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HOANG THI GIANG

LEAD CONTAMINATION IN CHILDREN LIVING NEAR THE MINE - THE RESULTS OF INTERVENTIONS AT TWO STUDY SITES IN BAC KAN AND THAI NGUYEN IN 2016-2018

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SUPERVISORS:

1. **PGS.TS. BS. DOAN NGOC HAI**
2. **PGS.TS.BS. PHAM MINH KHUE**

Reviewer 1: Prof. Tran Quoc Kham, MD, PhD
Ministry of Health

Reviewer 2: Prof. Hoang Khai Lap, MD, PhD
Thai Nguyen University of Medicine and Pharmacy

Reviewer 3: Assoc. Prof. Chu Văn Thang, MD, PhD
Hanoi Medical University

The dissertation will be examined by Examination Board of Haiphong University of Medicine and Pharmacy

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LIST OF WORKS RELATED TO THE DISSERTATION HAS BEEN PUBLISHED

1. **Hoang Thi Giang**, Doan Ngoc Hai, Pham Minh Khue, Lo Van Tung (2019), "Situation of lead poisoning and the physical and mental development among children living near mining sites in Bac Kan and Thai Nguyen", *Vietnam Journal of Preventive Medicine*, Vol 29, n^{0}3 – 2019, pg. 26-34, Article in Vietnamese

2. **Hoang Thi Giang**, Doan Ngoc Hai, Dinh Thi Dieu Hang, Pham Minh Khue, Lo Van Tung (2019), "Effectiveness of preventive measures against childhood lead poisoning in Bac Kan and Thai Nguyen province", *Vietnam Journal of Preventive Medicine*, Vol 29, n^{0}3 – 2019, pg. 18-25, Article in Vietnamese

3. Doan Ngoc Hai, Lo Van Tung, Duong Khanh Van, Ta Thi Binh, Ha Lan Phuong, Nguyen Dinh Trung, Nguyen Duc Son, **Hoang Thi Giang**, Nguyen Minh Hung and Pham Minh Khue, (2018), "Lead Environmental Pollution and Childhood Lead Poisoning at Ban Thi Commune, Bac Kan Province, Vietnam". *BioMed Research International*, Volume 2018, Article ID 5156812, page 1-7, Article in English

INTRODUCTION

Childhood lead contamination is a global public health problem, especially in developing countries, including Vietnam. According to World Health Organisation (WHO) in 2016, lead was considered to be the cause of 540,000 deaths; the loss of 13.9 million years of healthy life (DALYs); accounted for 63.8% of the burden of idiopathic intellectual disability, 3% of ischemic heart disease and 3.1% of stroke globally. Children who are contaminated to lead, even at the low levels of exposure, can be affected on their health and intellect, impact significantly on themselves, their family and society.

The Tan Long commune, Thai Nguyen province and Ban Thi commune, Bac Kan province have a long-standing developed lead-zinc ore mining, which is the main driving force for economic development. However, there are many problems with lead pollution, which cause the risk of lead contamination to people, especially children.

Therefore, we carried out this study "**Lead contamination in children living near the mine - the results of interventions at two study sites in Bac Kan and Thai Nguyen in 2016-2018**" aimed to the following objectives:

1- Describe the situation of blood lead contamination ≥ 10 µg/dl and the physical and mental development status of children living near the lead mine located in Ban Thi, Bac Kan and Tan Long, Thai Nguyen in the 2016-2018 period.

2- Determine some factors related to lead contamination in children in the study areas.

3- Evaluate the results of preventive interventions by health education and using pectin for children with blood lead levels ≥ 10 µg / dl in two study site.

THE NEW CONTRIBUTION OF THE DISSERTATION

The research has contributed to the national data on the status of lead contamination and of the physical and mental development in children living near the mine at Ban Thi, Bac Kan and Tan Long, Thai Nguyen - which has not been studied before in Viet Nam. Researching a large number of children with invasive testing is one of the major difficulties.

The study illustrated the low-cost models of intervention by health education combining with the use of pectin is feasible and effective, and they not only change people's attitudes and practices on preventing lead poisoning for children but also reduce lead contamination in children as well as contributing to improving children's health.

STRUCTURE OF THE DISSERTATION

The main part of the dissertation has 145 pages, consisting of the following sections:

Introduction: 2 pages

Chapter 1- Overview: 40 pages

Chapter 2 - Materials and Methods: 25 pages

Chapter 3 - Results: 40 pages

Chapter 4 - Discussion: 35 pages

Conclusions and recommendations: 3 pages

The dissertation has 143 references, including 34 Vietnamese and 109 English onces, 49 tables and 10 figures. There are totally 10 appendices of 61 pages.

Chapter 1 : OVERVIEW

1.1. Lead and its effects on children's health

1.1.1. Penetration pathways, accumulation and elimination of lead

Lead can penetrate into body through the respiratory, digestive, skin and mucous membranes. The penetration varies by inorganic or organic lead. In children, ingestion is the most common route of exposure because they have a habit of sucking on objects, toys or playing on a dirty background and poor hand hygiene. Lead absorption increases when having nutritional deficiencies such as iron, vitamin D and calcium.

When lead enters the body, it is particularly attached with red blood cells, the rest is attached with the protein then concentrated in organ systems. Lead is excreted mainly through urinary tract (> 75%) and gastrointestinal tract (15-20%).

1.1.2. Lead effects on children's health

Lead is associated with a wide range of toxicity in children across a very broad band of exposures, even some its effect at the low blood lead concentrations has not been studied yet. These toxic effects extend from acute, clinically obvious, symptomatic poisoning at high levels of exposure down to subclinical effects at lower levels. Lead poisoning can affect virtually every organ system in the body. The principal organs affected are the central and peripheral nervous system, the cardiovascular, gastrointestinal, renal, endocrine, immune and haematological systems.

1.1.3. Diagnosis and treatment of lead poisoning in children: follow Decision n^{o} 1548/QĐ-BYT of Ministry of Health date on 10/5/2012

Diagnosis:

a) Severe level: Blood lead levels (BLLs) >70 µg /dL

b) Moderate level: BLLs from 45 to 70 µg /dL

c) Mild level: BLLs from >10 to < 45µg /dL

In addition to blood lead testing, it is necessary to assess further by clinical symptoms, other probes such as hematology, blood biochemistry, 24 hours lead urinary and other tests if necessary.

Treatment: moderate and severe poisoning or complicated events need to be closely monitored and investigated, include symptomatic treatment, supportive treatment and limitation lead absorption.

1.2. Epidemiology of lead contamination in children

According to WHO in 2009, child lead poisoning accounted for about 0.6% of the global burden of disease. Estimated in 2016, lead exposure caused for 540,000 deaths and 13.9 million years of healthy life lost worldwide due to long-term health effects. The burden from lead contamination is mainly in low-income areas, related to the development of mining industries, the production and recycling of lead-containing products such as electronics and batteries...In Senegan, from November 2007 to March 2008, 18 children died due to illegal recycling of batteries, many other children living in contaminated areas had very high blood lead levels. In Haiti, a study conducted in 2015 also showed that 65.9% of 273 children aged of 9 months to 6 years having BLLs >5 µg/dl dued to waste battery activities. In the Philippines, 21% of children had BLLs >10 µg/dl out of 2861 children under 5 years old.

In Vietnam, the study of Dang Ngoc Anh in Chi Dao commune, Van Lam district, Hung Yen province (2008) showed that the percentage of students with urinary delta ALA >10 mg/l accounted

for 45.0%; Lo Van Tung's research on 109 children under 10 years old in Dong Mai lead recycling village (2011) showed that 100% of children screened had BLLs >10 μg/dL, 19 children with BLLs > 45μg/dL; other research conducted by Sanders A. P. among 20 children in Nghia Lo, Hung Yen province also showed that 80% of the subjects tested had a BLLs > 10 μg/dl.

1.3. Preventive intervention of lead contamination

- Interventions to minimize environmental pollution
- Medical intervention: screening and early treatment
- Community intervention: health education and using pectin

Chapter 2. MATERIALS AND METHODOLOGY

2.1. Research objects, location and timing:

2.1.1. Research objects

- Children aged of 3 to 14 years old, living in Tan Long commune, Đong Hy district, Thai Nguyen province and Ban Thi commune, Cho Don district, Bac Kan province

Inclusion criteria:

- Do not suffer from serious diseases such as cerebral palsy, disability...
- Parents or caregivers directly agree to participate in the study (sign consent form)

- Parents or caregivers directly

Inclusion criteria:

- Having children aged of 3 to 14 years old chosen into study
- Be caregivers directly the children everyday
- Agree participate to study

- Environment samples: soil, drinking water and air samples where the children live in to evaluate the lead contamination risk

2.1.2. Location

Tan Long commune, Đong Hy district, Thai Nguyen province and Ban Thi commune, Cho Don district, Bac Kan province

2.1.3. Timing: from June 2016 to September 2017

2.2. Methodology

2.2.1. Research design

Cross-sectional descriptive and commutinity invervention study.

2.2.2. Sample size and sampling method

2.2.2.1. Sample size for cross-sectional descriptive study

❖ *Sample size for evaluate lead contamination in children*

- 403 pairs of children aged 3 to 14 and their parents, including 195 children in Ban Thi and 208 children in Tan Long

❖ *Sample size for lead contamination in environment:* 180 samples, including 60 soils, 60 dringking waters and 60 air samples

2.2.2.2. Sample size for commutinity intervention study: 197 pairs of children and their parents, including 115 children in Ban Thi and 82 children in Tan Long

2.3. Data collection

2.3.2. Variables and research index:

- The situation of lead contamination and the physical and mental development status of children

+ Average of BLLs, BLLs following age, sex, location

+ Height, weight, chest index, Body Mass Index (BMI), red blood cell and Hemoglobin (Hb) following BLLs

+ Mental and behavior development index according to Raven, ASQ, DBC-P and Vanderbilt scale following BLLs

+ BLLs (CDC 2005): <10, from 10 – 45 and > 45µg/dl

- Determine some factors related to lead contamination in children in

the study areas

+ Environmental factors: lead concentration in soils, drinking water and air ambiance at study sites

+ Social demographics and behavior factors of children: age, sex, history of using “thuoc cam” (a kind of traditional medicine) , hand washing habits before meals, outdoor play time and characteristics of play area

+ Familial factors: parents work at the mine, the distance from home to the mine, the drinking water source used at home, the habit of clothes washing when there are people working at the mine and the knowledge, attitude and practice (KAP) of the father/mother about preventing lead poisoning for children

- Evaluate the results of preventive interventions by health education and using of pectin for children

+ Percentage of KAP of parents before and after intervention

+ BLLs changing and some symptoms related to chronic lead contamination in children before and after intervention

2.3.3. Data collection techniques and tools

2.3.3.2. Data collection tools for lead contamination risk in children and KAP of lead poisoning prevention among parents

Using two questionnaires based on the reference of previous studies and the theoretical framework for risk of childhood lead poisoning to interview the parent.

2.3.3.3. Blood lead and lead concentration in environment testing

Blood and environmental samples after collection will be analyzed to assess the lead concentration at the laboratory of the National Institute of Occupational and Environment Health (NIOEH) according to the corresponding technique.

References for lead concentration in soil, drinking water and air ambiance were Vietnamese Standard QCVN 03-MT:2015/BTNMT, QCVN 01:2009/BYT và QCVN 05:2013/BTNMT, respectively.

2.3.3.4. Examination and psychological technique in children:

- Examination technique: internal medical examination including weight, height, chest index performed by the pediatric specialists at the health station of Ban Thi and Tan Long communes
- Psychological evaluation technique:
  - Test ASQ (Ages and Stages Questionnaires) for children ≤6 years old
  - Test Raven for children >6 years old: calcul and classify IQ score
  - Neurological-behavior assessment: Development Behavior checklist (DBC-P) and Vanderbilt scale, for all children involved

2.3.3.5. For intervention phrase:

The intervention had two components: Health education of childhood lead poisoning prevention and using pectin

a. Health education component

Providing of leaflets and posters for parents at health station where children go for health checkups conbinning with implementing health education. The education sessions were organised with small groups of 20 to 30 people, conducted by researchers from NIOEH once a month for 3 months.

b. Using pectin intervention

- Free Pectin Complex product for children with BLLs ≥ 10 µg/dl, using guiding, monitor and evaluate the use according to the manufacturer's instructions. - Dosage and administration: children aged 3-12 years old take 4 capsules/day, 2 times; children over 12 years old take 12 tablets/day, 3 times. Duration: 6 months.

2.4. Data analyses: Data will be cleaned, entered into Epidata 3.1 software and processed by Stata software 12.0.

2.5. Ethical issues

The study was followed the approval protocol of Hai Phong University of Medicine and Pharmacy and received the consensus of the Health Center of Bac Kan and Thai Nguyen provinces. Children and their parents were clearly explained the purpose and meaning of the study and voluntarily participated in the study. All personal information is kept confidential and only used for research. When there were health abnormalities, they were notified and advised on treatment and preventive measures.

Chapter 3: RESULTS

3.1. The situation of lead contamination, physical and mental development among children aged 3-14 years

Table 3. 1. BLLs in children according to settings

BLLs (µg/dl)	**Ban Thi (n=195)$_{(1)}$**	**Tan Long (n=208)$_{(2)}$**	**Total (N=403)**	**$P_{1\&2}$**
	n (%)	n (%)	n (%)	
< 5	1 (0,51)	45 (21,63)	46 (11,41)	**<0,001**
5 - <10	37 (18,97)	55 (26,44)	92 (22,83)	
≥10 - 45	157 (80,51)	104 (50,0)	261 (64,76)	
> 45	0	4 (1,92)	4 (0,99)	
X ± SD	15,42± 6,45	13,47±11,48	14,41± 9,42	**<0,001**

Interpret: At Ban Thi, 80,51% of children had BLLs in the range 10 – 45 µg/dl. At Tan Long, 50% of children had BLLs in the range 10 – 45 µg/dl, 1,92% having above 45 µg/dl.

Table 3. 2. BLLs in children according to age group

BLLs (µg/dl)	Ban Thi (n=195) (n,%)			Tan Long (n=208) (n,%)		
	< 6 y*	6-10 y*	11-14 y*	< 6 y*	6-10 y*	11-14 y*
< 5	0	1 (0,88)	0	18 (32,73)	18 (18,56)	9 (16,07)
5-<10	5 (11,11)	24 (21,24)	8 (21,62)	8 (14,55)	30 (30,93)	17 (30,36)
≥10 – 45	40 (88,89)	88 (77,88)	29 (78,38)	29 (52,73)	46 (47,42)	29 (51,79)
> 45	0	0	0	0	3 (3,09)	1 (1,79)
P_{Khi2}	0,515			0,098		
X±SD	16,9 ± 6,74	15,31 ± 6,52	13,92 ± 5,58	12,94 ±11,11	13,31 ±11,28	14,29 ±12,33
P_{Anova}	0,109			0,811		

**years old*

Interpret: There were no significant differences about the BLLs among age groups in the both settings, with p > 0.05

Table 3. 5. BLLs in children according to gender

BLLs (µg/dl)	Ban Thi (n=195)		Tan Long (n=208)		Total (N=403)	
	Boy (n=109)	Girl (n=86)	Boy (n=123)	Girl (n=85)	Boy (n=232)	Girl (n=171)
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
5 - <10	14 (12,84)	24 (27,9)	57 (46,34)	43 (50,59)	71 (30,6)	67 (39,18)
≥10 – 45	95 (87,16)	62 (72,1)	64 (52,03)	40 (47,06)	159 (68,54)	102 (59,65)
> 45	0	0	2 (1,63)	2 (2,35)	2 (0,86)	2 (1,17)
$p_{Khi2/Fisher}$	**0,008**		0,702		0,146	
X ± SD	16,53 ± 5,95	14,01 ± 6,80	13,84 ± 11,19	12,92 ±11,92	15,08 ± 9,19	13,49 ± 9,69
$p_{ManWhitney}$	**0,006**		0,368		**0,020**	

Interpret: In the both sites, the mean of BLLs were more likely in boys than in girls, with $p < 0.05$

Table 3.6-3.7. Height, weight of children according to BLLs

BLLs (µg/dl)	**Height (cm) (X** ± SD**)**			**Weight (kg) (X** ± SD**)**		
	< 6 y*	**6-10 y***	**11-14 y***	**< 6 y***	**6-10 y***	**11-14 y***
< **10 (1)**	102,96 ± 8,55	123,08 ± 8,79	150,44 ±9,67	15,42 ±2,9	23,38 ±5,48	40,2 ±9,18
≥ 10 (2)	101,13 ± 7,89	122,85 ±10,74	146,52 ±9,24	14,9 ±2,08	22,87 ±5,83	37,76 ±10,2
$P_{(1\&2)}$ (Mann-Whitney)	0,370	0,718	0,059	0,39	0,36	0,141

**Years old*

Interpret: The height, weight of children in all age groups were lower in children having BLLs ≥10 µg/dl ($p>0,05$).

Table 3.8-3.9. Chest and BMI indexes in children according to BLLs

BLLs (µg/dl)	**Chest index (cm) (X** ± SD**)**			**BMI (X** ± SD**)**		
	< 6 y*	**6-10 y***	**11-14 y***	**< 6 y***	**6-10 y***	**11-14 y***
< **10 (1)**	51,54 ±3,19	57,23 ±5,22	69,52 ±8,29	14,49 ±1,6	15,27 ±2,22	17,55 ± 2,59
≥ 10 (2)	50,55 ±3,10	56,64 ±5,55	68,16 ±8,13	14,37 ±1,31	14,92 ±1,67	17,34 ± 3,2
$P_{(1\&2)}$ (Mann-Whitney)	0,098	0,239	0,426	0,899	0,615	0,334

**Years old*

Interpret: The chest and BMI indexes of children in all age groups were lower in children having BLLs ≥10 µg/dl ($p>0,05$).

Table 3.10. Hematological index in children according to BLLs

Hematological index / BLLs	Ban Thi (n=195) (X ± SD)		Tan Long (n=208) (X ± SD)		Total (N=403) (X ± SD)	
	RBC* (T/l)	**Hb (g /l)**	**RBC* (T/l)**	**Hb (g /l)**	**RBC* (T/l)**	**Hb (g /l)**
< 10 µg/dl (1)	4,57 ± 0,45	117 ± 7,93	4,78 ± 0,53	125,98 ±10,21	4,72 ± 0,52	123,5 ± 10,42
≥10 µg/dl (2)	4,60 ± 0,46	115,16 ± 10,47	4,86 ± 0,52	124,78 ±12,16	4,71 ± 0,5	120,08 ± 12,13
$p_{(1/2)\ (ManWhitney)}$	0,57	0,66	0,15	0,723	0,989	**0,009**

**Red blood cells*

Interpret: The Hb levels were lower in children having BLLs<10 µg/dl than the others (p<0,05). There was no differences about red blood cells between two groups (p>0,05).

Table 3. 11. Children's symptoms according to BLLs

BLLs (µg/dl) / Symptom	Ban Thi (n=195) (n, %)		Tan Long (n=208) (n, %)		Total (N=403) (n, %)	
	< 10 (n=38)	≥10 (n=157)	< 10 (n=100)	≥10 (n=108)	< 10 (n=138)	≥10 (n=265)
Stoma-chache	13 (34,21)	45 (28,66)	9 (9,0)	35 (32,41)	22 (15,94)	80 (30,19)
P_{Khi2}	0,502		**<0,001**		**0,002**	
Nausea, vomit	3 (7,89)	12 (7,64)	3 (3,00)	7 (6,48)	6 (4,35)	19 (7,17)
P_{Khi2}	0,958		0,241		0,265	
Anorexia	11 (28,95)	31 (19,75)	7 (7,0)	30 (27,78)	18 (13,04)	61 (23,02)
P_{Khi2}	0,216		**<0,001**		**0,017**	
Consti-pation	7 (18,42)	25 (15,92)	9 (9,0)	6 (5,56)	16 (11,59)	31 (11,70)
P_{Khi2}	0,709		0,337		0,975	
Lead line on the gums	8 (21,05)	17 (10,83)	7 (7,0)	24 (22,22)	15 (10,87)	41 (15,47)
P_{Khi2}	0,091		**0,002**		0,205	

Interpret: In Ban Thi, there were no significant differences in the symptoms of chronic lead poisonning between two groups of BLLs lower and upper 10 µg/dl. In Tan Long, the proportion of children having stomachache, anorexia and a lead line on the gums were more likely in the children having ≥10 µg/dl of BLLs than that of <10 µg/dl with p <0.05

Table 3. 15. The behavior development of children basing on Vanderbilt scale according to BLLs

BLLs (µg/dl) / **Vanderbilt scale**	**Ban Thi (n=195)**		**Tan Long (n=208)**		**Total (N=403)**	
	<10 (n=38)	≥10 (n=157)	<10 (n=100)	≥10 (n=108)	<10 (n=138)	≥10 (n=265)
Low attention (X± SD)	2,97 ± 3,00	2,70 ± 2,45	1,39 ±2,43	3,14 ± 3,03	1,82 ±2,68	2,88 ±2,71
p	0,873		**<0,001**		**< 0,001**	
Hyperactivity (X ± SD)	2,57 ± 2,69	2,28 ± 2,38	0,94 ±1,81	1,50 ± 1,75	1,39 ±2,12	1,96 ±2,17
p	0,747		**< 0,001**		**< 0,001**	
Behavior disorders (X ± SD)	1,34 ± 1,66	1,50 ± 1,61	0,74 ±1,31	0,77 ± 1,32	0,90 ±1,43	1,21 ±1,54
p	0,480		0,454		**0,018**	
Anxienty (X ± SD)	1,78 ± 1,93	1,37 ±1,77	0,59 ±1,20	1,0 ±1,47	0,92 ±1,53	1,22 ±1,66
p	0,215		**0,010**		**0,015**	

Interpret: The mean scores of low attention, hyperactivity, behavior disorders and anxienty disorders were higher in the children having ≥ 10 µg/dl of BLLs in both settings (p < 0,05).

3.2. Several factors related to lead contamination in children

3.2.1. Factors related to living environment of children

Table 3.16. Lead concentration in the soil

Settings	N	Mean ± SD (mg/kg)	Min	Max	Over of VN standard* (n/%)
Ban Thi (1)	30	2980,23 ± 6092,84	80,05	33820,62	30 (100,0)
Tan Long(2)	30	263,46 ± 367,84	11,72	1790,36	22 (73,33)
p1&2 (Mann Whitney test)		**< 0,001**			

**Vietnamese standard*

Interpret: The lead concentration in the soil was 10 times more likely in Ban Thi than in Tan Long, and it was 43-time higher than the standard in Vietnam

Table 3.17. Lead concentration in the air

Settings	N	Mean ± SD (µg/m3)	Min	Max	Over of VN standard (n/%)
Ban Thi (1)	30	5,89 ± 4,19	1,6	18,5	30 (100,0)
Tan Long (2)	30	6,79 ± 5,37	2	30,2	30 (100,0)
p1&2 (Mann Whitney test)		0,277			

Interpret: The lead concentrations in the air in Ban Thi and Tan Long were 4-4.5 times more likely than the VN standards

Table 3.18. Lead concentration in the drinking water

Settings	N	Mean ± SD (mg/L)	Min	Max	Over of VN standard (n/%)
Ban Thi (1)	30	0,0033 ±0,0031	0,002	0,0135	3 (10,0)
Tan Long (2)	30	0,0077 ±0,0191	0,0002	0,0993	4 (13,33)
p1&2 (Mann Whitney test)		0,581			

Interpret: The means of lead concentration in drinking water in Ban Thi and Tan Long were not higher than the standard in Vietnam. However, there were 10% and 13.33% of samples with over standard of lead concentration in Ban Thi and Tan Long, respectively.

3.2.2. Relevant factors of lead contamination related to behavior and habits of children in Ban Thi, Bac Kan and Tan Long, Thai Nguyen

Table 3.26. Relevant factors of lead contamination related to behavior and habits of children in multivariate regression analysis

Relevant factors		Ban Thi (n=195)	
		aOR (95%IC)	p
Age (years)	< 6	1	
	6 – 10	0,44 (0,14 – 1,37)	0,159
	11 - 14	0,53 (0,12 – 2,20)	0,385
Male		**2,66 (1,22 – 5,77)**	**0,013**
Playing areas surface is soil		1,97 (0,87 – 4,46)	0,103

Interpret: In multivariate regression analysis, there was an significant association between gender in male and lead contamination in Ban Thi, (AOR= 2,66, 95%CI: 1,22-5,77, p=0,013), while there were no significant associations in Tan Long.

3.2.3. Relevant factors of lead contamination related to children's family in Ban Thi, Bac Kan and Tan Long, Thai Nguyen

Table 3.34. Relevant factors of lead contamination related to children's family in multivariate regression analysis

Relevant factors		Tan Long (n=208)	
		aOR (95%IC)	**p**
Distance between children's house and ore-lead mining area ≤ 2km		**2,23 (1,19 – 4,20)**	**0,012**
Knowledge of lead contamination	*Low*	1,19 (0,33 – 4,26)	0,782
	Average	1,48 (0,70 – 3,12)	0,298
Bad attitude about lead contamination		0,73 (0,20 – 2,67)	0,641

Interpret: There was a significant association between the distance less than 2km from children's house to ore-lead mining area and lead contamination in Tan Long (aOR = 2,23, p <0,05), while there was no such association in Ban Thi.

3.3. Result of preventive intervention

3.3.1. Knowledge, attitude and practice of parent in preventing lead contamination for their children

Table 3.46. The results of parental knowledge, attitude and practice in preventing lead contamination for their children

Variable	Ban Thi (n=115)		Tan Long (n=82)		Total (N=197)	
	Before	After	Before	After	Before	After
Good knowlegde (n,%)	69 (60,0)	103 (89,57)	50 (60,98)	77 (93,9)	119 (60,41)	180 (91,37)
EI** (%)	49,0*		54,0*		51,2*	
Good attitude (n,%)	114 (99,13)	114 (99,13)	72 (87,8)	82 (100)	186 (94,42)	196 (99,49)
EI** (%)	0		14,0*		5,4*	
Good practice (n,%)	34 (29,57)	56 (48,7)	21 (25,61)	35 (42,68)	55 (27,92)	91 (46,19)
EI** (%)	64,7*		66,6*		65,4*	

**p<0,05, ** Effectiveness index*

Interpret: After intervention, the KAP of parents in preventing lead contamination has increased, the EI obtained 5,4% up to 66,6%.

3.3.2. Result of improving BLLs and several symptoms of lead contamination in children

Table 3.47. Result of BLLs in children

BLLs	Before	After	EI (%)	p
Ban Thi (n=115)				
≥ 10 µg/dl (n, %)	115 (100)	103 (89,57)	10,43	**<0,001**
Mean ± SD (µg/dl)	17,41±5,67	15,54± 5,55	10,74	**0,006**
Tan Long (n=82)				
≥ 10 µg/dl (n, %)	82 (100)	53 (64,63)	35,37	**<0,001**
Mean ± SD (µg/dl)	22,68±11,37	12,7 ± 4,93	44,0	**<0,001**
Total (N=197)				
≥ 10 µg/dl (n, %)	197 (100)	156 (79,19)	20,81	**<0,001**
Mean ± SD (µg/dl)	19,6 ± 8,88	14,35±5,47	26,8	**<0,001**

Interpret: After intervention, the proportion of children having ≥ 10 µg/dl of BLLs decreased by 20,81%, and the mean of BLLs decreased by 26,8% (p<0,05).

Table 3.48. The results of symptoms of lead concentration in children (N=197)

Symptoms	Before n (%)	After n (%)	CSHQ (%)	p
Nausea, vomit	14 (7,11)	12 (6,09)	14,3	0,694
Stomachache	59 (29,95)	38 (19,29)	35,6	**0,003**
Anorexia	48 (24,37)	32 (16,24)	33,3	**0,013**
Constipation	22 (11,17)	8 (4,06)	64	**0,006**

Interpret: After intervenion, the proportion of children having symptoms of stomachache, anorexia and constipation decreased significantly in both settings with p<0,05. Thereby, the effectiveness index was the highest in improving constipation (64%).

Chapter 4: DISCUSSION

4.1. The situation of lead contamination and physical, mental development of children aged 3-14 years

4.1.1. The situation of lead contamination in children

Among 403 children in final analysis, including 195 children in Ban Thi, Bac Kan and 208 children in Tan Long, Thai Nguyen, there were 80.51% of children having BLLs in the range of 10 – 45 µg/dl and no one had BLLs above 45 µg/dl in Ban Thi, while 50% and 1.92% children having blood lead concentration of 10 – 45 µg/dl and > 45 µg/dl, respectively, in Tan Long. The mean of BLLs in children was more likely in Ban Thi, as compared to tan Long (15,42 ± 6,45 µg/dl in comparision with 13,47 ± 11,48 µg/dl, $p < 0.05$), and the mean in total was 14,41 ± 9,42 µg/dl (table 3.3). Therefore, the situation of lead contamination in both settings was indeed worrying. Our results were in line with the study in Dong Mai craft villages with 70.4% children having BLLs in the range of 10-45µg/dl. Also, in Nigeria, a national program (2010) reported that 118 children aged under-5 year died due to lead poisoning, in which 59% of them had BLLs above 10 µg/dl.

The highest proportion of lead contamination was 69% in children aged under-6 year ($p<0.05$), and the mean of BLLs was relatively uniform in age groups ($p>0.05$) (table 3.5). The proportion of lead contamination and mean of BLLs were more likely in boys than in girls.

4.1.2. The situation of physical and mental development in children

The height, weight, chest index and BMI were lower in age groups under-6, between 6 and 10 and 11-14 years old in the group

of children having BLLs ≥ 10 µg/dl compared with the other group. In particular, the gap is likely to increase in the higher age groups (Table 3.6-3.9). Although the difference is not statistically significant with p> 0.05, this result still showed that lead contamination can affect the physical development of children. A longitudinal follow-up study within 10 years in Russia on 481 children also showed that BMI was also higher than that of children with high BLLs (p <0.05).

Regarding hematological index, the table 3.11 showed that the Hb mean in the group of < 10 µg/dl BLLs was 123.5 ± 10.42 g/l, which was higher than the group of ≥ 10 µg/dl BLLs with 120,5 g/l and p = 0,009 (p <0,05).

In Tan Long, children having BLLs ≥10 µg/dl had the a 3-4 times higher proportion in stomachache, anorexia and having a lead line on the gums than those having no lead contamination with p <0.05.

According to DBC-P scale (table 3.14), children having BLLs ≥10 µg/dl were more likely to have the risks of break/protest, self-satisfaction, disorders of communication, anxiety and public relationship. According to Vanderbilt scale (table 3.15), the mean scores of low attention, hyperactivity, disorders of behavior and anxiety were significantly higher in the children having BLLs ≥10µg/dl in two settings (p<0,05). These results illustrated that the lead contamination can affect to the mental health development in children.

4.2. Relevant factors of lead contamination in children

4.2.1. Factors related to living environment of children

The lead concentration in the soil in Ban Thi was 2980,23 ± 6092,84 mg/kg, which was 12 times more likely than that in Tan Long with 263,46 ± 367,84 mg/kg (p<0,05) and 43 times higher than

in the Vietnamese standard levels with 70 mg/kg dry soil (table 3.18). 100% and 73% of soil samples exceeded the standard in Ban Thi and Tan Long, respectively.

The lead concentration mean in the air in both settings was 4-4.5 times higher than that of standard in Vietnam. All air samples were over standard level.

The lead concentration means in drinking water in Ban Thi and Tan Long were in the Vietnamese standard levels (table 3.18). However, there were 3 samples in Ban Thi and 4 samples in Tan Long exceeding the standard levels.

4.2.2. Relevant factors of lead contamination related to behavior and habits in children

In multivariate analysis, the boys were 2.6 times more likely to contaminate lead than the girls (95%CI: 1,22 – 5,77, p=0,013) in Bac Kan (table 3.26), while there was any association in Tan Long.

4.2.3. Relevant factors of lead contamination related to family

In multivariate analysis, among the factors related to children's family (table 3.34), the current study found only a significant association between the distance within 2km from children's house to ore-lead mining area and lead contamination in children in Tan Long (aOR = 2,23; 95%CI 1,19-4,20; p=0,012).

As a result, the risk of lead contamination in children was remarkably related to living environment in both settings. Therefore, the intervention programs concerning to environmental issues and relocation of residents far from ore-lead mining areas in order to reduce the effects of lead contamination on children's health were necessary.

4.3. Results of preventing intervention

In the cross-sectional period, 265 children suffered from lead contamination, in which 261 people had the BLLs from 10 to 45 µg/dl and 4 people with above 45 µg/dl, consisted 157 and 108 children were found in Ban Thi and Tan Long. All of children and their family were invited into the intervention phrase. After 6 months, the number of children obtained was 197, including 115 children in Ban Thi and 85 children in Tan Long.

4.3.1. Results in improving parental knowledge, attitude and practice in preventing lead contamination in children

After 6 months of intervention, the knowledge, attitude and practice of parents changed positively in both study settings, and the remarkable changes were in knowledge and practice (table 3.46). The EI of knowledge was 49% in Ban Thi and was 54% in Tan Long. The EI of attitude was 14% in Tan Long, while that number in Ban Thi did not change because of the high proportion before intervention. The EI of practice was 64,7%, 66,6% and 65,4% in Ban Thi, Tan Long and both settings, respectively ($p<0,05$).

4.3.2. Results in improving blood lead levels and symptoms of lead contamination in children

Table 3.47 showed the significant changes in BLLs after 6 months of intervention. In details, the BLLs mean and the proportion of children having BLLs ≥10 µg/dl decreased significantly ($p<0.05$). In Ban Thi, the proportion of children having BLLs ≥10 µg/dl decreased by 10.43%, the BLLs mean reduced to 1.87 µg/dl, and the EI was 10.74% ($p <0,05$), while the figures for that in Tan Long decreased by 35.37%, 9.98 µg/dl and 44%, respectively ($p <0.05$). In the total, the proportion of children having BLLs ≥10 µg/dl decreased by 20.81%, and the BLLs reduced to 26.8% ($p<0.001$).

After intervention, there was no children having BLLs > 45 µg/dl. The reduction in Tan Long was higher than in Ban Thi, which might relate to the improvement in parental KAP in Tan Long.

Besides, our study showed the improving of some chronic symptoms of lead contamination in children in two study sites. After intervention, the proportion of chidlldren having stomachache, anorexia and constipation fell down with the range of 33,3% and 64% ($p<0,05$) (table 3.48).

4.4. Limitation of research

Firstly, the study has not mentioned the factors related to the lead contamination with nutritional problems in children and the risk from food lead contaminated. Secondly, the lack of a control group for comparison after intervention might limit some research results. Thirdly, there are no environmental interventions, many studies have shown that the combination of health education, environmental interventions and medical mesures could give more effective.

CONCLUSION

4.1. The lead contamination status and the physical and mental development status among the children aged of 3 to 14 years old

- Proportion of children having BLLs ≥ 10 µg/dl was 65,76% in general, 80,51% in Ban Thi and 51,92% in Tan Long. In Tan Long, 1,92% had BLLs > 45µg/dl. Average of BLLs in Ban Thi was 15,41 ± 6,44 µg/dl and in Tan Long was 13,47 ± 11,48 µg/dl, in two sites was 14,41 ± 9, 42 µg/dl
- The height was lower from 1 to 4 cm, the weight was lower from 0.5 to 2.5 kg, the chest index was lower from 0.5 to 1.3 cm and

the BMI was lower from 0.12 to 0.3 of all age groups among those having BLLs ≥10 µg/dl (p> 0.05)

- Hb index in children having BLLs <10 µg/dl was 123 g/l higher than other group with 120.08 g/l (p <0.05)
- Children having BLLs ≥10 µg/dl had a higher risk of anxiety disorder and attention-deficit hyperactivity disorder according to DBC-P and Vanderbilt scale (p <0.05)

4.2. Relevant factors related to lead contamination in children

4.2.1. Environmental factors

- Lead in soil: 100% sample soils in Ban Thi and 73,33% sample soils in Tan Long exceeding the Vietnamese standard. Lead concentration in soil was 43 times higher in Ban Thi and 3,5 times higher in Tan Long than the Vietnamese standard
- Lead in air: 30% of air samples exceeding the Vietnamese standard, average of lead concentration in air were 4 times higher than the Vietnamese standard in both Ban Thi and Tan Long
- Lead in drinking water: 9.68% in Ban Thi and 13.33% in Tan Long exceeding the permitted standard

4.2.2. Factors related to children and their family

In the multivariate regression model, two factors related to lead contamination in children was male sex (aOR = 2.66, 95% CI: 1.22-5.77, p = 0.013) in Ban Thi, Bac Kan and distance from house to mining area less than 2 km (aOR = 2.23; 95% IC: 1.19-4.2 ; p = 0.012) in Tan Long, Thai Nguyen.

4.3. The results of preventive interventions by health education and using of pectin

4.3.1. Improving of knowledge, attitudes and practices of parents

After intervention, in both locations, the parental KAP on preventing of childhood lead contamination increased significantly, the EI achieved from 5.4 to 66.6% ($p<0,05$).

4.3.2. Amelioration of blood lead level and some symptoms of chronic lead infection among children

- Lead contamination: At Ban Thi, the rate of BLLs ≥10 µg/dl decreased by 10.43% and the average BLLs decreased by 1,87 µg/dl, EI was 26.8% ($p<0.05$). At Tan Long, the rate of BLLs ≥10 µg/dl decreased by 35.37% and the average BLLs decreased by 9,98 µg/dl, EI was 44% ($p<0.05$). In total, the rate of BLLs ≥ 10 µg/dl decreased by 20.81% and the average BLLs decreased by 26.8% ($p<0.001$), there was no child having BLLs > 45 µg/dl after intervention
- Lead contamination symptoms: Stomachache, anorexia, constipation decreased after intervention, EI decreased by 35.6%, 33.3% and 64%, respectively.

RECOMMENDATION

1. It is necessary to have integrated blood lead screening measures in the primary health care program in these two areas aimed to early detection of blood lead levels ≥ 10 µg/dl in children.
2. Relocation of residential areas away from where affected by lead ore mining activities
3. Implement the health education measures in combination with the use of pectin in areas whereas high risk of lead pollution in the country such as ore mining and recycling...
4. There should be more interventions to reduce lead pollution in soil, drinking water and air ambiance to get higher effectiveness in preventing lead poisoning for children in particular and people in general in these two sites.