paints (both yellow) with non-detectable soluble lead content but with total lead content of 10,700 ppm and 13,500 ppm, and another paint (yellow) with a soluble lead content of 41 ppm that contained a total lead content of 17,400 ppm.

Of all 141 paints analyzed, 48 paints (34 percent of paints) contained dangerously high total lead levels above 10,000 ppm and would not be allowed for sale in any country restricting the use of lead in decorative paint. The highest total lead level detected was in a yellow paint that contained 116,000 ppm. The next highest total lead concentration, 102,000 ppm, was found in a green paint.

Seventy of 71 paints with total lead concentration less than 600 ppm contained soluble lead concentrations of less than 90 ppm. However, it was not possible to even approximately predict total lead levels of the paints based on their soluble lead content, since total lead levels in the 89 paints with soluble lead levels below 90 ppm ranged from below 4 ppm up to 17,400 ppm.

3.1 BRANDS

The distribution of the total lead concentration by brand is presented in Table A3 (Appendix A).

Of the 47 brands included in the study, all paints from nine of the brands and at least one or more paint from 46 of the brands contained a soluble lead content less than 90 ppm. This clearly shows that the technology exists in China to produce paint within the current regulatory limit.

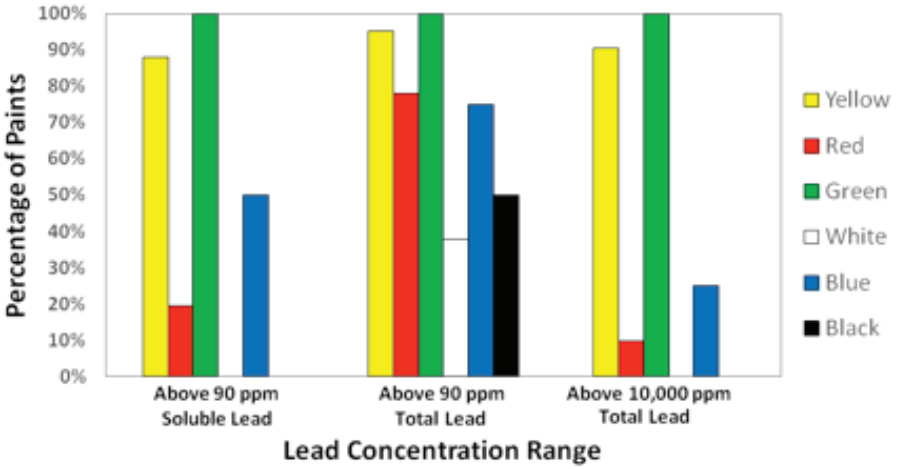
In addition, all paints included from four of the brands and at least one or more paint from 28 of the brands contained a total lead content less than 90 ppm. This shows that it is technologically feasible to follow a 90 ppm total lead limit for paints in the People's Republic of China.

On the other hand, one or more paint from 39 of the brands (83 percent of brands) contained lead at dangerously high levels above 10,000 ppm total lead. It is therefore apparent that the vast majority of the brands that were sampled are producing paints with dangerously high lead content.

3.2 COLORS

More than 90 percent of the paints sampled were white, yellow and red. Results for all colors are included in Table A4 (Appendix A), and the result distribution in Figure 2.

Figure 2. Distribution of Lead Concentrations in Solvent-Based Paints by Color.



Yellow and green paints contained the highest amount of lead irrespective of the analytical method used. Of the 141 paints included in the study, 45 were white and 96 colored. A majority of the colored paints were red (41 paints) and yellow (42 paints). Almost all yellow paints (88 percent) exceeded the 90 ppm soluble lead limit and 95 percent had a total lead content of above 10,000 ppm. All five green paints contained a soluble lead content above 90 ppm, as well as a total lead content above 10,000 ppm. A fifth of the red paints contained a soluble lead content above 90 ppm, and 10 percent of the red paints contained a total lead content above 10,000 ppm.

White paints generally contained the least amount of lead. No white paints contained a soluble lead content above 90 ppm or above 10,000 ppm total lead content. Seventeen (38 percent) of the white paints contained total lead content above 90 ppm.

The average lead content per color showed the same trends, where green and yellow paints had total lead content averages of 54,100 ppm and 43,800 ppm and soluble lead content averages of 1,530 and 1,390 ppm, respectively.

3.3 COMPARISON WITH EARLIER STUDIES

One earlier study conducted in 2009 has analyzed both total and soluble lead content of new paints in China.[20] It showed (Table A5, Appendix A) that out of 58 paints analyzed by Lin et al., 32 paints (55 percent of paints) contained a soluble lead content above 90 ppm as compared to 52 paints (37 percent) in this study. Also, in the Lin et al study 14 paints (24 percent of paints) contained a total lead content above 5,000 ppm that can be compared to the 50 paints (36 percent of paints) that contained a lead content above 5,000 ppm in the current study and 16 paints (25 percent of paints) in the Clark et al study. Although these three studies show slightly different percentages, they are still within the same range for percent of samples containing more than 5,000 ppm total lead (24 to 36 percent).

The Clark et al study conducted in 2009 also assessed the total lead content of new paints in China.[15] Out of the 64 paints, 28 paints (44 percent of paints) contained a total lead content above 90 ppm, compared to 99 paints (70 percent of paints) in the current study.

Information was not available on the brands sampled in the Lin et al study. Most of the paints in the current study were from brands not included in the Clark et al study, mainly because of changes in availability. However, three brands were included in both the current and Clark et al study (Table A6, Appendix A). For one of these three brands, there was a major decrease in the

concentration of lead in yellow paint, from 207,000 ppm to 910 ppm. For another brand, concentrations in white and red paints were relatively low in both studies, ranging from 42 ppm to 122 ppm, but the concentration of lead in the yellow paint was very high (131,000 ppm) in 2009 and still very high (66,000 ppm) in the current study. The limited data available were not adequate for the development of changes of overall lead content over time for most of the brands to be made.

3.4 SOLUBLE VERSUS TOTAL LEAD CONTENT

Only one other study, conducted by Lin et al, is publicly available that has performed analysis of total and soluble lead on the same samples and that could be used to assess possible relationships between soluble and total lead content of paint.[20] Lin's study showed that 23 of 26 paints with a soluble lead content below 90 ppm had a high likelihood to also have a total lead content below 600 ppm. However, this does not include a comparison between total and soluble lead content of specific paints, but is based on the overall percentage of paints with lead content above and below 90 ppm soluble and 600 ppm total lead content.

In this study, a similar conclusion could have been drawn since 50 percent of the paints contained a total lead content above 600 ppm and 37 percent contained a soluble lead content above 90 ppm. However, looking at the results for the individual paints (see Table A2, Appendix A), there is clearly no such correlation. The worst cases are shown in Table A7, Appendix A.

4. CONCLUSIONS AND RECOMMENDATIONS

Despite standards controlling the lead content of paint for interior and exterior use, this study shows that paint with very high levels of lead are still easily available on the market in China. However, it also shows that it is feasible to produce both white and brightly colored paint with no added lead in China, since paints from several of the brands contained only low levels of lead. Due to lack of appropriate labeling, consumers have no way of distinguishing between paints with high and low lead content. The lead concentration found in studies prior to the current one are similar to the recent data indicating that lead concentrations have exceeded the regulatory limit for a number of years.

Also, this study shows that a soluble lead limit can lead to a false sense of safety, since several paints with a low soluble lead content had a very high total lead content. Almost twice as many paints did not comply with a 90 ppm total lead limit than complied with a soluble limit of 90 ppm.

It is clear that compliance to the current regulation needs improved enforcement. In addition, the use of soluble lead content limits cause uncertainty about the risk reduction of the current regulation, as well as imposes additional trade barriers for paint export.

RECOMMENDATIONS

For the government and relevant agencies:

- Review the procedures for ensuring compliance and enforcement of current national regulatory controls on lead in paint through a multi-stakeholders process involving representatives of relevant government agencies, the paint industry, civil society and other relevant sectors.
- Establish effective procedures for monitoring and enforcing full compliance with existing regulatory controls on the lead content of paints manufactured and/or sold in China.
- Consider possible revisions to existing regulatory controls on the lead content of paints to be based on the paint's total lead content instead of

its soluble lead content and to include a dust lead hazard warning on the labels.

For the paint industry:

- Discontinue using lead-based pigments and lead-based drying catalysts as paint ingredients.
- Participate in an independent third-party certification program which verifies that your paints do not contain added lead compounds.
- Provide information on product label indicating the lead content of the paint.
- Provide label warnings of possible lead dust hazards when old painted surfaces are disturbed.
- Seek assistance from paint industry associations, suppliers of raw materials and manufacturers of brands who eliminated lead from their paint to facilitate a cost-effective transition to lead-free paint production

For individual, household and institutional consumers:

- Ask for unleaded paints and only purchase paint from businesses that sell unleaded paints.
- Be aware of lead paint and dust hazards, and precautions to take to minimize exposure.

For public health organizations:

- Support efforts to end the manufacture, sale and use of leaded paints.
- Support policy measures that will eliminate childhood lead exposure from all sources.
- Inform the public about childhood health and occupational health risks linked with lead paints and lead in dust.
- Promote efforts to make blood lead testing and analysis of dust lead levels in homes, schools and other places where children spend time available.
- Encourage specifications of "lead safe paints" on purchase orders of paint consumers such as schools, day-care centers and housing property owners or managers.
- Support efforts to assess health risks from lead paint previously used in housing and other areas where children can be exposed.

For all stakeholders:

- Support efforts to end the manufacture, sale and use of leaded paints.
- Support policy measures that will eliminate childhood lead exposure from all sources.
- Join in efforts to inform the public about childhood health and occupational health risks linked with lead paints and lead in dust. Support efforts to analyze dust samples in housing and day care centers to help assess the current health hazards from leaded paints previously used.
- Support an independent, third-party certification and labeling program that will help consumer choose paint with no added lead.

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APPENDIX

TABLE A1. SOLVENT-BASED ENAMEL DECORATIVE PAINTS INCLUDED IN THE STUDY.

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-100	JINGSHILIANXING	Beijing Xihongmen Honglian Coatings Factory	white	10/31/14	No
CHN-101	JINGSHILIANXING	Beijing Xihongmen Honglian Coatings Factory	yellow	10/31/14	No
CHN-102	JINGSHILIANXING	Beijing Xihongmen Honglian Coatings Factory	red	10/31/14	No
CHN-103	SHIJILIANSHI	Beijing Hongshi Paint Co., Ltd.	white	10/31/14	No
CHN-104	Forbidden City	Beijing Forbidden City Paint Co., Ltd.	yellow	10/31/14	No
CHN-105	Forbidden City	Beijing Forbidden City Paint Co., Ltd.	white	10/31/14	No
CHN-106	HONGSHI	Beijing Hongshi Paint Co., Ltd.	white	10/31/14	No
CHN-107	HONGSHI	Beijing Hongshi Paint Co., Ltd.	red	10/31/14	No
CHN-108	HONGSHI	Beijing Hongshi Paint Co., Ltd.	yellow	10/31/14	No
CHN-109	ZHENDI	Beijing Zhuangdazhendi Trade Co., Ltd.	red	10/31/14	Yes
CHN-110	ZHENDI	Beijing Zhuangdazhendi Trade Co., Ltd.	yellow	10/31/14	No
CHN-111	ZHENDI	Beijing Zhuangdazhendi Trade Co., Ltd.	white	10/31/14	No
CHN-112	QCH	Beijing Shenglongbofa	yellow	10/31/14	No
CHN-113	QCH	Beijing Shenglongbofa	red	10/31/14	No
CHN-114	QCH	Beijing Shenglongbofa	white	10/31/14	No
CHN-115	Monarch	Da Tsing Ma Group HK	yellow	10/31/14	No
CHN-116	Monarch	Da Tsing Ma Group HK	red	10/31/14	No
CHN-117	Monarch	Da Tsing Ma Group HK	white	10/31/14	No
CHN-118	Beacon	Tianjin Beacon Paint & Coatings Co., Ltd.	red	10/03/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-119	Beacon	Tianjin Beacon Paint & Coatings Co., Ltd.	white	10/03/14	No
CHN-120	Beacon	Tianjin Beacon Paint & Coatings Co., Ltd.	yellow	10/03/14	No
CHN-121	Jinliang	(Unknown)	yellow	10/03/14	No
CHN-122	Jinliang	(Unknown)	white	10/22/14	No
CHN-123	Jinliang	(Unknown)	red	10/03/14	No
CHN-124	DIAOWANG	Tianjin Hongguangweiye Coatings Co., Ltd.	white	10/03/14	No
CHN-125	DIAOWANG	Tianjin Hongguangweiye Coatings Co., Ltd.	yellow	10/03/14	No
CHN-126	DIAOWANG	Tianjin Hongguangweiye Coatings Co., Ltd.	red	10/03/14	No
CHN-127	Yanta	Baoding Jinxiang Paint Co., Ltd.	yellow	10/03/14	No
CHN-128	Yanta	Baoding Jinxiang Paint Co., Ltd.	white	10/03/14	No
CHN-129	Yanta	Baoding Jinxiang Paint Co., Ltd.	red	10/03/14	No
CHN-131	Jinbao	Shenyang Nanyang Chemical Factory	white	10/03/14	No
CHN-132	Jinbao	Shenyang Nanyang Chemical Factory	yellow	10/03/14	No
CHN-133	Jinbao	Shenyang Nanyang Chemical Factory	red	10/03/14	No
CHN-134	JFM	Shenyang Jinfeima Paint Co., Ltd.	white	10/22/14	No
CHN-135	JFM	Shenyang Jinfeima Paint Co., Ltd.	red	10/03/14	No
CHN-136	JFM	Shenyang Jinfeima Paint Co., Ltd.	yellow	10/03/14	No
CHN-137	Zhen Bao	Foshan Nanhai East New Chemical Co., Ltd.	yellow	10/23/14	No
CHN-138	Zhen Bao	Foshan Nanhai East New Chemical Co., Ltd.	white	10/23/14	No
CHN-139	Zhen Bao	Foshan Nanhai East New Chemical Co., Ltd.	red	10/23/14	No
CHN-140	XYANG	(Invisible)	yellow	10/23/14	No
CHN-141	XYANG	(Invisible)	red	10/23/14	No
CHN-142	XYANG	(Invisible)	white	10/23/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-143	SHUANG TA	Zhengzhou Shangta Coating Co., Ltd.	white	10/23/14	No
CHN-144	Huaxiang	Changsha Huaxiang Paint Co., Ltd.	red	10/23/14	No
CHN-145	Huaxiang	Changsha Huaxiang Paint Co., Ltd.	white	10/23/14	No
CHN-146	Shanbao	(Unknown)	yellow	10/23/14	No
CHN-147	Shanbao	(Unknown)	red	10/23/14	No
CHN-148	Shanbao	(Unknown)	white	10/23/14	No
CHN-149	HaiXing	Huai'an Paint Factory Co., Ltd.	yellow	10/21/14	No
CHN-150	HaiXing	Huai'an Paint Factory Co., Ltd.	white	10/21/14	No
CHN-151	HaiXing	Huai'an Paint Factory Co., Ltd.	red	10/21/14	No
CHN-152	Wuyu	Suzhou Jiren Coatings Co., Ltd.	yellow	10/21/14	No
CHN-153	Tongrun	Changsha Yili Coating Technology Co., Ltd.	red	10/21/14	No
CHN-154	Tongrun	Changsha Yili Coating Technology Co., Ltd.	white	10/21/14	No
CHN-155	Bamboo	Guangzhou Pearl Chemical Industry Group, Ltd.	red	10/21/14	No
CHN-156	Bamboo	Guangzhou Pearl Chemical Industry Group, Ltd.	white	10/21/14	No
CHN-157	Bamboo	Guangzhou Pearl Chemical Industry Group, Ltd.	yellow	10/21/14	No
CHN-158	JI REN	Suzhou Jiren Coatings Co., Ltd.	red	10/21/14	No
CHN-159	JI REN	Suzhou Jiren Coatings Co., Ltd.	white	10/21/14	No
CHN-160	JI REN	Suzhou Jiren Coatings Co., Ltd.	yellow	10/21/14	No
CHN-161	XIANGHONG	Changsha Huatai Coatings Co., Ltd.	white	10/21/14	No
CHN-162	XIANGHONG	Changsha Huatai Coatings Co., Ltd.	yellow	10/21/14	No
CHN-163	XIANGHONG	Changsha Huatai Coatings Co., Ltd.	red	10/21/14	No
CHN-164	JIATE	Changsha Yili Coating Technology Co., Ltd.	white	10/21/14	No
CHN-165	JINXING	Foshan Gaoming Huatushi Coatings Co., Ltd.	white	10/21/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-166	JINXING	Foshan Gaoming Huatushi Coatings Co., Ltd.	yellow	10/21/14	No
CHN-167	JINXING	Foshan Gaoming Huatushi Coatings Co., Ltd.	red	10/21/14	No
CHN-168	Duodeli	Foshan Nanhai East New Chemical Co., Ltd.	red	10/21/14	No
CHN-169	Duodeli	Foshan Nanhai East New Chemical Co., Ltd.	yellow	10/21/14	No
CHN-170	Duodeli	Foshan Nanhai East New Chemical Co., Ltd.	white	10/21/14	No
CHN-171	HTS	Foshan Gaoming Huatushi Coatings Co., Ltd.	red	10/21/14	No
CHN-172	HTS	Foshan Gaoming Huatushi Coatings Co., Ltd.	yellow	10/21/14	No
CHN-173	HTS	Foshan Gaoming Huatushi Coatings Co., Ltd.	white	10/21/14	No
CHN-174	Wuyang	Guangzhou Wuyang Paints Co., Ltd.	yellow	10/21/14	No
CHN-175	Wuyang	Guangzhou Wuyang Paints Co., Ltd.	white	10/21/14	No
CHN-176	Wuyang	Guangzhou Wuyang Paints Co., Ltd.	red	10/21/14	No
CHN-177	ERXING	Foshan Xiqiao Xinsheng Chemical Co., Ltd.	yellow	10/21/14	No
CHN-178	ERXING	Foshan Xiqiao Xinsheng Chemical Co., Ltd.	red	10/21/14	No
CHN-179	ERXING	Foshan Xiqiao Xinsheng Chemical Co., Ltd.	white	10/21/14	No
CHN-180	Sanyuan	Guangzhou Hong Mian Chang Jiang Coatings Co., Ltd.	red	10/21/14	No
CHN-181	Sanyuan	Guangzhou Hong Mian Chang Jiang Coatings Co., Ltd.	yellow	10/21/14	No
CHN-182	Sanyuan	Guangzhou Hong Mian Chang Jiang Coatings Co., Ltd.	white	10/21/14	No
CHN-183	QSP	Dongxing Chemical Industry Co., Ltd.	yellow	10/21/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-184	QSP	Dongxing Chemical Industry Co., Ltd.	white	10/21/14	No
CHN-185	QSP	Dongxing Chemical Industry Co., Ltd.	red	10/21/14	No
CHN-186	GANG WEI SHI	Foshan Xiqiao Dasheng Chemical Co., Ltd.	red	10/21/14	No
CHN-187	GANG WEI SHI	Foshan Xiqiao Dasheng Chemical Co., Ltd.	yellow	10/21/14	No
CHN-188	GANG WEI SHI	Foshan Xiqiao Dasheng Chemical Co., Ltd.	white	10/21/14	No
CHN-189	JIALILAI	JIALILAI Chemicals Factory	white	10/21/14	No
CHN-190	JIALILAI	JIALILAI Chemicals Factory	yellow	10/21/14	No
CHN-191	JIALILAI	JIALILAI Chemicals Factory	red	10/21/14	No
CHN-192	YECAI	Foshan Nanhai Xinghe Chemical Industry Co., Ltd.	yellow	10/21/14	No
CHN-193	YECAI	Foshan Nanhai Xinghe Chemical Industry Co., Ltd.	white	10/21/14	No
CHN-194	YECAI	Foshan Nanhai Xinghe Chemical Industry Co., Ltd.	red	10/21/14	No
CHN-195	JINXIANGSHAN	Foshan Nanhai Xinghe Chemical Industry Co., Ltd.	yellow	10/21/14	No
CHN-196	JINXIANGSHAN	Foshan Nanhai Xinghe Chemical Industry Co., Ltd.	red	10/21/14	No
CHN-197	JINXIANGSHAN	Foshan Nanhai Xinghe Chemical Industry Co., Ltd.	white	10/21/14	No
CHN-198	Apple Paint	Foshan Nanhai Huaren Chemical Industry Co., Ltd.	red	10/21/14	No
CHN-199	Apple Paint	Foshan Nanhai Huaren Chemical Industry Co., Ltd.	yellow	10/21/14	No
CHN-200	LONGJIANG	Fujian Tenglong Industry Company	white	10/30/14	No
CHN-201	LONGJIANG	Fujian Tenglong Industry Company	red	10/30/14	No
CHN-202	LONGJIANG	Fujian Tenglong Industry Company	yellow	10/30/14	No
CHN-203	QUANXIN	Hunan Xintian Chemical Coatings Co., Ltd.	red	10/30/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-204	QUANXIN	Hunan Xintian Chemical Coatings Co., Ltd.	white	10/30/14	No
CHN-205	QUANXIN	Hunan Xintian Chemical Coatings Co., Ltd.	yellow	10/30/14	No
CHN-206	Shiny	Shantou Dazhong Shiny Paints Co., Ltd.	red	10/22/14	No
CHN-207	Shiny	Shantou Dazhong Shiny Paints Co., Ltd.	yellow	10/22/14	No
CHN-208	Shiny	Shantou Dazhong Shiny Paints Co., Ltd.	white	10/22/14	No
CHN-209	Guxiang	Hunan Xintian Chemical Coatings Co., Ltd.	white	10/22/14	No
CHN-210	Guxiang	Hunan Xintian Chemical Coatings Co., Ltd.	yellow	10/22/14	No
CHN-211	Katefu	Foshan Nanhai East New Chemical Co., Ltd.	green	09/22/14	No
CHN-212	Katefu	Foshan Nanhai East New Chemical Co., Ltd.	black	09/22/14	No
CHN-213	Katefu	Foshan Nanhai East New Chemical Co., Ltd.	white	09/22/14	No
CHN-214	Katefu	Foshan Nanhai East New Chemical Co., Ltd.	red	09/22/14	No
CHN-215	Katefu	Foshan Nanhai East New Chemical Co., Ltd.	yellow	09/22/14	No
CHN-216	Katefu	Foshan Nanhai East New Chemical Co., Ltd.	blue	09/22/14	No
CHN-217	Bullhead Shark	Foshan Nanhai Huasheng Chemical Co., Ltd.	blue	09/22/14	No
CHN-218	Bullhead Shark	Foshan Nanhai Huasheng Chemical Co., Ltd.	yellow	09/22/14	No
CHN-219	Bullhead Shark	Foshan Nanhai Huasheng Chemical Co., Ltd.	white	09/22/14	No
CHN-220	Bullhead Shark	Foshan Nanhai Huasheng Chemical Co., Ltd.	green	09/22/14	No
CHN-221	Bullhead Shark	Foshan Nanhai Huasheng Chemical Co., Ltd.	black	09/22/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-222	Bullhead Shark	Foshan Nanhai Huasheng Chemical Co., Ltd.	red	09/22/14	No
CHN-223	Huaren	Huaren Chemical Co., Ltd.	green	09/22/14	No
CHN-224	Huaren	Huaren Chemical Co., Ltd.	white	09/22/14	No
CHN-225	Huaren	Huaren Chemical Co., Ltd.	blue	09/22/14	No
CHN-226	Huaren	Huaren Chemical Co., Ltd.	yellow	09/22/14	No
CHN-227	Huaren	Huaren Chemical Co., Ltd.	red	09/22/14	No
CHN-228	Huaren	Huaren Chemical Co., Ltd.	black	09/22/14	No
CHN-229	Pan Zhi Hua	Panzhihua Rongxin Paint Co., Ltd. China	yellow	09/22/14	No
CHN-230	Pan Zhi Hua	Panzhihua Rongxin Paint Co., Ltd. China	white	09/22/14	No
CHN-231	Pan Zhi Hua	Panzhihua Rongxin Paint Co., Ltd. China	black	09/22/14	No
CHN-232	Pan Zhi Hua	Panzhihua Rongxin Paint Co., Ltd. China	blue	09/22/14	No
CHN-233	Pan Zhi Hua	Panzhihua Rongxin Paint Co., Ltd. China	red	09/22/14	No
CHN-234	Caiyanpai	Foshan Nanhai Xiqiao Qiaopai Chemical Co., Ltd.	white	09/22/14	No
CHN-235	Caiyanpai	Foshan Nanhai Xiqiao Qiaopai Chemical Co., Ltd.	red	09/22/14	No
CHN-236	Caiyanpai	Foshan Nanhai Xiqiao Qiaopai Chemical Co., Ltd.	yellow	09/22/14	No
CHN-237	Caiyanpai	Foshan Nanhai Xiqiao Qiaopai Chemical Co., Ltd.	green	09/22/14	No
CHN-238	Zhonghua	Kunming Zhonghua Coatings Co., Ltd.	white	09/22/14	No
CHN-239	Zhonghua	Kunming Zhonghua Coatings Co., Ltd.	yellow	09/22/14	No

Sample No.	Brand	Manufacturer	Color	Date of Purchase (m/d/y)	Is there website on label?
CHN-240	Zhonghua	Kunming Zhonghua Coatings Co., Ltd.	green	09/22/14	No
CHN-241	Zhonghua	Kunming Zhonghua Coatings Co., Ltd.	red	09/22/14	No

TABLE A2. RESULTS OF LABORATORY ANALYSIS OF SOLVENT-BASED ENAMEL DECORATIVE PAINTS.

Sample No.	Brand	Color	Total Lead Concentration, Dry Weight (ppm)	Soluble Lead Concentration, Dry Weight (ppm)	Country of Brand Headquarters	Country of Manufacture	Is there information on can about lead content of paint?
CHN-100	JINGSHILIANXING	white	4	ND	China	China	No
CHN-101	JINGSHILIANXING	yellow	69,000	1,980	China	China	No
CHN-102	JINGSHILIANXING	red	100	6	China	China	No
CHN-103	SHIJILIANSHI	white	6	ND	China	China	No
CHN-104	Forbidden City	yellow	116,000	4,210	China	China	No
CHN-105	Forbidden City	white	36	ND	China	China	No
CHN-106	HONGSHI	white	7	13	China	China	No
CHN-107	HONGSHI	red	39	ND	China	China	No
CHN-108	HONGSHI	yellow	113,000	2,170	China	China	No
CHN-109	ZHENDI	red	900	ND	China	China	No
CHN-110	ZHENDI	yellow	78,000	1,710	China	China	No
CHN-111	ZHENDI	white	98	ND	China	China	Yes
CHN-112	QCH	yellow	45,000	1,370	China	China	No
CHN-113	QCH	red	360	25	China	China	No
CHN-114	QCH	white	280	ND	China	China	no
CHN-115	Monarch	yellow	113,000	1,910	China	China	no
CHN-116	Monarch	red	92,000	4,190	China	China	no
CHN-117	Monarch	white	240	46	China	China	no
CHN-118	Beacon	red	122	9	China	China	no
CHN-119	Beacon	white	81	13	China	China	no
CHN-120	Beacon	yellow	66,000	3,260	China	China	no
CHN-121	Jinliang	yellow	10,700	ND	China	China	no
CHN-122	Jinliang	white	39	ND	China	China	no
CHN-123	Jinliang	red	87	ND	China	China	no
CHN-124	DIAOWANG	white	310	7	China	China	no

Sample No.	Brand	Color	Total Lead Concentration, Dry Weight (ppm)	Soluble Lead Concentration, Dry Weight (ppm)	Country of Brand Headquarters	Country of Manufacture	Is there information on can about lead content of paint?
CHN-125	DIAOWANG	yellow	12,200	615	China	China	no
CHN-126	DIAOWANG	red	370	ND	China	China	no
CHN-127	Yanta	yellow	28,000	587	China	China	no
CHN-128	Yanta	white	98	ND	China	China	no
CHN-129	Yanta	red	680	67	China	China	no
CHN-131	Jinbao	white	62	ND	China	China	no
CHN-132	Jinbao	yellow	29,000	2,180	China	China	no
CHN-133	Jinbao	red	198	126	China	China	no
CHN-134	JFM	white	< 4	ND	China	China	no
CHN-135	JFM	red	52	ND	China	China	no
CHN-136	JFM	yellow	78,000	2,770	China	China	no
CHN-137	Zhen Bao	yellow	43,000	1,780	China	China	no
CHN-138	Zhen Bao	white	280	ND	China	China	no
CHN-139	Zhen Bao	red	147	7	China	China	no
CHN-140	XYANG	yellow	41,000	573	China	China	no
CHN-141	XYANG	red	192	41	China	China	no
CHN-142	XYANG	white	250	ND	China	China	no
CHN-143	SHUANG TA	white	76	ND	China	China	no
CHN-144	Huaxiang	red	3,000	181	China	China	no
CHN-145	Huaxiang	white	91	ND	China	China	no
CHN-146	Shanbao	yellow	31,000	153	China	China	no
CHN-147	Shanbao	red	3,400	8	China	China	no
CHN-148	Shanbao	white	< 4	7	China	China	no
CHN-149	HaiXing	yellow	50,000	1,530	China	China	no
CHN-150	HaiXing	white	350	32	China	China	no
CHN-151	HaiXing	red	11,700	564	China	China	no
CHN-152	Wuyu	Yellow	15,100	2,000	China	China	no

Sample No.	Brand	Color	Total Lead Concentration, Dry Weight (ppm)	Soluble Lead Concentration, Dry Weight (ppm)	Country of Brand Headquarters	Country of Manufacture	Is there information on can about lead content of paint?
CHN-153	Tongrun	Red	630	12	China	China	no
CHN-154	Tongrun	White	< 4	14	China	China	no
CHN-155	Bamboo	Red	28	6	China	China	no
CHN-156	Bamboo	White	51	ND	China	China	no
CHN-157	Bamboo	Yellow	11	58	China	China	no
CHN-158	JI REN	Red	1,580	200	China	China	no
CHN-159	JI REN	White	640	20	China	China	no
CHN-160	JI REN	Yellow	50,000	1,780	China	China	no
CHN-161	XIANGHONG	White	< 3	ND	China	China	no
CHN-162	XIANGHONG	Yellow	38,000	1,460	China	China	no
CHN-163	XIANGHONG	Red	660	41	China	China	no
CHN-164	JIATE	White	24	ND	China	China	no
CHN-165	JINXING	White	5	ND	China	China	no
CHN-166	JINXING	Yellow	11,500	180	China	China	no
CHN-167	JINXING	Red	70	ND	China	China	no
CHN-168	Duodeli	Red	48	11	China	China	no
CHN-169	Duodeli	Yellow	13,500	ND	China	China	no
CHN-170	Duodeli	White	35	ND	China	China	no
CHN-171	HTS	Red	15	16	China	China	no
CHN-172	HTS	Yellow	10,600	213	China	China	no
CHN-173	HTS	White	11	ND	China	China	no
CHN-174	Wuyang	Yellow	64,000	2,090	China	China	no
CHN-175	Wuyang	White	1,030	22	China	China	no
CHN-176	Wuyang	Red	108	ND	China	China	no
CHN-177	ERXING	Yellow	11,400	186	China	China	no
CHN-178	ERXING	Red	270	10	China	China	no
CHN-179	ERXING	White	13	ND	China	China	no

Sample No.	Brand	Color	Total Lead Concentration, Dry Weight (ppm)	Soluble Lead Concentration, Dry Weight (ppm)	Country of Brand Headquarters	Country of Manufacture	Is there information on can about lead content of paint?
CHN-180	Sanyuan	Red	100	10	China	China	no
CHN-181	Sanyuan	Yellow	53,000	2,040	China	China	no
CHN-182	Sanyuan	White	330	ND	China	China	no
CHN-183	QSP	Yellow	50,000	1,150	China	China	no
CHN-184	QSP	White	31	ND	China	China	no
CHN-185	QSP	Red	38	ND	China	China	no
CHN-186	GANG WEI SHI	Red	510	18	China	China	no
CHN-187	GANG WEI SHI	Yellow	24,000	255	China	China	no
CHN-188	GANG WEI SHI	White	32	ND	China	China	no
CHN-189	JIALILAI	White	62	ND	China	China	no
CHN-190	JIALILAI	Yellow	12,800	2,280	China	China	no
CHN-191	JIALILAI	Red	178	ND	China	China	no
CHN-192	YECAI	Yellow	17,400	41	China	China	no
CHN-193	YECAI	White	28	ND	China	China	no
CHN-194	YECAI	Red	36	ND	China	China	no
CHN-195	JINXIANGSHAN	Yellow	17,700	148	China	China	no
CHN-196	JINXIANGSHAN	Red	145	ND	China	China	no
CHN-197	JINXIANGSHAN	White	< 3	ND	China	China	no
CHN-198	Apple Paint	Red	2,100	49	China	China	no
CHN-199	Apple Paint	Yellow	37,000	445	China	China	no
CHN-200	LONGJIANG	White	220	ND	China	China	no
CHN-201	LONGJIANG	Red	31,000	2,300	China	China	no
CHN-202	LONGJIANG	Yellow	104,000	2,810	China	China	no
CHN-203	QUANXIN	Red	310	ND	China	China	no
CHN-204	QUANXIN	White	1,440	66	China	China	no
CHN-205	QUANXIN	Yellow	42,000	480	China	China	no
CHN-206	Shiny	Red	189	ND	China	China	no

Sample No.	Brand	Color	Total Lead Concentration, Dry Weight (ppm)	Soluble Lead Concentration, Dry Weight (ppm)	Country of Brand Headquarters	Country of Manufacture	Is there information on can about lead content of paint?
CHN-207	Shiny	Yellow	60	ND	China	China	no
CHN-208	Shiny	White	19	ND	China	China	no
CHN-209	Guxiang	White	25	ND	China	China	no
CHN-210	Guxiang	Yellow	910	1,300	China	China	no
CHN-211	Katefu	Green	102,000	394	China	China	no
CHN-212	Katefu	Black	77	ND	China	China	no
CHN-213	Katefu	White	19	ND	China	China	no
CHN-214	Katefu	Red	200	21	China	China	no
CHN-215	Katefu	Yellow	29,000	1,830	China	China	no
CHN-216	Katefu	Blue	1,000	111	China	China	no
CHN-217	Bullhead Shark	Blue	16,700	133	China	China	no
CHN-218	Bullhead Shark	Yellow	42,000	994	China	China	no
CHN-219	Bullhead Shark	White	1,300	43	China	China	no
CHN-220	Bullhead Shark	Green	42,000	2,430	China	China	no
CHN-221	Bullhead Shark	Black	9,100	58	China	China	no
CHN-222	Bullhead Shark	Red	3,000	108	China	China	no
CHN-223	Huaren	Green	24,000	994	China	China	no
CHN-224	Huaren	White	27	ND	China	China	no
CHN-225	Huaren	Blue	37	46	China	China	no
CHN-226	Huaren	Yellow	97,000	1,650	China	China	no
CHN-227	Huaren	Red	96	ND	China	China	no
CHN-228	Huaren	Black	27	ND	China	China	no
CHN-229	Pan Zhi Hua	Yellow	76,000	4,630	China	China	no
CHN-230	Pan Zhi Hua	White	860	39	China	China	no
CHN-231	Pan Zhi Hua	Black	960	9	China	China	no
CHN-232	Pan Zhi Hua	Blue	1,070	79	China	China	no
CHN-233	Pan Zhi Hua	Red	1,100	63	China	China	no

Sample No.	Brand	Color	Total Lead Concentration, Dry Weight (ppm)	Soluble Lead Concentration, Dry Weight (ppm)	Country of Brand Headquarters	Country of Manufacture	Is there information on can about lead content of paint?
CHN-234	Caiyanpai	White	38	ND	China	China	no
CHN-235	Caiyanpai	Red	10,800	889	China	China	no
CHN-236	Caiyanpai	Yellow	6,100	2,040	China	China	no
CHN-237	Caiyanpai	Green	18,600	1,110	China	China	no
CHN-238	Zhonghua	White	122	7	China	China	no
CHN-239	Zhonghua	Yellow	94,000	1,300	China	China	no
CHN-240	Zhonghua	Green	84,000	2,720	China	China	no
CHN-241	Zhonghua	Red	990	78	China	China	no

TABLE A3. DISTRIBUTION OF LEAD CONCENTRATION BY BRAND.

Brand	No. of Samples	No. of Samples Above 90 ppm Soluble Lead	No. of Samples Above 90 ppm Total Lead	No. of Samples Above 10,000 ppm Total Lead	Minimum Total Lead Concentration (ppm)	Maximum Total Lead Concentration (ppm)
Apple Paint	2 (red, yellow)	1	2	1	2,100	37,000
Bamboo	3	0	0	0	11	51
Beacon	3	1	2	1	81	66,000
Bullhead Shark	6	4	6	3	1,300	42,000
Caiyanpai	4	3	3	2	38	18,600
DIAOWANG	3	1	3	1	310	12,200
Duodeli	3	0	1	1	35	13,500
ERXING	3	1	2	1	13	11,400
Forbidden City	2 (yellow, white)	1	1	1	36	116,000
GANG WEI SHI	3	1	2	1	32	24,000
Guxiang	2 (yellow, white)	1	1	0	25	910
HaiXing	3	2	3	2	350	50,000
HONGSHI	3	1	1	1	7	113,000
HTS	3	1	1	1	11	10,600
Huaren	6	2	3	2	27	97,000
Huaxiang	2 (red, white)	1	2	0	91	3,000
JFM	3	1	1	1	< 4	78,000
JI REN	3	2	3	1	640	50,000
JIALILAI	3	1	2	1	62	12,800
JIATE	1 (white)	0	0	0	24	24
Jinbao	3	2	2	1	62	29,000
JINGSHILIANXING	3	1	2	1	4	69,000
Jinliang	3	0	1	1	39	10,700
JINXIANGSHAN	3	1	2	1	< 3	17,700
JINXING	3	1	1	1	5	11,500
Katefu	6	3	4	2	19	102,000

Brand	No. of Samples	No. of Samples Above 90 ppm Soluble Lead	No. of Samples Above 90 ppm Total Lead	No. of Samples Above 10,000 ppm Total Lead	Minimum Total Lead Concentration (ppm)	Maximum Total Lead Concentration (ppm)
LONGJIANG	3	2	3	2	220	104,000
Monarch	3	2	3	2	240	113,000
Pan Zhi Hua	5	1	5	1	860	76,000
QCH	3	1	3	1	280	45,000
QSP	3	1	1	1	31	50,000
QUANXIN	3	1	3	1	310	42,000
Sanyuan	3	1	3	1	100	53,000
Shanbao	3	1	2	1	< 4	31,000
SHIJILIANSHI	1 (white)	0	0	0	6	6
Shiny	3	0	1	0	19	189
SHUANG TA	1 (white)	0	0	0	76	76
Tongrun	2 (red, white)	0	1	0	< 4	630
Wuyang	3	1	3	1	108	64,000
Wuyu	1 (yellow)	1	1	1	15,100	15,100
XIANGHONG	3	1	2	1	< 3	38,000
XYANG	3	1	3	1	192	41,000
Yanta	3	1	3	1	98	28,000
YECAI	3	0	1	1	28	17,400
Zhen Bao	3	1	3	1	147	43,000
ZHENDI	3	1	3	1	98	78,000
Zhonghua	4	2	4	2	122	94,000

TABLE A4. DISTRIBUTION OF TOTAL AND SOLUBLE LEAD CONCENTRATION BY COLOR.

Color	No. of Samples	No. of Samples Above 90 ppm Soluble Lead	No. of Samples Above 90 ppm Total Lead	No. of Samples Above 10,000 ppm Total Lead	Minimum Soluble Lead Concentration (ppm)	Maximum Soluble Lead Concentration (ppm)	Minimum Total Lead Concentration (ppm)	Maximum Total Lead Concentration (ppm)
Black	4	0	2	0	ND	58	27	9,100
Blue	4	2	3	1	46	133	37	16,700
Green	5	5	5	5	394	2,720	18,600	102,000
Red	41	8	32	4	ND	4,190	15	92,000
White	45	0	17	0	ND	66	< 3	1,440
Yellow	42	37	40	38	ND	4,630	11	116,000
Total	**141**	**52 (37%)**	**99 (70%)**	**48 (34%)**	**ND**	**4,630**	**<3**	**116,000**

ND = not detected
na = not available

TABLE A5. COMPARISON OF TOTAL AND SOLUBLE LEAD CONCENTRATION IN CURRENT STUDY WITH THOSE OF PREVIOUS STUDIES.

Study	No. of Samples	No. (%) of Samples Above 90 ppm total lead	No. (%) of Samples Above 90 ppm soluble lead	No. (%) of Samples Above 600 ppm total lead	No. (%) of Samples Above 10,000 ppm total lead	Minimum Soluble Lead Concentration ppm	Minimum Total Lead Concentration (ppm)	Maximum Soluble Lead Concntration	Maximum Total Lead Concentration (ppm)
Lin et al (2009)	58	na	32 (55%)	29 (50%)	n.a.	n.a.	0.8	n.a.	153,000
Clark et al (2009)	64	28 (44%)	n a	21 (33%)	16 (25%)	n.a.	Below 9	n.a.	207,000
Current Study	141	99 (70%)	52 (37%)	70 (50%)	48 (34%)		Below 3		116,000

na = not available

TABLE A6. TOTAL LEAD CONCENTRATION IN SAMPLES FROM PAINT BRANDS INCLUDED IN CURRENT STUDY AND IN A PREVIOUS STUDY (CLARK ET AL 2009).

Brand	Color	Total Lead Concentration in Current Survey (ppm)	Total Lead Concentration in Previous Study (ppm)
Beacon	White	81	101
Beacon	Yellow	66,000	131,000
Beacon	Red	122	43
Guxiang	Yellow	910	207,000
Guxiang	White	25	Not sampled
Shiny	Yellow	60	21
Shiny	Red	189	Not sampled
Shiny	White	19	Not sampled

TABLE A7. DIFFERENCE IN SOLUBLE AND TOTAL LEAD LEVELS IN SOME PAINTS.

Series Number	Color	Soluble Lead Content (ppm)	Total Lead Content (ppm)
CHN-121	yellow	ND	10,700
CHN-169	yellow	ND	13,500
CHN-192	yellow	41	17,400
CHN-221	black	58	9,100
CHN-217	blue	133	16,700
CHN-195	yellow	148	17,700
CHN-146	yellow	153	31,000
CHN-166	yellow	180	11,500
CHN-177	yellow	186	11,400
CHN-172	yellow	213	10,600
CHN-187	yellow	255	24,000
CHN-211	green	394	102,000
CHN-199	yellow	445	37,000
CHN-205	yellow	480	42,000
CHN-151	red	564	11,700
CHN-140	yellow	573	41,000
CHN-127	yellow	587	28,000

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