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**NATIONAL INSTITUTE OF
OCCUPATIONAL AND ENVIRONMENTAL
HEALTH**

REPORT

**INITIAL STUDY TO UNDERSTAND THE EXISTENCE
OF LEAD IN PAINT USED IN PRESCHOOL
AND IN THE CHILD'S FAMILY IN HAI HAU DISTRICT,
NAM DINH PROVINCE, VIETNAM**



**In charge of the project: Research Centre for Gender, Family and
Environment in Development (CGFED)**

**Co-ordinating unit: Department of School Hygiene and Health,
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Environmental Health (NIOEH)**

HA NOI – 2019

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1. There is a great need for a lot of communication programs to raise awareness for people, especially children, pupils, labors about the harmful effects of lead on health and preventive measures.	20
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LIST OF ABBREVIATIONS

ALA	Delta-aminolevulinic acid dehydratase
BLL	Blood lead levels
CDC	Center of Disease Control and Prevention
EPA	Environmental Protection Agency
ICP-MS	Inductively coupled plasma mass spectrometry
TCCP	Permitted Standards
TCVN	Vietnam Standards
WHO	World Health Organization

SUMMARY OF MAIN FINDINGS

The research was conducted to survey the situation of lead contamination in toy paint and blood lead concentration of children of Hai Phu preschool, Hai Hau district, Nam Dinh province. Lead content in 15 paint samples collected at schools and households are determined by EPA 3052 SMEWW 3125 B:2012 ICP-MS method; 16 samples of preschool toys are measured by X-MET 8.000A – Oxford portable fluorescent device; blood lead concentration of 30 childrens were determined by the ICP-MS method.

The results showed that 40% (6/15) paint samples collected on wall and from households contained lead exceeding the allowed standard, in which the highest lead level was 852.05mg/kg. Paint samples in hot colors (red, yellow) has a lead content higher than the permitted standard than the blue paint samples.

37,5% (6/16) of toy samples contained lead with the highest is 4895ppm and 193 ppm. In the 6 lead contained toy samples, the wooden toy samples covered by paint (4 samples) have higher lead level than the plastic toy samples (2 samples).

The average blood lead level for children is $2,87 \pm 1,22$ $\mu\text{g/dL}$, lower than the CDC's recommendation. No children have lead poisoning according to the Vietnam Ministry of Health's Guidelines for diagnosis and treatment of lead poisoning (The blood lead level >10 $\mu\text{g/dL}$).

The above results show that in rural areas, where people mainly work in agriculture, children are less likely to be exposed to lead from production activities. Children are also less likely to be exposed to lead due to their households' routines.

RATIONALE

According to the World Health Organization, lead is one of ten heavy metals that should be most concerned about human health, especially children. It is estimated that in the world in 2000, about 120 million people were exposed to lead, mainly children [31], adding about 600.000 children being intellectually affected each year and 143.000 deaths due to lead exposure, especially in developing countries [41]. Children are at risk of lead poisoning from many different sources, such as leaded gasoline, lead paint, toys, mining activities, recycled battery, environmental pollution, etc. Lead poisoning can cause diverse and complex injuries on most organs and systems in the body such as hematopoiesis, cardiovascular, osteoarthritis, urinary, kidneys, and intellectual. In the world, there are many research on children's lead poisoning and activities preventing lead poisoning for children in some countries that have been successful. In Vietnam, there are some studies about lead poisoning at children in Vietnam, focusing on children living in high-risk areas such as craft villages, lead production recycling areas, etc. The research on lead in toys, learning equipments at 2 preschools in Hanoi city shows that 9.7% of children's toys contain lead with an average content of 625,3ppm and 01/61 samples of wall paint containing lead [10].

To have more scientific information about the risk of lead contamination from paints and toys for children, the Research Centre for Gender, Family and Environment in Development (CGFED) worked in collaboration with the National Institute of Occupational and Environmental Health (NIOEH) to carry out: "Survey on lead contamination from paints, toys, and risks of lead exposures in preschool children in Hai Phu commune, Hai Hau district, Nam Dinh province".

Project Objectives:

- 1) Survey the situation of paint, lead-contaminated toys in preschools in Hai Phu commune, Hai Hau district, Nam Dinh province.
- 2) Survey the blood lead concentration in children of Hai Phu commune's preschool, Hai Hau district, Nam Dinh province.

Chapter I. OVERVIEW

1.1 Research in the world

1.1.1. *Lead in paint and toys*

Before the 1950s, lead-based paint was used to paint houses quite popular. The most popular places to use lead paint are walls, doors, door frames, windows, wooden and furniture. Lead paint becomes a danger when it starts being worn, chipped or peeled or while it is removed by scraping.

After lead gasoline, lead paint is a great source of lead exposure for children. Lead poisoning from lead paint has been described since 1892 in Australia. Children are exposed to lead due to the cracked, damaged indoor paint that contain leads in the home, as well as dust and sand spreaded in their learning and playing environments. In particular, in the case of new paint, the paint surface is often sanded to create adhesion to new paint. Thus, lead in the old paint will peel off and spread widely in the air as lead dust particles [8]. Children are also exposed to lead from their habit of putting their hands in their mouths or directly swallowing the dry paint chips from toys, furniture or other items coated with lead paint. This is the common habit of children under 6 years old and smaller. One child at the age from one to six typically swallow from 100 – 400 mg dust and sand [44]. To prevent lead poisoning for children, in 1978, the United States banned the use of paints with lead content over 0.06% (60 ppm) to paint toys, furniture, walls, building construction for public purposes. The new 2009 US standard requires products designed for kids under 12 years old to use paint with lead content over 300 ppm in any part of the product. In South Africa, the limit of lead concentration in paint below 600 ppm has been applied since 2009 [44].

Despite the ban on lead-based paints has been issued and applied in many parts of the world, studies show that lead levels in paint remain high. Thailand banned the use of lead paint two decades ago, but samples of 5/7 paint brands tested contained lead content up to 30.000 ppm. In the Russia Federation, interior paint containing lead has been stricted by the laws of the Former Soviet Union and the Russian Federation in recent times. But independent research show that in Russia, lead paint can easily found in the market [44].

A study of lead content in paint was conducted in many countries on continents in the world in 2009 showed that 50% of samples have lead content exceeding 600ppm, of which Sri Lanca has 45%, Philipines has 36%, Thai Land has 30%, Tanzania has 73%, South Africa has 62%, Nigeria has 100%, Senegan has 53%, Belarus has 50%, Mexico has 67%, Brazil has 28%, India has 31% [11].

Toys are also lead exposure source for children. It is because toys are painted with lead paints or made from lead contained materials. According to a research in 2007 in America, 35% of 1.268 toy samples were tested with high lead content levels. Toys with lead concentration exceed 600 ppm are considered as the danger and need to be

recalled [41]. The number of recalled toys reach millions, most of them are imported from China [43].

1.1.2. The situation of child's lead poisoning in the world

Lead in paint and home dust remains an important source of lead exposure. In the United States, lead in old paint is a source of child's lead exposure that has been clearly documented [21]. In the United States, the importance of low-grade home dust for small children's BLL has been clearly demonstrated in NHANES data analysis [17]. The importance of lead-based paint is main source causing indoor highly elevated lead concentration, described in the recent national representative research on indoor dust in urban houses across Canada [33].

According to the report on the prevalence of lead contamination by the Agency of Toxic Substances and Diseases Registry (ATSDR – 1988), in the United States, the accumulation of lead in blood can be as high as 5,9 – 11,7 millions of children [12].

Data analysis of the second national health and nutrition survey (1980) showed that: around 85% of preschool-aged children in the US have lead absorption and blood lead concentration level over 10µg/dl [26].

According to Brody D.J et al. (1994), the compiled data from the third national health and nutrition survey showed that 8,9% equivalent to 1.7 US children from 1 to 5 years old having blood lead level from 0,48 mmol/l (10µg/dl) or more [15].

Research conducted in Vermont State of America (1995) on 350 2-year-old children found that 9% of children had BLL>10 µg/dl; 2,7% of children had BLL among 15 - 20 µg/dl and 1,5% had BLL>20µg/dl, meaning that there were 13,2% of children in the high-risk group [29].

In Russia (1997), assessing the risk of adverse effects of lead on children was conducted according to the biodynamic models of lead penetration into the body [48]. For cities having not so high lead content in the environment, the average blood lead concentration of children is close to the non-hazardous level (10µg/dL). In cities with developed industries, the index might be twice as high. Calculating the risk by CDC's assessment frame showed that around 44% of children in big cities may emerge behaviours and education due to lead affects, nearly 9% of children need medical interventions; 0,2% of children are in the risk and about 0,01% need urgent medical intervention and timely treatment method [49].

According to research results of many centers in Europe (Bulgaria, Denmark, Egypt/Greece, Hungary, Italy, Romania, Germany, Yugoslavia), the majority of school-age children have BLL fluctuating around 5 - 60 µg/dL [45].

Examination results of 199 children aged from 3-6 years at Wolcele, Birmingham District – England (1988), blood lead levels ranged from 4.1-33.5 µg/dl, an average of 9.74 µg/dl [39]. Research conducted in South Africa showed a rather unfavourable picture: more than 90% of children have BLL > 10 µg/dL [47].

A survey implemented in Jakarta, Indonesia over 397 children aged 6-12 years old showed that 35% of children in the study group had BLL ≥ 10 $\mu\text{g/dL}$, of which 2.4% have BLL $\geq 20\mu\text{g/dL}$ [32].

In Dakar, Senegal from November 2007 to March 2008, 18 children died from diseases relating to central nervous system. The cause of death is lead contamination due to lead battery recycle activities in the community. The results of the subsequent investigation indicated that lead poisoning occurred due to children inhale or ingest heavy lead polluted soil and dust from illegal and unsafe lead battery recycle activities [30].

According to studies in China, the average blood lead level of children is 9,2 $\mu\text{g/dl}$ and 33.8% of children have blood lead concentration ≥ 10 $\mu\text{g/dL}$, boy child have average blood lead level is 9.64 $\mu\text{g/dL}$, higher than statistic meaning compared with girl child (8.94 $\mu\text{g/dL}$) [42]. Research conducted in 165 children in the electronic waste recycled city of Guiyu (2007) showed that number of children with blood lead level ≥ 10 $\mu\text{g/dL}$ accounted for 81.8% (135/165) [46]. Results of an other research in Guiyu (2008) indicated that 79,0% of children (109/135) have blood lead level $\geq 10\mu\text{g/dL}$. Researchers argued that the blood lead level of children in Guiyu highly increased due to environmental polluted from lead-contained electronic device recycling activities [25].

The above data are evidence of a dangerous picture of reality and the intensity of child lead poisoning in the world and in Vietnam. Control of lead concentration in blood of children in countries has become an urgent issue. Many countries in the world like America, Germany, Denmark, Austria, Mexico, Thailand have implemented national programs to reduce environmental pollution due to lead and limit adverse impacts of lead to children's health [48]

1.2 Research in Vietnam

1.1.3. Lead in paint and children's toys

At present, there is no regulation about the permitted lead concentration used for each type of paint in Vietnam. A study in Vietnam conducted in October 2015 by the Research Centre for Gender, Family and Environment in Development (CGFED) showed that solvent-based paint for housing contained lead concentration at relatively high level have been widely used in the paint market in Vietnam. The study investigated and analyzed 26 solvent paint boxes representing 11 paint brands and 11 paint manufacturers used to paint houses widely sold in many stores in Hanoi. The survey results showed that 14/26 solvent paint boxes for house paint (accounting for 54%) had lead concentrations exceeding 600 ppm – regulated lead concentration limits in some countries such as Singapore, Korea, and Sri Lanka. Moreover, 5/26 paint cans (accounting for 19%) contained lead concentration at dangerous level over 10.000 ppm. 4 out of 11 paint brand were tested (accounting for 36%), there was at least 1

paint sample with paint concentration exceed 10.000 ppm. Red paint, yellow paint when analyzed are two samples containing the highest lead concentration of all paint samples exceeding 10.000 ppm. 3 out of total 9 red paint samples (accounting for 33%), and 2 out of total 8 yellow paint samples (accounting for 25%) contained lead concentration over 10.000 ppm. In addition, on 26 paint cans, there were no information of lead concentration provided on the label and most of the 26 packaging labels contain very little information about paint composition. Most of the warning and notting information box only refers to the flamablity of paint without mentioning the effects of lead dust in paint on children and pregnant women [8].

Toys imported from China dominate the cheap toy market and may be a risk of lead contamination like toys in the United States. Vietnam has set standards for lead concentration in all types of toys, clay and hand-painted $\leq 90 \mu\text{g/g}$ (mg/kg) (Vietnam Standards 6238-3:2011) [1]. However, the control of lead concentration in toys is difficult and inadequate in the quality management, especially in the context of the prevalence of China toys in the market. The authors has not found any research about the real situation of lead poisoning in children's toys in Vietnam.

1.1.4. Lead poisoning status in Vietnamese children

In Vietnam, there have been studies on the status of lead contamination of children recently. However, these studies have not focused on the risk of lead poisoning in children due to the use of lead paint and lead containing toys.

According to research of Havens et al. (2012) on 311 children in Ho Chi Minh city, provinces of Dong Nai, Binh Duong, Binh Phuoc and Ba Ria – Vung Tau, 92.9% of children have blood lead level $<10 \mu\text{g/dL}$, 7.1% of children have blood lead level $\geq 10 \mu\text{g/dL}$ and only 2.9% (9 children) have blood lead level $>20 \mu\text{g/dL}$, 0.96% (3 children) have blood lead level $>35 \mu\text{g/dL}$ [16].

Research of Dang Anh Ngoc implemented in Chi Dao commune, Van Lam district, Hung Yen province (2008) showed that the rate of school pupils having concentration of delta – ALA urinary over 10mg/L was quite high, accounting for 45.0%; at 5-10 mg/L accounting for 40.4% and less than 5 mg/L accounting for 14.6%. This shows that the lead poisoning of children in the lead recycled village is very high [5].

Results of research by Lo Van Tung (2018) on the situation of lead contamination in paint, toys carried out in 2 preschools in Hanoi showed that 9.7% of toy samples having lead with an average concentration of 625.3 ppm, 7 times higher than Vietnam Standards 6238-3:2011 about child safe toy; 1/61 sample of wall paint have lead concentration of 1800 ppm [10].

The study of Lo Van Tung et al. conducted on 109 children under 10 years old in Dong Mai craft village (2011) showed that 100% of children under 10 years old were screening tested have higher blood lead levels over $10 \mu\text{g/dL}$; of the 24 children having repeated blood vien teste, there were 19 children have blood lead level over $45 \mu\text{g/dL}$ [9].

Research on children from 3-14 years old living near the lead zinc mining area in Ban Thi commune, Bac Kan province showed that the rate of lead poisoning (children with blood lead level $>10\mu\text{g/dL}$) is 79.49% [3]. The rate of children from 3-14 years old with history of using lead poisoned "orange" herbal supplement (a kind of traditional herbal detox medicine for kids) in Bac Giang province is 2.8%, in Quang Ninh province is 7.0% [2].

The study of Doan Ngoc Hai et al. (2018) on the risk of lead contamination of children in two preschools in Hanoi showed that the average lead concentration in hair of children is $4,8\pm 4,7\mu\text{g/g}$, the proportion of children at risk of exposure to lead accounted for 30.4%, serious lead exposure accounts for 1.0%. Lead in hair highly increases due to children living with relatives exposed to lead in work [4].

1.3 Impact of lead on children's health

Children are exposed to lead through many ways from lead paint on walls, windows, doors, and surfaces that have been painted with lead-based paint that has begun to crack or become damaged by these sources. Lead will be distributed around their learning and play environments in the form of dust and sand.

The habit of putting hands into mouth is quite common among children age six and under, and this group is easily affected by lead exposure. Each typical one-to-six swallow from 100-400 milligrams of dust and sand daily [44].

There is no safe blood lead threshold for children. Lead-damage injuries in children often occur when blood lead levels are lower than in adults because children are more susceptible to lead toxicity [40]. The lowest blood lead level of $2\mu\text{g/dL}$ has affected the development of the child nervous system [18].

Symptoms of encephalopathy and death may occur at blood lead levels $\geq 100\mu\text{g/dL}$. Symptoms of the central nervous system may be observed when blood lead levels are at $40-60\mu\text{g/dL}$, neurological dysfunction, and attenuation of neurotoxic effects can occur when blood lead levels $30-50\mu\text{g/dL}$. Recent studies also show behavioral disorders in children with blood lead levels below $10\mu\text{g/dL}$ [13], [18].

Lead causes digestive disorders in children including abdominal pain, constipation, nausea, vomiting, loss of appetite and weight loss when blood lead levels are between 60 and $100\mu\text{g/dL}$ [13], [20], [34]. Lead infiltration can lead to anemia due to reduced hemoglobin synthesis and reduced red blood cell life. Decreased hemoglobin synthesis can occur when blood lead levels are $50\mu\text{g/dL}$ for adults and $40\mu\text{g/dL}$ for children.

At low doses, lead may decrease peripheral neurotransmitter rates [36], impair hearing [35,37], lower IQ [14, 24, 28], impair attention, and disorders. Linguistic function, impaired access to educational programs, and adaptability to the school environment [27]. Lead also affects children's physical development such as reducing their height, bust, head circumference [19,23,38].

Chapter II. SUBJECTS AND METHODS OF RESEARCH

2.1. Research Subjects

- Wall paint and children's toys in preschools
- Blood lead concentration of preschool children

2.2. Research location

Hai Phu commune preschool, Hai Hau district, Nam Dinh province

2.3. Research duration

From March to August 2019

2.4. Research content

- Determination of lead content in wall paint and children's toys
- Survey of blood lead levels of preschool children
- Investigation of risks of lead poisoning in children

2.5. Research methodology

2.5.1. *Research design*

Cross-sectional descriptive study

2.5.2. *Sample size of the study*

2.5.2.1. *Samples of wall paint and toys*

- It is expected to gather 30 samples of wall paint.
- Practical tests: 15 samples of paint and quick measurement of lead concentration in 16 samples of toys.

2.5.2.2. *Children*

- It is expected to test blood concentration for 30 children.
- Reality: Test lead concentration in 30 vein blood samples.

2.5.3. *Techniques of sample collecting and analyzing*

2.5.3.1. *Techniques of collecting samples of paint, toys and determining lead content*

a) Paint samples

- *Sample collecting*

Tools: Razor; clean A4 paper sheet, polyethylene bag.

Techniques of sample collecting:

- + Use clean paper to wipe the surface of the wall
- + Use a razor blade to obliterate a thinny paint on the wall surface and hold it in a clean paper, avoid to obliterate excessively into cement or baits under the paint cover.

+ Collect the paint samples into the polyethylene bags, seal the bags and transport them to the Department of Laboratory and Analysis of National Institute of Occupational and Environmental Health.

- *Determination of lead content*

- Determination of lead content in paint samples at the National Institute for Occupational and Environmental Health is conducted under EPA 3052 SMEWW 3125 B:2012 ICP-MS method by IC-PMS technique.
- Assessment: refer to WHO standards.

b) Toy samples

- Sample collection

+ Members of research team took samples in 3 classrooms, representing for children at the age of 3, 4, and 5.

+ The collected samples represent for materials, types and colors.

- Determination of lead content

- Rapid measurement of lead content in toy models, with X-MET 8.000 - Oxford Fluorescent X-ray handheld device in plastic mode (for toys made from plastic materials, wall paint), and the Alloy mode (for toys made from metal). Range of analytical elements: Mg ->U. The unit of measurement is ppm.
- Evaluation of lead content in children's toys and belongings according to Vietnam Standards 6238-3: 2008 (ISO 8124-3: 1997) on children's toy safety – Part 3: Limiting the level of contamination of some harmful elements [7].

2.5.3.2. *Techniques of collecting blood samples and analyzing blood lead concentration*

a) Collection of blood samples

Venous blood samples are taken using a disposable medical cylinder. Before taking blood, wipe off with alcohol to avoid contamination of blood samples leading to false results and ensure the safety for children. Blood taken into the cylinder will be divided and stored in anti-freeze tubes. Blood volume and anticoagulant composition depend on the purpose of testing.

b) Determination of blood lead levels

- Lead concentration is determined by the method of Inductively Coupled Plasma Mass Spectrometry (ICP-MS).
- Diagnostic criteria for lead poisoning are based on Decision No. 1548 / QD-BYT dated 10th May 2012 of the Ministry of Health promulgating guidelines for lead poisoning diagnostic and treatment [6] (children are lead poisoned when blood lead levels are $>10\mu\text{g/dL}$), specifically:
 - + Light poisoning: Blood lead level is from $10-45\mu\text{g/dL}$
 - + The average level: Blood lead level is from $45-70\mu\text{g/dL}$

+ Severe level: blood lead level is $>70 \mu\text{g/dL}$

2.5.3.3. *Survey on risk of lead poisoning in children*

- Survey tool: Prepared questionnaires.
- Survey techniques:
 - To guide preschool teacher on how to answer the questionnaire
 - Preschool teacher directly guide to parents of preschool children to answer and collect the questionnaires To guide preschool teacher on how to answer the questionnaire
 - Project members re-check the questionnaires, if there are unclear issues or questions have not been answered, send back to the parents to answer and fill in all information in the questionnaire.

2.6. Method of data analysis

The collected data will be entered by Excel 2007 software. Data processed using SPSS 20.0 software. The statistical indicators are median, average, standard deviation, minimum, maximum, percentage. Statistical tests are t-test, test Anova, Turkey test to compare the average value, test χ^2 (to compare percentages).

2.7. Ethical issues in research

- Preschool, parents of the children are explained clearly about the purpose, content, benefits and even possible disadvantages in the research process. Only those children who have been volunteeredly signed in the agreement by their family to participate in the research are included in the list of research subjects.
- Research subjects have the right to refuse to participate in the reseach at any time during the research process.
- Ensure absolute safety, especially biosecurity for all research subject during their participation in the research.
- Test results are sent to each research participant. When detecting abnormal signs of blood lead levels, the research team will notify their parents and consult on treatment and prevention measures.

Chapter III: RESEARCH RESULTS

3.1 Lead content in paint at home and preschool of preschool children

Survey results show that preschools use some types of paint to decorate the wall paint, but the color paint layer is too thin to be tested because of mixing with the inside lime layers. In households: Most of the children's houses selected in the study used lime to sweep walls (23/30 houses). So the research team took paint samples at their relative's house where children often visit after school.

Table 3.1. Lead concentration in samples of paint wall

Samples of paint wall	Total	Number of lead containing samples exceeds the permitted standards*				
		n	%	Average	Minimum	Maximum
1. Paint samples (mg/kg)	15	6	40%	541,27	390,19	852,05
- In preschool	5	5	100%	559,36	394,19	852,05
- At household	10	1	10%	450,83	450,83	450,83

* According to the Vietnamese Standard 6238-3:2018 on Safety of children's toys – Part 3: Limiting the level of contamination of some toxic elements, permitted standards on lead content in coating paint of children's toys are 90mg/kg.

Thus, the above table shows:

There are 6/15 paint samples with lead content exceeding the permitted standards with an average concentration of 541.27mg/kg, 6 times higher than permitted standard. In which, samples of paint wall have the highest lead concentration is 852.05mg/kg.

Remarkably, all 5/5 wall paint samples at preschool have an average lead content exceeds the permitted standards with an average of 559.36 mg/kg, 6 times higher than permitted standards. These paint patterns are in blue, yellow, red, green, blue)

Among these 5 paint samples, the lowest lead content is 394.19 mg/kg (the blue paint sample) and the highest lead content is 852.05 mg/kg (the yellow paint sample).

These paint samples are taken from paintings on the walls and on toys in the school yard.

At household: 1/10 paint samples have lead content 5 times higher than permitted standards with the lead content of 450.83 mg/kg. The paint sample was took from living room and kitchen.

Table 3.2 List of paint samples with lead content exceeding the permitted standards

Code	Description	Location	Postion	Paint color	Lead content (mg/kg)
HH-NĐ01	Wall paint	Household	Living room and kitchen	N/A	450.83
HH-NĐ06	Paint sample from on the wall picture	Preschool	Wall picture close to the stair	Green	460.03
HH-NĐ07	Paint samples from the horse merry go round	Preschool	Horse merry go round at the kindergarten's yard	Yellow	852.05
HH-NĐ08	Paint samples from the horse merry go round	Preschool	Horse merry go round at the kindergarten's yard	Red	632.79
HH-NĐ09	Paint samples from the horse merry go round	Preschool	Horse merry go round at the kindergarten's yard	Green	457.75
HH-NĐ10	Paint samples from the horse merry go round	Preschool	Horse merry go round at the kindergarten's yard	Blue	394.19

Except for only one paint sample collected from household having unspecified paint color, the paint samples collect at preschool showed that the hot color paint (yellow, red) have higher lead content than the blue paint samples. The result is similar to the results of CGFED's research in 2016: paint samples in red, yellow color always have higher lead content than paint samples in other colors [8].

In summary, although paint is not widely used at the survey sites, however 100% of paint samples collected from preschool and 10% of paint samples from households have lead content exceed the permitted standards.

3.2 Lead content in toys for preschool children

Toys are one of the sources of lead exposure to children. The reason is that toys are painted with paint or made of lead-containing materials. When using lead-contaminated toys, the risk of children with lead exposure may be caused by swallowing or inhaling dust particles containing lead sloughing off from toys.

Survey samples of preschool toys includes plastic toys (10/16 samples) and painted wooden toys (6/16 samples). Rapid measurement results by X-ray fluorescence device showed that 6/16 (37.5%) of samples contained lead with the highest content of 4895ppm and the lowest of 193ppm. Of the 6 paint samples that contain lead, 2 samples are plastic toys (with lead content are 193ppm and 475ppm) and 4 toy samples are painted wooden toys with lead content from 1121ppm – 4895ppm). Patterns of lead-containing toys are green, yellow, brown, and red.

Table 3.3 List of preschool toy samples contain lead

Description of paint sample	Material	Paint color	Lead content (ppm)
Brick	Plastic	Yellow	193
Rose apple	Plastic	Brown	475
Rectangular block	Painted wood	Yellow	4570
Rectangular bar	Painted wood	Green	4895
Rectangular bar	Painted wood	Red	1121
Car	Painted wood	Red-Gray	1993 (test the red paint)

The proportion of lead-containing toys in this study is equivalent to that of some studies in the US in 2007 with 35% of toys having high lead content. In the US, toys with lead content above 600ppm are considered hazardous and need to be recalled. Number of recalled toys up to millions and most of these toys are imported from China [43].

In this study, samples of lead-containing toys are green, yellow, brown, and red. Similar to the study of Joseph A. Greenway (1986) on 535 toys at American preschools: toys in yellow color have much higher lead content than other colored toys [22].

Thus, the results of this study show that toys also have the potential risks of causing lead poisoning for children because lead concentrations in some toy models exceed the permitted standards. Currently, the control of lead content in toys has many difficulties, the most inadequate is in the context of Chinese toys dominate children's toys' market in Vietnam.

3.3 Blood lead test results of children

The study was conducted on 30 children, of which 16 were boys (53.3%) and 14 girls (46.7%), the age of children from 4-6 years old, the number of children were divided equally for ages (Table 3.4)

Table 3.4. Characteristics of research participants

Age	Male		Female		Total
	n	%	n	%	
4	5	50,0	5	50,0	10
5	3	30,0	7	70,0	10
6	8	80,0	2	20,0	10
General	16	53,3	14	46,7	30

To assess the lead poisoning status in children, the study group conducted totality test of blood lead concentration for children. Results in the Table 3.5 show: The average blood lead concentration of children is $2,87 \pm 1,22$ $\mu\text{g/dL}$. Children have the highest blood lead concentration of $8,6$ $\mu\text{g/dL}$, and the lowest blood lead concentration of $1,3$ $\mu\text{g/dL}$.

The average blood lead concentration among boys and girls was nearly the same, and the differences was not statistical significant.

At the ages: the highest average blood lead concentration in children at 5 year: $3,47$ $\mu\text{g/dL} \pm 1,86$. There was no statistically significant difference in the average blood lead concentration between ages.

Table 3.5. Blood lead concentration by age and sex

Age/sex	Amount	Blood lead levels ($\mu\text{g/dL}$)			
		Average	SD	Minimum	Maximum
Age					
4	10	2,83	0,58	1,56	3,46
5	10	3,47	1,86	2,22	8,6
6	10	2,32	0,49	1,3	2,8
Comparison between ages: $p > 0,05$					
Sex					
Male	16	2,85	0,53	1,56	3,88
Female	14	2,9	1,72	1,3	8,6
Comparison between male and female: $p > 0,05$					
General	30	2,87	1,22	1,3	8,6

The blood lead concentration of children in this study is lower than the recommendation on CDC (5 $\mu\text{g} / \text{dL}$)

Compared with other research results in Vietnam, the average blood lead level of children in this study is lower than that of children in other regions. In Ho Chi Minh city and some surrounding provinces, the blood lead level of children is 3.6 µg/dL [16]; in the mining area is 14.4±9.4 µg/dL, in the industrial zone is 8.6±11.9 µg/dL; in the area of craft villages is 6.6±6.6 µg/dL [2]. Research in some locations in other provinces such as Bac Giang, Hanoi, and Quang Ninh also show that the average blood lead level of children is higher than that of this research (Quang Ninh: 5.2±4.6 µg/dL, Hanoi: 4.0±2.4 µg/dL, Bac Giang: 3.9±4.6 µg/dL) [2].

Analyzing the blood lead levels by sex, we found that there is no statistically significant difference between men and women ($p>0.05$).

The average blood lead level of 4-year-old children was: 2.83±0.58 µg/dL, 5-year-old children was 3.47±1.86 µg/dL, 6-year-old children: 2.32±0.49 µg/dL. The blood lead level of 5-year-old children tends to be higher than that of children at the age of 4 and 6. However, the difference is not statistically significant difference ($p>0.05$).

According to Table 3.6 about the distribution of blood lead levels in children shows that no children have lead poisoning according to the Decision No. 1548/QĐ-BYT (100% of children have blood lead level under 10 µg/dL). However, according to the recommendation of the US CDC in 2012 on the blood lead level that needs attention and action (<5 µg / dL), there is one girl child at the age of 5 have blood lead level of 8.6 µg / dL. Results of interviews with parents of the child show that in this family, there are people working in production facilities related to lead. This may be the cause of increased blood lead level of the child as the relative might bring lead back to home on their clothes and personal belongings. The research team announced test results to the child's family and recommended prevention methods to avoid being lead exposure for children.

Table 3.6. Distribution of children based on blood lead level

Age/Sex	Blood lead level (µg/dL)					
	BLL <5		BLL: 5-10		BLL >10	
<i>Age</i>						
4	10	100	0	0	0	0
5	9	90	1	10	0	0
6	10	100	0	0	0	0
<i>Sex</i>						
Male	16	100	0	0	0	0
Female	13	92,9	1	7,1	0	0
<i>Total</i>	29	96,7	1	3,3	0	0

Lead is a heavy metal with high toxic and does not have a safe blood lead threshold for children. The lowest blood level of 2 µg/dL has affected the development of the

child's nervous system [18]. However, compared to research in other areas of Vietnam, the blood lead levels of children in this research are much lower. This is a research with small number of samples, but research results also give a positive signal that in rural areas where people mainly work in agriculture, the risk of being lead exposed of children is lower than in other areas.

3.4. Risk factors for lead exposure in children

The study used a set of questionnaires to investigate the risk of children exposed to lead from their living environments.

3.4.1 Risks of lead exposure in child family

Results in the Table 3.7 show that 89.66% of children do not live near the active/on-going manufacture facilities having risk of lead contamination. This is a particular feature of the selected research site: in rural area, the main occupation of the people is pure agriculture and services and not close to the areas of mining, processing, metal recycle. There are 3/30 children living near production facilities, however, all the 3 facilities are 500-1000m far away from the children's houses. These are the main facilities to purchase lead batteries. 100% of the respondents in the research said that activities of those manufacture facilities do not cause polluted environment.

Table 3.7. Source of lead exposure in child families

<i>Content</i>		<i>Number</i>	<i>Percentage</i>
Houses near manufacture locations have potential risks to cause lead contamination	Yes	3	10,34
	No	26	89,66
Distance from manufacture locations to the house	500-1000m	3	100
Do manufacture locations cause polluted environment?	Yes	0	0
	No	30	100
Storage, use of lead containing slag, ore and waste products at home	Yes	0	0
	No	30	100
Use "thuốc cam" (a kind of traditional herbal medicine for kids) to cure diseases	Yes	0	0
	No	30	100
Drinking water sources	Tap water	5	16,67
	Well water	22	73,33
	Both of the two above water sources	3	10
Living with the lead exposed people	Yes	8	26,7
	No	22	73,3

100% of children’s families participating in the study did not store and use lead-containing slag, ore, and waste products at home.

Study about the main water source being used in households, there are 2 main water sources being used: well water 73.33%, tap water 16.67%.

100% of children participating in the study did not use “thuốc cam” (a kind of traditional herbal medicine for kids) (one of the sources of lead exposure for children).

The results in Table 3.7 also show that there are 8/30 children living in the same house as those working in production facilities related to lead, of which 1 child living with relatives working at lead recycling facilities should have The risk of blood lead is higher than other children. According to the research of Doan Ngoc Hai and colleagues on lead poisoning situation in Vietnamese children in some high-risk areas, children living with relatives are exposed to lead in ore mining and processing, working at a color metallurgy factory has a higher blood lead level than other children with a statistically significant difference [2]. Research by William E Daniell and Lu Van Tung in Dong Mai village (2015) shows that children have higher blood lead levels > 30 µg / dL in families with lead recycling participants than children in families without participants in recycling lead [9].

The above results show that children in the study area are less likely to be exposed to lead sources due to production activities such as other localities that have mining or recycling of lead-containing wastes. Some samples of house paint, lead containing toys all exceed the permitted standards. However, the risk of child lead contamination depends on many factors such as the possibility of dispersal of lead into the environment due to paint being destroyed or peeled. In addition, the risk of lead exposure is due to children’s behavioral habits such as washing hands with soap, putting hands and toys into mouth.

3.4.2 Risk of lead exposure due to hygienic conditions at family and unsafe behaviors of children

Table 3.8. Behavior at risk of causing lead infection of children

Content		Number	Rate
Often wash hand before meal	No	0	0
	Sometimes	7	23,33
	Often	23	76,67
Use soap to wash hands	No	0	0
	Sometimes	14	46,67
	Often	16	53,33
Children have habits of putting hands/toys into their mouth	No	13	43,33
	Sometimes	16	53,33
	Often	1	3,33

Children have habits of sitting or lying play on the yard/ground	No	15	50
	Sometimes	15	50
	Often	0	0
The surface of the yard/ground where children often play	Ground	1	3,3
	Title	14	46,67
	Cement	13	43,33
	Others	2	6,7

According to WHO, a children between the ages of 1 to 6 can swallow about 100-400mg of indoor sand dust everyday [44]. Therefore, some children's behavior can cause child lead exposure such as the habit of putting hands/toys/belongings into their mouths and playing (sitting or lying) on the yard/ground. Research results (Table 3.8) showed that 53.33% of children sometimes have the habit of putting hands/toys into their mouth; 43.33% of children do not have this habit. Some other hygiene habits of children: 76.67% of children often wash their hands before meal. 53.33% of children often use soap to wash their hands. Thus, the rate of children washing their hands before meal and using soap to wash hands is quite good; however, adults in families should notice to remind and help children wash their hands more often to reduce the risk of disease and expose to harmful factors in the environment.

Research results (Table 3.8) show that 66.67% of children live in roofed houses, 20% of children live in four-level houses. 76.67% of house wall are whitewashed, only 16.67% of house wall are painted. However, of the paint samples surveyed, 1/10 samples in households with lead concentration in paint is 450.83 mg/kg, 5 times higher than the permitted standard. The family's house wall was painted in 2012.

The surface of the yard where children often play is mainly brick yard (46.67%) and cement (43.33%). The floor where children live are 100% ceramic floor. 100% of households using the method of dry sweep and wet wipe to clean the floor where children play. This also help to reduce the risk of being lead exposure for children through reduction of dust spreading inside the house.

Table 3.9. The hygienic conditions at children's family

Content		Number	Rate
Kinds of houses children living	Roofed house	20	66,67
	Tile-roofed house	6	20
	Other	4	13,33
House wall	Paint	5	16,67
	Whitewash	23	76,67
	Other	2	6,66
Ways of floor	Dry sweep/Wet wiping	30	100

cleansing	Vacuuming	2	6,7
Floor where children often play	Ceramic tiles	30	100

In summary, children in the study area are less likely to be exposed to lead from production activities. Children are also less likely to be exposed to lead due to household routines.

CONCLUSIONS

Through the research results, we have some conclusions as follow:

1. Finding out 40% of paint samples collected from preschool and households contain lead exceeds the permitted standard. The average lead concentration in these samples is 541,27 (390,19 - 852,05) mg/kg. Paint samples in hot colors (red, yellow) have lead content exceeding the permitted standard higher than the blue paint samples.
2. Detecting 37.5% of toy samples in preschool contain lead. The average lead concentration of those toys is 2207,83 (193-4895) ppm. Of the 6 paint samples containing lead, the painted wooden toy samples (4 samples) have higher lead content than the plastic ones (2 samples).
3. The average blood lead concentration of children is $2,87 \pm 1,22$ $\mu\text{g/dL}$, lower than the CDC's recommendation. No children have lead poisoning according to the Guidelines for the diagnosis and treatment of lead poisoning of the Ministry of Health of Vietnam.

RECOMMENDATIONS

From the the search results, we propose recommendations as follows:

1. There is a great need for a lot of communication programs to raise awareness for people, especially children, pupils, labors about the harmful effects of lead on health and preventive measures.
2. The State and related agencies need to enhance the control of the quality of interior paint and children's toys, ensuring lead concentration in paint, toys under the permitted standards.
3. The State should issue regulations on the management of lead in paints, especially decorative and household paints.

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ANNEXES

1. Questionnaire on the risk of lead exposure

MINISTRY OF HEALTH
NATIONAL INSTITUTE OF
OCCUPATIONAL AND
ENVIRONMENTAL HEALTH (NIOEH)

RESEARCH CENTRE FOR GENDER,
FAMILY AND ENVIRONMENT
IN DEVELOPMENT
(CGFED)

QUESTIONNAIRE ON THE RISK OF LEAD EXPOSURE

(For parents or child caregivers)

CODE *(recorded by researcher)*

A. GENERAL INFORMATION

1. Full name of the respondent

Year of birth:.....

Sex: 1. Male 2.

Female

Relationship to children: 1. Father 2. Mother
3. Grand parents 4. Others

2. Full name of the children

Year of birth

Sex: 1. Male 2. Female

3. Full name of the father

Year of birth Occupation:

4. Full name of the mother

Year of birth Occupation:

5. Address: Lane..... Village.....

Commune.....District.....

Province/City

6. Child lives at the above address since the year of:.....

We hope that you answer the question below by circleing the appropriate answer

B. SOURCE OF CONTAMINATION

1	Are there any manufacturing facilities near your home involved in the following activities?	1. No <i>(move to the question 2 below)</i> 2. Mining, producing lead, and zinc 3. Producing non-ferrous metallurgy industry 4. Activities of manufacturing, repairing, purchasing, and recycling lead batteries
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		5. Activities related to metal casting and recycling 6. Other activities (related to lead)
1.1	Is this facility still in operation?	1. No (since the year?...../.....) 2. Yes
1.2	Distance from the production facility to your house	1. At home 2. below 100 m ; 3. 100 – 200 m 4. 200 – 500 m 5. 500 - 1000 m 6. >1000m
1.3	Do you think that production facilities pollute the living environment of the family?	1. No 2. Yes
2	Does your family store, use lead-containing slag, ore, and waste products at home?	1. No 2. Yes (please specify what type?) 2.1. Old battery case 2.2. Lead contained slag, ore 2.3. Lead finished products 2.4. Others
3	Have your children ever used traditional medicine (thuốc cam) for kids?	1. No 2. Yes 3. Don't know
3.1	When was the last time of using detox medicine?	Month /
3.2	Children have to take detox medicine when:	1. Thrush 2. Mouth sores 3. Anorexia 4. Constipation 5. Diarrhea 6. Other diseases:.....
4	The main source of water use in family (where children live) is:	1. Tap water 2. Borehole water 3. Rain water 4. Water from rivers and streams 5. Water from pond and lake
5	Is there any family members who are living	1. None 2. Mining and processing of lead zinc minerals (at

	<p>in the same house with the child exposed to lead in following activities?</p>	<p>mines, processing plants, etc.)</p> <p>3. Working at a factory or non-ferrous metallurgy factory</p> <p>4. Working at battery manufacturing company</p> <p>5. Working at a lead recycling facility (collecting, manufacturing and repairing lead batteries; recovering, recycling, shearing, polishing lead containing materials, solder, lead-plating or welding with lead-based alloys, etc.)</p> <p>6. Do other jobs (being lead exposed):</p> <ul style="list-style-type: none"> - Selling petrol and oil; - Repairing cars and motorcycles - Welder - Casting and typesetting with lead alloy; - Diluting, use of paint, varnish, printing ink, mastics, leaded pigments; - Manufacturing, using lead-type ceramic glazes; - Enameled, printed flower with lead compound - Manufacturing and using leaded glass; <p>7. Others: (please specify).....</p>
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C. HYGIENE CONDITIONS OF THE FAMILY

<p>1</p>	<p>Type of house (where the child lives)?</p>	<p>1. Thatched roof house</p> <p>2. Wooden house</p> <p>3. Roofed house</p> <p>4. House with flat roof</p> <p>5. Apartment</p> <p>6. Villa</p> <p>7. Others:.....</p>
<p>2</p>	<p>Are walls are painted with lime or paint?</p>	<p>1. No paint, no lime</p> <p>2. Sweep the lime</p> <p>3. Painted</p>
<p>2.1</p>	<p>If being swept with lime or rolled with paint, when was the last time?</p>	<p>Year</p>
<p>3</p>	<p>How is the floor usually cleaned?</p>	<p>1. Sweep (dry)times/week</p> <p>2. Wipe (weat) times/week</p>

		3. Vacuum cleaner times/week
4	Where children often play, the ground is often made of?	1. Soil 2. Flooring pads 3. Terracotta bricks 4. Cement 5. Tiles 6. Others:.....

D. CHILDREN'S BEHAVIOR

1	Does the child often wash their hand clean before meal?	1. No 2. Sometimes 3. Often
2	Does the child use soap to wash his/her hand?	1. No 2. Sometimes 3. Often
3	Does the child have habits of putting fingers or toys, equipments into mouth?	1. No 2. Sometimes 3. Often
4	Does the child have habit of laying down on the floor, ground to play?	1. No 2. Sometimes 3. Often
5	Which kind of play-ground where the child can play or spend more time on?	1. Soil 2. Bricks 3. Cements 4. Others.....
6	Does child have the following signals? Trẻ có các biểu hiện nào sau đây không?	1. Abnormal pain 2. Vomitting 3. Anoxeria 4. Tired 5. Anemia 6. Irritable, stimulating 7. Slower development than other 8. Study poorly 9. Hearing loss 10. Others:

2. Test results of wall paint samples

No	Code	Type	Address	Location	Lead content (Pb) (mg/kg)
1	HH-NĐ01	Wall paint	Child's house	Living room, kitchen	450,83
2	HH-NĐ02	Wall paint	Child's house	Sleeping room	6,08
3	HH-NĐ03	Wall paint	Child's house	Living room	14,49
4	HH-NĐ04	Cement Wall paint	Child's house	Living room	24,30
5	HH-NĐ05	Wall paint	Child's house	Living room	14,95
6	HH-NĐ06	Wall paint	Preschool	Base of the stair close to the 1 st floor, paint sample from wall-picture (the picture in green color)	460,03
7	HH-NĐ07	Wall paint	Preschool	Collect paint samples from the horse merry go round at the kindergarten playground (scrape paint from horse in yellow paint)	852,05
8	HH-NĐ08	Wall paint	Preschool	Collect paint samples from the horse merry go round at the kindergarten playground (scrape paint from horse in red paint)	632,79
9	HH-NĐ09	Wall paint	Preschool	Collect paint samples from the horse merry go round at the kindergarten playground (scrape paint from horse in green paint)	457,75
10	HH-NĐ10	Wall paint	Preschool	Collect paint samples from the horse merry go round at the kindergarten playground (scrape paint from horse in blue paint)	394,19
11	HH-NĐ16	Wall paint	Child's house	Outdoor balcony at the 2 nd floor	53,26

No	Code	Type	Address	Location	Lead content (Pb) (mg/kg)
12	HH-NĐ17	Wall paint	Child's house	Step under the kitchen	7,85
13	HH-NĐ18	Wall paint	Child's house	Door edge at the living room	6,14
14	HH-NĐ19	Wall paint	Child's house	Under the stairs at 1st floor	4,23
15	HH-NĐ20	Wall paint	Child's house	Outer wall corner	15,00

3. Test results of toy samples

No.	Content	Results	Notes
1	Sample 1 – Plastic toy in green color (gas stoves)	N/A	
2	Sample 2 – Plastic toy in pink color (cutting board)	N/A	Cd: 63ppm+-20
3	Sample 3 – Plastic toy in yellow color (brick)	Pb: 189+-28;	Cr: 64-+18
4	Sample 4 – Plastic toy in red color (brick)	N/A	
5	Sample 5 – Plastic toy in brick-color (brick)	N/A	Br: 1367+-15; Cr: 5
6	Sample 6 – Plastic toy in yellow color (chair)	N/A	
7	Sample 7 – Plastic toy in blue color (dish)	N/A	
8	Sample 8 – Plastic toy in dark red color (the cylinder block)	N/A	
9	Sample 9 – Plastic toy in cerise color (triangle block)	N/A	
10	Sample 10 – Plastic toy in brown color (Rose apple)	Pb: 475+-91	
11	Sample 11 – Wooden toy coated by yellow paint (rectangular block)	Pb:2984+-18	Cr: 2283+-26;
12	Sample 12 – Wooden toy coated by green color (rectangular bar)	Pb:4895+-29	Cr:2222+-31;
13	Sample 13 – Plastic toy in red color (round perforated rectangular pods)	N/A	
14	Sample 14 – Plastic toy in yellow color (round perforated rectangular pods)	N/A	
15	Sample 15 – Wooden toy coated by red paint (rectangular bar)	Pb: 1173+-45	Cr: 1075+-18;
16	Sample 16 – Wooden toy coated by red-grey paint (car)	Pb: 1711+-79	Cr: 1072+-23

4. Test results of lead in children's blood

No	Code	Sex	Year of birth	Result ($\mu\text{g/dL}$)
1	1	Female	2015	2,22
2	2	Female	2013	1,30
3	3	Male	2013	2,83
4	4	Male	2013	2,74
5	5	Male	2013	1,94
6	6	Male	2013	2,34
7	7	Female	2013	2,14
8	8	Male	2013	2,66
9	9	Male	2013	2,79
10	10	Female	2013	1,92
11	11	Female	2013	2,48
12	12	Male	2015	2,85
13	13	Male	2015	1,56
14	14	Male	2014	3,88
15	15	Female	2014	8,60
16	16	Male	2014	2,94
17	17	Female	2014	2,79
18	18	Female	2014	2,69
19	19	Male	2014	3,26
20	20	Female	2014	2,61
21	21	Male	2015	2,75
22	22	Male	2015	2,98
23	23	Female	2015	3,46
24	24	Male	2015	3,00
25	25	Male	2015	3,23
26	26	Male	2015	3,38
27	27	Male	2015	2,84
28	28	Female	2014	3,17
29	29	Female	2014	2,54
30	30	Female	2014	2,22