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ASSOCIATION BETWEEN LIVING IN AN E-WASTE RECYCLING AREA AND HEALTH EFFECTS AMONG CHILDREN IN BURIRAM, THAILAND

Mr. Krittayot Panyakhong

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Title	Association between living in an e-waste recycling area and health effects among children in Buriram, Thailand
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หัวเรื่อง	การศึกษาความสัมพันธ์ระหว่างการอาศัยอยู่ในพื้นที่คัดแยกขยะ อิเล็กทรอนิกส์กับผลกระทบทางสุขภาพของเด็กในจังหวัดบุรีรัมย์
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บทคัดย่อ

การอาศัยอยู่ในพื้นที่คัดแยกขยะอิเล็กทรอนิกส์สามารถส่งผลให้ประชากรที่มีความไวต่อการรับสัมผัส เช่น เด็ก ได้รับสารมลพิษจากขยะอิเล็กทรอนิกส์และอาจส่งผลเสียต่อระบบต่าง ๆ ในร่างกาย ก่อให้เกิดความเสี่ยงต่อการเกิดโรคร้ายแรงตามมา การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาความสัมพันธ์ระหว่างการอาศัยอยู่ในพื้นที่คัดแยกขยะอิเล็กทรอนิกส์กับผลกระทบทางสุขภาพของเด็กในจังหวัดบุรีรัมย์ โดยใช้การศึกษาแบบตัดขวาง (Cross-sectional study) วิเคราะห์ข้อมูลผู้ป่วยเด็ก 125,823 คน (อายุ 0-15 ปี) ทดสอบความสัมพันธ์ใช้แบบจำลองการถดถอยโลจิสติกเพื่อคำนวณความสัมพันธ์และระดับความเสี่ยง adjusted odd ratio (AOR) ผลการศึกษาแสดงให้เห็นว่าในตำบลที่มีการคัดแยกขยะอิเล็กทรอนิกส์มีความชุกของโรคมากกว่าพื้นที่อ้างอิงอย่างมีนัยสำคัญทางสถิติ 5 โรค และพบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติ ระหว่างการอาศัยอยู่ในพื้นที่คัดแยกขยะอิเล็กทรอนิกส์กับการเกิดโรคเนื้องอก (AOR [95%CI] = 3.150 [1.722-5.761]) โรคของเลือดและอวัยวะสร้างเลือดและความผิดปกติบางอย่างของกลไกภูมิคุ้มกัน (AOR [95%CI] = 1.723 [1.303-2.279]) โรคของระบบประสาท (AOR [95%CI] = 2.033 [1.320-3.132]) โรคของตาและอวัยวะเคียงลูกตา (AOR [95%CI] = 3.001 [1.596-5.643]) และโรคของระบบสืบพันธุ์และระบบปัสสาวะ (AOR [95%CI] = 1.728 [1.149-2.599]) ในกลุ่มเด็กอายุ 0-6 ปี พบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการเกิดโรคของเลือดและอวัยวะสร้างเลือดและความผิดปกติบางอย่างของกลไกภูมิคุ้มกัน (AOR [95%CI] = 2.086 [1.442, 3.016]) โรคของระบบประสาท (AOR [95%CI] = 2.826 [1.694, 4.715]) โรคของตาและอวัยวะเคียงลูกตา (AOR [95%CI] = 3.862 [1.708, 8.734]) โรคของผิวหนังและเนื้อเยื่อใต้ผิวหนัง (AOR [95%CI] = 1.858 [1.058, 3.263]) โรคของระบบกล้ามเนื้อโครงร่างและเนื้อเยื่อเกี่ยวพัน (AOR [95%CI] = 3.143 [1.164, 8.487]) และโรคของระบบสืบพันธุ์และระบบปัสสาวะ (AOR [95%CI] = 1.947 [1.107, 3.422]) ในกลุ่มเด็กอายุ 7-12 ปี พบ

ความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการเกิดโรคเนื้องอก (AOR [95%CI] = 5.890 [2.845, 12.195]) และในกลุ่มเด็กอายุ 13-15 ปี พบความสัมพันธ์อย่างมีนัยสำคัญทางสถิติกับการเกิดโรคของระบบย่อยอาหาร (AOR [95%CI] = 2.051 [1.110-3.789]) และโรคของระบบสืบพันธุ์และระบบปัสสาวะ (AOR [95%CI] = 2.743 [1.214-6.199]) ผลการศึกษาชี้ให้เห็นว่าเด็กที่อาศัยอยู่ในพื้นที่คัดแยกขยะอิเล็กทรอนิกส์มีความเสี่ยงต่อการเกิดโรคเกี่ยวกับระบบต่าง ๆ ในร่างกายมากกว่าบริเวณอื่น โดยเฉพาะกลุ่มเด็กเล็ก 0-6 ปี เป็นกลุ่มที่ควรให้ความสำคัญในการลดการรับสัมผัสสารมลพิษที่ผ่านการดูดซึมทางผิวหนัง การหายใจ และการกิน ด้วยเด็กเล็กใช้เวลาเกือบ 24 ชั่วโมงในบ้านที่มีการคัดแยกขยะอิเล็กทรอนิกส์ การศึกษานี้ไม่ได้วิเคราะห์การรับสัมผัสมลพิษเชิงปริมาณหรือมลพิษจากแหล่งอื่น ๆ

คำสำคัญ : ขยะอิเล็กทรอนิกส์, ผลกระทบต่อสุขภาพ, เด็ก, ความสัมพันธ์

Title Association between living in an e-waste recycling area and health effects among children in Buriram, Thailand

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Abstract

Living in an e-waste recycling area could harm sensitive population like children to be exposed to toxic substances such as heavy metals and toxic chemicals. These can impact various systems of the children body. This work aimed to investigate association between living in e-waste recycling sites and children health effects in Buriram, the largest e-waste site in Thailand. This cross-sectional study analyzed 125,823 inpatient children records (aged 0 to 15 years old) from Buriram Hospital. A logistic regression model was fitted to investigate the association and adjusted odd ratio (AOR). The result showed statistically higher prevalence for 5 diseases in e-waste subdistricts and statistically confirmed the association and increased risk for neoplasms (AOR [95%CI] = 3.150 [1.722-5.761]), blood and immune diseases (AOR [95%CI] = 1.723 [1.303-2.279]), nervous system diseases (AOR [95%CI] = 2.033 [1.320-3.132]), eye diseases (AOR [95%CI] = 3.001 [1.596-5.643]) and genitourinary system diseases (AOR [95%CI] = 1.728 [1.149-2.599]). For young children (0-6 years old), we found statistically increased AORs for blood and immune mechanism diseases (AOR [95%CI] = 2.086 [1.442, 3.016]), nervous system diseases (AOR [95%CI] = 2.826 [1.694, 4.715]), eye diseases (AOR [95%CI] = 3.862 [1.708, 8.734]), skin diseases (AOR [95%CI] = 1.858 [1.058, 3.263]), musculoskeletal system diseases (AOR [95%CI] = 3.143 [1.164, 8.487]) and genitourinary system diseases (AOR [95%CI] = 1.947 [1.107, 3.422]). In middle age group (7-12 years old), the association was statistically

confirmed for neoplasms (AOR [95%CI] = 5.890 [2.845, 12.195]) and eye diseases (AOR [95%CI] = 2.732 [1.001, 7.457]). For old children (13-15 years old.), significantly increased AORs were observed for digestive system disease (AOR [95%CI] = 2.051 [1.110-3.789]) and genitourinary system disease (AOR [95%CI] = 2.743 [1.214-6.199]). The findings confirmed the association between childhood living in an e-waste recycling area and greater risks of various disease. The young group are at a priority to reduce exposure through skin absorption, inhalation and digestion as spending almost 24 hours in home as an e-waste workplace. This work did not account for chemical exposure or other contaminant sources.

Keywords: E-waste, health effects, children, association

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CHATPER I

INTRODUCTION

1.1 Problem statement

Electrical and electronic waste, also referred to informal word as e-waste, is defined as any electronic equipment or any electronic products such as televisions, mobile phones, computers, printers, lighting equipment or any electronic machines which are discarded, broken or nearing the end of useful life (Chan & Wong, 2013). E-waste is a source of a variety of materials that contain various toxic metal and persistent organic pollutants. Over 1,000 different chemicals which are heavy metals, polycyclic aromatic hydrocarbon (PAHs), polychlorinated biphenyls (PCBs) and brominated flame retardants, such as polybrominated diphenyl ethers (PBDEs), plus a number of plastics components identified in the e-waste streams (Schluep et al., 2009).

Disposal of e-waste is emerging environmental problem, as these wastes have become the most rapidly growing waste in the world, which is almost three time faster than the municipal waste stream is growing generally (Sankhla et al., 2016). If e-waste is handled informal recycling, these chemicals can release these chemical into the air, soil, groundwater and terrestrial ecosystems (Leung, Cai, & Wong, 2006), also could cause environmental problem and serious health effects to human. Studies found that soil samples from e-waste recycling area in Nigeria and China are highly contaminated to the toxic chemicals that are associated with human health (Alabi et al., 2012). Children's health can be easily affected from toxicants in many exposure pathways. Children between 0 to 15 years old have imperfect immune and they are very active in indoor and outdoor activities (Bearer, 1995). Previous studies had reported the association between living near to an e-waste recycling area and respiratory symptom among children (Zeng et al., 2016) and other effects such as cardiovascular disease(Cong et al., 2018), low lung

function symptom (X. Zheng et al., 2018) and thyroid disruption and reduced mental development (L. Liu et al., 2018).

It was reported that 50% - 80% of e-waste collected for recycling in developing countries, ends up in recycling center in Asia (Puckett et al., 2002). In Thailand, the domestic consumption of electrical and electronic devices is increasing rapidly, which is leading to rapidly growing e-waste volumes. Buriram is one of the biggest e-waste recycling area in Thailand. There are two e-waste recycling sites in Buriram which are Daeng Yai sub-district, Ban Mai Chaiyaphot district and Ban Pao sub-district, Phutthaisong district. The main occupation of population in both districts is agriculture. The average income from agriculture is about 30,000 baht per year. Their supplementary occupation is e-waste recycling job by purchasing and separating discarded electrical or electronic devices from household in their area including the outside by importing from industrial factories in neighboring provinces. The average income from e-waste recycling is about 60,000 to 80,000 baht per year, which is the main income of people in this area. Total population of those districts are 10,286 people which are 5,052 men and 5,234 women, there are 15 major e-waste buyers and 374 separators, e-waste is collected for separating in this area around 383 tons per week, remaining e-waste that is useless about 46 tons per week. In addition, Thailand has no strict laws on electrical and electronic waste management. It may lead to an increase in e-waste in this area, resulting in the risk of health problems on people in the area (Saijai Withayaanumas, 2017). As there are few studies on the impacts from e-waste recycling in Thailand, therefore this study aims to investigate the association between living near to e-waste recycling area and the health effects among children in Buriram which has many e-waste recycling sites.

2. Research objectives

1.2.1 To compare characteristics of children in Daeng Yai sub-district and Ban Pao sub-districts (e-waste exposed zone) with other districts (reference zone).

1.2.2 To determine and compare prevalence of diseases between the e-waste exposed zone and the reference zone.

1.2.3 To investigate the association between living in the e-waste exposed zone and health effects among children in Buriram

1.3 Scope of the research

1.3.1 This study was a cross-sectional design.

1.3.2 The study population were children aged 0-15 years who were admitted in Buriram Hospital

1.3.3 The period of this study was between 2007 – 2018

1.3.4 The study covered 14 diseases (certain infectious and parasitic diseases, neoplasms, diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism, endocrine, nutritional and metabolic disease, mental, behavioral and neurodevelopmental disorders, disease of the nervous system, diseases of the eye and adnexa, diseases of the ear and mastoid process, diseases of the circulatory system, diseases of the respiratory system, diseases of the digestive system, diseases of the skin and subcutaneous tissue, diseases of the musculoskeletal system and connective tissue and diseases of the genitourinary system).

1.4 Expected benefits

1.4.1 The prevalence of adverse health effects in children between the expose area and reference area can be used to develop surveillance program.

1.4.2 The strength of association between living in an e-waste recycling area and children's health effects can be used to plan for e-waste education and management to reduce exposure.

1.4.3 The found increased risk could be used for prioritizing financial support and risk reduction measures for age-specific group.

CHAPTER II

LITERATURE REVIEW

2.1 Definition of electronic waste

Electrical and electronic waste, also referred to informal word as e-waste, is defined as any electronic equipment or any electronic products such as televisions, mobile phones, computers, printers, lighting equipment or any electronic machines which are discarded, broken or nearing the end of useful life (Chan & Wong, 2013).

2.2 Categories of electronic waste

Electronic equipment has a wide range of products which have different feature and lifetime, thus causing different aspect of e-waste. It covers 10 categories that were shown in **Table 2.2.1** (Parliament, Council, The, & Union, 2003).

Table 2.2.1 Categories and products of e-waste

No	Category	Products
1	Large household appliances	Refrigerators, freezer, washing machines, electric stoves, microwaves, electric fans, air conditioner appliances, etc.
2	Small household appliances	Vacuum cleaners, toasters, fryers, electric knives, irons, appliances for tooth brushing, shaving, massage and other body care appliances, etc.

3	**IT and telecommunications equipment**	Printer units, mainframes, personal computers, copying equipment, telephones, other products or equipment of transmitting sound, images or other information by telecommunications, etc.
4	Consumer equipment and photovoltaic panels	Radio sets, television sets, video cameras, video recorders, hi-fi recorders, audio amplifiers, musical instruments, etc.
5	Lighting equipment	Luminaires for fluorescent lamps apart from luminaires in households, straight fluorescent lamps, compact fluorescent lamps, etc.
6	Electrical and electronic tools	Drills, saws, sewing machines, equipment for turning, milling, sanding, grinding, sawing, cutting, shearing, drilling, making holes, punching, folding, bending or similar processing of wood, metal and other materials, etc.
7	Toys, leisure and sports equipment	Electric trains or car racing sets, hand-held video game consoles, video games, computers for biking, diving, running, rowing, sports equipment with electric or electronic components, coin slot machines, etc.
8	Medical devices	Radiotherapy equipment, cardiology equipment, dialysis equipment, pulmonary ventilators, nuclear medicine equipment, laboratory equipment for in-vitro diagnosis, analyzers, etc.

9	Monitoring and control instruments	Smoke detector, heating regulators, thermostats measuring, weighing or adjusting appliances for household or laboratory equipment, other monitoring and control instruments used in industrial installations (for example, in control panels), etc.
10	Automatic dispensers	Automatic dispensers for hot drinks, automatic dispensers for hot or cold bottles or cans 65, automatic dispensers for solid products, automatic dispensers for money, all appliances which deliver automatically all kind of products

2.3 Hazardous chemicals in electronic waste

Hundreds of different materials are used to make electronic devices. It contains many toxic metals, acids and compounds that are harmful to the environment and human including lead, mercury, cadmium, plastic, chromium, beryllium, acid, selenium, polychlorinated biphenyls, etc**.** These pollutants can impact on various systems in the body, showing in **Table 2.2.2** (Vats & Singh, 2014)**.**

Table 2.2.2 Hazards association with metal/acid/compound and sources

Metal/Acid /Compound	**Source and Associated Hazards**
Lead	Mechanical destruction of CRTs, removal of soldering from microchips. Being a neurotoxin affects the kidneys and the reproductive system, mental development in children. In addition, toxins can accumulate in the environment causing acute effects and can be chronic in plant and animals.

Mercury	Damage to the immune system, impairs fetus growth and harms infants through mother's milk and can enter the human food chain through water. Inhalation of high concentration of mercury vapor can impact to the nervous system.
Cadmium	Grinding and milling of plastics, CRTs and circuit boards. Being a carcinogen causes Itai-itai disease, affects the kidneys and softens bones.
Plastics	It can be found in circuit boards, cabinets and cables all contain carcinogens. BFRs or brominated flame retardants give out carcinogenic brominated dioxins and furans. Dioxins can harm reproductive and immune systems.
Chromium	It is used to protect metal housings and plates in a computer from corrosion. The Chromium 6 can damage liver and kidneys and cause bronchial maladies including asthmatic bronchitis and lung cancer.
Beryllium	It can be found in switch boards and printed circuit boards. It is carcinogenic and can cause lung diseases.
Acid	The sulfuric and hydrochloric acids are used to separate metals from circuit boards. Fumes of chlorine and sulfur dioxide can cause respiratory problems. They are also corrosive to the eye and skin.
Beryllium oxide (Beryllia)	They can cause cancer by inhalation into the body.
Beryllium metal.	It can also cause cancer by inhalation. However, Beryllium component scrap is classified as non-hazardous in the OECD, Basel and EU regime.
Selenium	Exposure of selenium in high concentrations can cause selenosis.

Polychlorinated biphenyls (PCBs)	It is used as dielectric fluids, heat transfer fluids, additives in adhesives and plastics. It can cause cancer in animals. Also, effects on the immune system, reproductive system, nervous system, endocrine system.

2.4 Health impacts caused by electronic waste

Recycling or separating metal from electronic waste by improperly causing health risks to those involved and can contaminate in the environment. Toxic substances in electronic waste can enter the body through inhalation, digestion and skin contact. People who are working in the separation will be at risk of getting pollutants directly. As for those who live in the surrounding area or family members may be toxic from contamination in soil, air, water and food. In addition, those who work in the e-waste recycling area may be exposed to pollutants in clothing and skin causing children who are in the same house to be harmed as well. Accumulation of pollutants from e-waste would express on the health outcome and could cause impact to body systems such as thyroid function (Guangen et al., 2011), lung function (G. Zheng et al., 2013), reproductive health (Guo et al., 2010), growth (Huo et al., 2007), mental health outcome (J. Liu et al., 2011), DNA damage (Q. Liu et al., 2009) and gene expression (Zhang et al., 2011).

2.5 Epidemiology study

Epidemiological study is the study of the distribution and determinants of health-related event in a given population and applying the results of those studies for health prevention and control. Epidemiological studies were classified into 2 studies: observational and experimental studies. The observational studies were also divided into 2 studies: descriptive studies and analytical studies. Analytical studies comprise ecological studies, cross-sectional studies, cohort studies and case-control studies. And there are 3 experimental studies: clinical trials, field trials and community trials, showing in **Figure 2.5.1** (Kasim, 2012)**.**

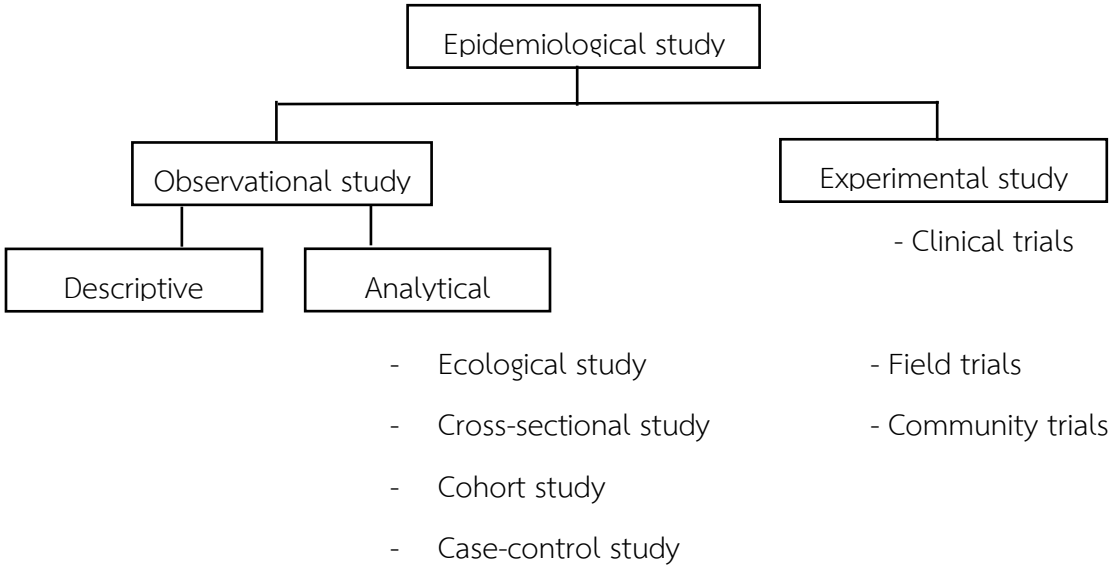

Figure 2.5.1 Classification of epidemiological study

CHAPTER III

METHODOLOGY

3.1 Description of study area

Daeng Yai sub-district, Ban Mai Chaiyaphot district and Ban Pao sub-district, Phutthaisong district are the biggest e-waste recycling area in Buriram, which located in the northeast of Thailand. Most people were engaged in e-waste recycling in their home (Home e-waste). E-waste and transformers have been an informal process or simply recycling in these 2 sub-districts considered as exposed areas. Control areas were other districts without e-waste recycling activities whose local residents worked mainly in agriculture without any history of e-waste recycling. However, the population, lifestyle, culture, education and traffic density were not different to those of Daeng Yai and Ban Pao sub-districts. Total population of those districts were 10,286 people which were 5,052 men and 5,234 women, there were 15 major e-waste buyers and 374 separators. E-waste was collected for separating in this area around 383 tons per week. Remaining e-waste was useless about 46 tons per week. It was reported that both areas had Pb and As levels in soil more than the levels of WHO standard (Saijai Withayaanumas, 2017).

3.2 Study design

Cross-sectional study was used in this study to investigate the association between living near to an e-waste recycling site and health effects on children, aged between 0-15 years old in Buriram and its vicinity. This work included two group of children as exposed group and reference group and can be further classified as cases and controls.

- **Exposed group**: Children who living in Daeng Yai sub-district and Ban Pao sub-district of e-waste activities
- **Reference group**: Children who living in the other sub-districts without e-waste recycling activities.
- **Cases:** Children who diagnosed with a specific disease
- **Controls:** Children who diagnosed with other diseases

Children who living in e-waste recycling area in Daeng Yai sub-district (Ban Mai Chaiyaphot district) and Ban Pao sub-district (Phutthaisong district) were compared with children who living in the other sub-districts to determine prevalence for diseases regarding the International Classification of Disease, Revision 10 (ICD-10) as shown in **Table 3.2.1.**

Table 3.2.1 ICD-10 codes

Disease	**ICD-10 code**
Certain infectious and parasitic diseases	A00 – B99
Neoplasms	C00 - D49
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	D50 - D89
Endocrine, nutritional and metabolic disease	E00 - E89

Mental, behavioral and neurodevelopmental disorders	F01 - F99
Disease of the nervous system	G00 - G99
Diseases of the eye and adnexa	H00 – H59
Diseases of the ear and mastoid process	H60 – H95
Diseases of the circulatory system	I00 - I99
Diseases of the respiratory system	J00 - J99
Diseases of the digestive system	K00 – K95
Diseases of the skin and subcutaneous tissue	L00 – L99
Diseases of the musculoskeletal system and connective tissue	M00 – M99
Diseases of the genitourinary system	N00 – N99

3.3 Data collection

Patient hospitalization data on children who suffered on diseases were acquired from the hospital's computer database of the Buriram Hospital between 2007 - 2018. The data were obtained on daily inpatients with variables including; age, gender, living address and disease diagnoses regarding to ICD 10.

3.4 Statistical analysis

Characteristics and prevalence exploratory analysis and analytical risk analysis were performed using Statistic Analysis System (SAS®) university edition for descriptive and inferential statistics. Chi-square was used to compare the differences of children's characteristics between the exposed group and the reference group and to determine prevalence of diseases. Logistic regression analytical analysis was performed to investigate

the association between living in e-waste recycling site in Daeng Yai sub-district and Ban Pao sub-district and diseases.

The association between living in an e-waste recycling area and associated diseases was determined with odd ratio (OR) and 95% confidence interval (CI). The crude odd ratio can be calculated from a 2x2 table as shown in **Table 3.4.1** by Equations (1), (2) and (3)

Table 3.4.1 Table 2x2 showing number of inpatient children with and without a specific disease in children living in exposed and reference area.

	a specific disease (cases)	**other diseases (controls)**
Daeng Yai sub-district and Ban Pao sub district (exposed zone)	A	B
Other sub-districts (reference zone)	C	D

A = Children who lived in Daeng Yai sub-district and Ban Pao sub-district with a specific disease

B = Children who lived in Daeng Yai sub-district and Ban Pao sub-district with other diseases

C = Children who lived in Other sub-districts with a specific disease

D = Children who lived in Other sub-district with other diseases

$$\text{Crude odd ratio (OR)} = \frac{AD}{BC} \quad (1)$$

$$\text{SE}\{\ln(\text{OR})\} = \sqrt{\frac{1}{A}+\frac{1}{B}+\frac{1}{C}+\frac{1}{D}} \quad (2)$$

SE = Standard error

$$95\%\ CI = \exp\{\ln(OR) \pm 1.96\ x\ SE\{\ln(OR)\} \quad (3)$$

If an OR is greater than 1 that means living in the exposed area associated with a specific disease while an odd ratio is less than 1 or equal to 1 that means no association between living in exposed area and a specific disease. Furthermore, If a 95% CI lower bound of OR is greater than 1, that OR is considered as statistically significant increased risk.

Logistic regression can be used for controlling confounder factors that have influence on diseases such as age and sex. The obtained result can be called "adjusted odd ratio (AOR)". Logistic regression can be calculated as following Equations (4) and (5):

$$\text{Prob (a specific disease)} = Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_1 X_n \quad (4)$$

$$\text{Adjusted odd ratio} = \frac{prob(case\ incidence)}{prob(control\ incidence)} = e^{\beta_{0+}\ \beta_{1X1+}\ \beta_{2X2+\ldots+}\ \beta_{1Xn}} \quad (5)$$

Where Z = Prob (a specific disease)

X_1 = Living area

X_2 = Sex

X_3 = Age

β_0 = Constant

β_n = Coefficients

CHAPTER IV

RESULTS AND DISCUSSION

A total of 125,823 inpatient children records from the Buriram Hospital between 2007 to 2018 were analyzed. The number of children in the exposed zone and the number of children in the reference zone are shown in Table 4.1. It presents a distribution that 0.29% of granted hospital admission records were in the exposed zone and 99.71% were in the reference zone.

Table 4.1 Distribution of inpatient children according to residence area

Area	**Number of children (%)**
Exposed zone	366 (0.29)
Reference zone	125,457 (99.71)
total	125,823 (100)

The characteristics of the children are shown in **Table 4.2**. The inpatient records of children consisted variables of living address, age (0 – 15 years), and sex. Age was categorized into 3 group 0–6, 7–12, 13–15 years. The age distribution between two areas was statistically different. The results showed that the highest number of children aggregated in 0-6 years with 56.28% followed by 7-12 years with 30.60% and 13-15 years with 13.11% respectively. The results showed that there were more boys in the exposed zone (60.38%) than those in the reference zone (58.03%) while less girls in the exposed zone (39.62%) than those in the reference zone (41.97%).

Table 4.2 Frequencies and Chi-square statistic of children in exposed zone and reference zone

Characteristic	Exposed zone N= 366 (%)	Reference zone N = 125,457 (%)	Total N = 125,823 (%)	p-value
Age				
0-6	206 (56.28)	80,647 (64.28)	80853 (64.26)	0.0014 *
7-12	112 (30.60)	28682 (22.86)	28794 (22.88)	
13-15	48 (13.11)	16128 (12.86)	16176 (12.86)	
Sex				
Male	221 (60.38)	72805 (58.03)	73026 (58.04)	0.3628
Female	145 (39.62)	52652 (41.97)	52797 (41.96)	

*Statistically significant difference at p-value < 0.05

4.1 All age analysis

The prevalence of diseases between the exposed zone and the reference zone are shown in **Table 4.3**. When comparing differentiation of all 14 diseases in the exposed zone and the reference zone, we found that 9 of 14 diseases were more prevalent in the exposed zone than in the reference zone. Four of nine diseases showed statistically significant higher prevalence in the e-waste exposed area at $p < 0.001$ for neoplasms, diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism, diseases of the nervous system, and diseases of the eye and adnexa. One of nine diseases showed statistically higher prevalence in the exposed sub-districts at $p < 0.05$ which was diseases of the genitourinary system. These prevalence results were consistent with other toxicological report. Xu et al. 2015 reported that human exposure to e-waste in China could cause several toxicities on human. We found that 2 of 14 diseases were with statistically lower prevalence in the e-waste exposed zone than in the reference zone for certain infectious and parasitic diseases ($p < 0.001$)

and endocrine, nutritional and metabolic diseases ($p < 0.05$). Both disease groups were not reported or not relevant to toxicants found in e-waste activities (Xu et al. 2015). Many areas in the reference zone clearly had higher population density compared with those 2 less dense districts in the exposed zone. The reference zone with more populated districts may have more infectious and parasite sources such as municipal sewage, insufficient and improper toilets, food waste, vectors, contaminated food, school etc. These sources could cause infectious diseases more prevalent in the reference area. In addition, parents of children in the exposed zone clearly had better economic status to afford better food quality, sanitary toilets and health care as well as owned vehicles as they had greater income from e-waste recycle. So, we found lower prevalence for endocrine, nutritional and metabolic disease and infectious and parasitic diseases in the e-waste exposed zone than in the reference zone. For diseases of the respiratory system, its prevalence was close between two zones as many adverse respiratory health effects and cold were common in children and may not be purely related to e-waste sources. There were no children admitted with mental, behavioral and neurodevelopmental disorders and diseases of the ear and mastoid process in the exposed zone, thus their prevalence cannot be estimated for those e-waste subdistricts due to a small number of populations in Daeng Yai and Ban Pao sub-district.

Table 4.3 The prevalence of diseases

Disease	**Exposed zone N = 366**	**Reference zone N = 125,457**	**Total N = 125,823**	**p-value**
Certain infectious and parasitic diseases	39 (10.66)	28,675 (22.86)	28,714 (22.82)	<.0001**
Neoplasms	11 (3.01)	1,199 (0.96)	1,210 (0.96)	<.0001**
Diseases of the blood and blood-forming organs and	59 (16.12)	12,407 (9.89)	12,466 (9.91)	<.0001**

certain disorders involving the immune mechanism				
Endocrine, nutritional and metabolic diseases	30 (8.20)	17,864 (14.24)	17,894 (14.22)	0.0010*
Mental, Behavioral and Neurodevelopmental disorders	0	847 (0.68)	847 (0.67)	0.1147
Diseases of the nervous system	22 (6.01)	3,791 (3.02)	3,813 (3.03)	0.0009**
Diseases of the eye and adnexa	10 (2.73)	1,138 (0.91)	1,148 (0.91)	0.0002**
Diseases of the ear and mastoid process	0	370 (0.29)	370 (0.29)	0.2981
Diseases of the circulatory system	9 (2.46)	2,065 (1.65)	2,074 (1.65)	0.2225
Diseases of the respiratory system	87 (23.77)	32,280 (25.73)	32,367 (25.72)	0.3918
Diseases of the digestive system	51 (13.93)	14,095 (11.23)	14,146 (11.24)	0.1026
Diseases of the skin and subcutaneous tissue	17 (4.64)	4,254 (3.39)	4,271 (3.39)	0.1859
Diseases of the musculoskeletal system and connective tissue	6 (1.64)	1,532 (1.22)	1,538 (1.22)	0.4672
Diseases of the genitourinary system	25 (6.83)	4,940 (3.94)	4,965 (3.95)	0.0045*

*Statistically significant difference at p-value < 0.05

**Statistically significant difference at p-value < 0.001

This work estimated AORs (result of logistic regression for predicting the diseases among children by adjusting for age and sex) as shown in **Table 4.4**. We found positive association in 9 out of 14 diseases. Five of 9 AORs were statistically significant increased risks in a descending order for neoplasms (AOR [95%CI] = 3.150 [1.722, 5.761]), diseases of the eye and adnexa (AOR [95%CI] = 3.001 [1.596, 5.643]), diseases of the nervous system (AOR [95%CI] = 2.033 [1.320, 3.132]), diseases of the genitourinary system (AOR [95%CI] = 1.728 [1.149, 2.599]) and diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (AOR [95%CI] = 1.723 [1.303, 2.279]). AOR analyses confirmed that there were statistically increased risks in children population living in the e-waste recycling area for various health effects. These findings agree with most results of waste site studies. I et al. 2015 reported that children, who living near to a non-sanitary landfill that had some toxic substances like the e-waste recycling site, had an increased risk of rash and itching on body, mental and behavioral and cold. Wong et al. 2010 found that people involved in testing of manufactured products (such as electronics, equipment, chemicals, etc.) were at a statistically significant increased risk of B-cell neoplasm. Huo et al. 2019 studied the decreased erythrocyte CD44 and CD58 expression link of e-waste Pb toxicity to change in erythrocyte immunity in preschool children and found relationship between Pb exposure and the change of erythrocyte immunity. Everett et al. 2008 reported that seven of the 11 PCBs in blood were significantly associated with hypertension. However, we cannot estimate AORs of mental, behavioral and neurodevelopmental disorders, and diseases of the ear and mastoid process because there were no children who suffered from these diseases in the exposed zone. The found magnitude of risk level could be used to for plaining in environmental health education and managment to reduce the risks. Financial support for taking care these children health and improving their houses as e-waste workplaces to protect them from those associated disease is needed.

Table 4.4 Adjusted odd ratio of diseases.

Disease	Adjusted Odd Ratio[a]	95% CI
Certain infectious and parasitic diseases	0.405	0.291, 0.565
Neoplasms	3.150	1.722, 5.761 *
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1.723	1.303, 2.279 *
Endocrine, nutritional and metabolic diseases	0.533	0.367, 0.775
Mental, Behavioral and Neurodevelopmental disorders	-	-
Diseases of the nervous system	2.033	1.320, 3.132 *
Diseases of the eye and adnexa	3.001	1.596, 5.643 *
Diseases of the ear and mastoid process	-	-
Diseases of the circulatory system	1.448	0.745, 2.814
Diseases of the respiratory system	0.968	0.755, 1.242
Diseases of the digestive system	1.225	0.907, 1.656
Diseases of the skin and subcutaneous tissue	1.393	0.855, 2.268
Diseases of the musculoskeletal system and connective tissue	1.256	0.558, 2.828
Diseases of the genitourinary system	1.728	1.149, 2.599 *

* Statistically significant increased risks

[a]Adjusted for age and sex

4.2 Age specific analysis

The prevalence of diseases between the exposed zone and the reference zone for children aged 0-6 years are shown in **Table 4.5**. When comparing differentiation of those diseases in the exposed zone and the reference zone, we found that 8 of 14 diseases had greater prevalence in the exposed zone than in the reference zone. Three

of eight diseases were observed for statistically significant higher prevalence at $p < 0.001$ for diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism, diseases of the nervous system, and diseases of the eye and adnexa. Three of eight diseases were found for statistically significant higher prevalence at $p < 0.05$ for diseases of the skin and subcutaneous tissue, diseases of the musculoskeletal system and connective tissue and diseases of the genitourinary system. There were no children with mental, behavioral and neurodevelopmental disorders, and diseases of the ear and mastoid process in exposed zone so their prevalence could not be determined.

Table 4.5 The prevalence of diseases (0 – 6 years)

Disease	**Exposed zone N = 206**	**Reference zone N = 80,647**	**Total N = 80,853**	**p-value**
Certain infectious and parasitic diseases	20 (9.71)	18497 (22.94)	18517 (22.90)	<.0001**
Neoplasms	2 (0.97)	577 (0.72)	579 (0.72)	0.6641
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	34 (16.50)	7017 (8.70)	7051 (8.72)	<.0001**
Endocrine, nutritional and metabolic diseases	18 (8.74)	11047 (13.70)	11065 (13.69)	0.0386*
Mental, Behavioral and Neurodevelopmental disorders	0	137 (0.17)	137 (0.17)	0.5538
Diseases of the nervous system	16 (7.77)	2330 (2.89)	2346 (2.90)	<.0001**
Diseases of the eye and adnexa	6 (2.91)	619 (0.77)	625 (0.77)	0.0004**

Diseases of the ear and mastoid process	0	238 (0.30)	238 (0.29)	0.4349
Diseases of the circulatory system	4 (1.94)	931 (1.15)	935 (1.16)	0.2911
Diseases of the respiratory system	65 (31.55)	27164 (33.68)	27229 (33.68)	0.5184
Diseases of the digestive system	11 (5.34)	6037 (7.49)	6048 (7.48)	0.2423
Diseases of the skin and subcutaneous tissue	13 (6.31)	2812 (3.49)	2825 (3.49)	0.0275*
Diseases of the musculoskeletal system and connective tissue	4 (1.94)	505 (0.63)	509 (0.63)	0.0171*
Diseases of the genitourinary system	13 (6.31)	2736 (3.39)	2749 (3.40)	0.0210*

*Statistically significant difference at p-value < 0.05

**Statistically significant difference at p-value < 0.001

The prevalence of diseases between exposed zone and reference zone for children aged 7 – 12 years are shown in **Table 4.6**. When comparing differentiation of those diseases in the exposed zone and the reference zone, we found that 7 out of 14 diseases had greater prevalence in the exposed zone than in the reference zone. One of seven diseases showed statistically significant higher at $p < 0.001$) in neoplasm. Another one of seven diseases showed statistically significant higher at ($p < 0.05$) in diseases of the eye and adnexa. In addition, there were no children with mental, behavioral and neurodevelopmental disorders and diseases of the ear and mastoid process in exposed zone.

Table 4.6 The prevalence of diseases (7 - 12 years)

Disease	**Exposed zone N = 112**	**Reference zone N = 28,682**	**Total N = 28,794**	**p-value**
Certain infectious and parasitic diseases	13 (11.61)	7094 (24.73)	7107 (24.68)	0.0013*
Neoplasms	8 (7.14)	392 (1.37)	400 (1.39)	<.0001**
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	18 (16.07)	3276 (11.42)	3294 (11.44)	0.1228
Endocrine, nutritional and metabolic diseases	8 (7.14)	3955 (13.79)	3963 (13.76)	0.0416*
Mental, Behavioral and Neurodevelopmental disorders	0	296 (1.03)	296 (1.03)	0.2798
Diseases of the nervous system	6 (5.36)	897 (3.13)	903(3.14)	0.1766
Diseases of the eye and adnexa	4 (3.57)	363 (1.27)	367 (1.27)	0.0299*
Diseases of the ear and mastoid process	0	95 (0.33)	95 (0.33)	0.5418
Diseases of the circulatory system	2 (1.79)	655 (2.28)	657 (2.28)	0.7247
Diseases of the respiratory system	17 (15.18)	3675 (12.81)	3692 (12.82)	0.4548
Diseases of the digestive system	25 (22.32)	5111 (17.82)	5136 (17.84)	0.2142
Diseases of the skin and subcutaneous tissue	4 (3.57)	1055 (3.68)	1059 (3.68)	0.9522

Diseases of the musculoskeletal system and connective tissue	2 (1.79)	587 (2.05)	589 (2.05)	0.8457
Diseases of the genitourinary system	5 (4.46)	1231(4.29)	1236 (4.29)	0.9284

*Statistically significant difference at p-value < 0.05

**Statistically significant difference at p-value < 0.001

For children aged 13-15, the prevalence of diseases between the exposed zone and the reference zone are shown in **Table 4.7**. When comparing differentiation of those diseases in the exposed zone and the reference zone, we found that 6 out of 14 diseases had greater prevalence in the exposed zone than in the reference zone. Two of six diseases showed statistically significant difference at $p < 0.05$ in diseases of the digestive system and diseases of the genitourinary system. There was no children with mental, behavioral and neurodevelopmental disorders, diseases of the nervous system, diseases of the eye and adnexa, diseases of the ear and mastoid process, diseases of the skin and subcutaneous tissue, and diseases of the musculoskeletal system and connective tissue in exposed zone, thus their prevalence could not be estimated. This could be due to a small number of populations in Daeng Yai and Ban Pao sub-district. It can be noticed that these older children group was healthier than those two younger children groups as having no prevalence in exposed zone as older children had more complete immune system than young children.

Table 4.7 The prevalence of diseases (13 - 15 years)

Disease	**Exposed zone N = 48**	**Reference zone N = 16,128**	**Total N = 16,176**	**p-value**
Certain infectious and parasitic diseases	6 (12.50)	3084 (19.12)	3090 (19.10)	0.2439
Neoplasms	1 (2.08)	230 (1.43)	231 (1.43)	0.7016
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	7 (14.58)	2114 (13.11)	2121 (13.11)	0.7623
Endocrine, nutritional and metabolic diseases	4 (8.33)	2862 (17.75)	2866 (17.72)	0.0881
Mental, Behavioral and Neurodevelopmental disorders	0	414 (2.57)	414 (2.56)	0.2608
Diseases of the nervous system	0	564 (3.50)	564 (3.49)	0.1872
Diseases of the eye and adnexa	0	156 (0.97)	156 (0.96)	0.4935
Diseases of the ear and mastoid process	0	37 (0.23)	37 (0.23)	0.7397
Diseases of the circulatory system	3 (6.25)	479 (2.97)	482 (2.98)	0.1820
Diseases of the respiratory system	5 (10.42)	1441 (8.93)	1446 (8.94)	0.7194
Diseases of the digestive system	15 (31.25)	2947 (18.27)	2962 (18.31)	0.0203*
Diseases of the skin and subcutaneous tissue	0	387 (2.40)	387 (2.39)	0.2774

Diseases of the musculoskeletal system and connective tissue	0	440 (2.73)	440 (2.72)	0.2460
Diseases of the genitourinary system	7 (14.58)	973 (6.03)	980 (6.06)	0.0132*

*Statistically significant difference at p-value < 0.05

AORs and 95% CI of children aged 0-6 years are shown in **Table 4.8**. For this youngest group, we found positive association in 8 out of 14 diseases. Six of eight diseases showed AORs with statistically significant increased risks in diseases of the eye and adnexa (AOR [95%CI] = 3.862 [1.708, 8.734]), diseases of the musculoskeletal system and connective tissue (AOR [95%CI] = 3.143 [1.164, 8.487]), diseases of the nervous system (AOR [95%CI] = 2.826 [1.694, 4.715]), diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (AOR [95%CI] = 2.086 [1.442, 3.016]), diseases of the genitourinary system (AOR [95%CI] = 1.947 [1.107, 3.422]), and diseases of the skin and subcutaneous tissue (AOR [95%CI] = 1.858 [1.058, 3.263]). However, we cannot calculate AORs of mental, behavioral and neurodevelopmental disorders and diseases of the ear and mastoid process because there were no children who suffered from these diseases in the exposed zone.

Table 4.8 Adjusted odd ratio of diseases (0 – 6 years)

Disease	**Adjusted Odd Ratio[a]**	**95% CI**
Certain infectious and parasitic diseases	0.361	0.227, 0.572
Neoplasms	1.352	0.335, 5.452
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	2.086	1.442, 3.016 *
Endocrine, nutritional and metabolic diseases	0.602	0.371, 0.979
Mental, Behavioral and Neurodevelopmental disorders	-	-
Diseases of the nervous system	2.826	1.694, 4.715 *
Diseases of the eye and adnexa	3.862	1.708, 8.734 *
Diseases of the ear and mastoid process	-	-
Diseases of the circulatory system	1.690	0.627, 4.556
Diseases of the respiratory system	0.908	0.677, 1.219
Diseases of the digestive system	0.697	0.379, 1.280
Diseases of the skin and subcutaneous tissue	1.858	1.058, 3.263 *
Diseases of the musculoskeletal system and connective tissue	3.143	1.164, 8.487 *
Diseases of the genitourinary system	1.947	1.107, 3.422 *

[a]Adjusted for sex

* Statistically significant increased risks

AORs and 95% CI of children aged 7-12 years were shown in **Table 4.9**. For this middle age group, we noticed positive association in 6 out of 14 diseases. Two of 6 AORs demonstrated statistically significant increased risks for neoplasm (AOR [95%CI] = 5.890 [2.845, 12.195]) and diseases of the eye and adnexa (AOR [95%CI] = 2.732 [1.001, 7.457]). Other has also reported risk of neoplasm in children who lived nearby area with heavy metals. García-Pérez et al., 2016 found the association between living proximity to a

processing of metals and childhood renal tumors. However, we cannot determine AORs of mental, behavioral and neurodevelopmental disorders and diseases of the ear and mastoid process because there were no children who suffered of these diseases in exposed zone. These findings confirmed that youngest children group who lived in the e-waste recycling area had more chance to be exposed to more toxic substances and developed various e-waste associated diseases. These significant increased AORs agreed with most results of waste site studies. I et al. 2015 observed an increased risk of rash and itching on body in exposed children living near to a non-sanitary landfill that had some toxic substances like the e-waste recycling site. A hospital admission case-control study by Wong et al. 2010 found that people involved in testing of electronics and equipment were at a statistically significant increased risk of B-cell neoplasm. Huo et al. 2019 reported that e-waste Pb toxicity changed in erythrocyte immunity in preschool children and found relationship between Pb exposure and the change of erythrocyte immunity. PCB which can be found in e-waste from fluids in electrical apparatus so Everett et al. 2008 reported blood PCB were significantly associated with hypertension.

Table 4.9 Adjusted odd ratio of diseases (7 - 12 years)

Disease	**Adjusted Odd Ratio[a]**	**95% CI**
Certain infectious and parasitic diseases	0.407	0.228, 0.726
Neoplasms	5.890	2.845, 12.195 *
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1.518	0.915, 2.517
Endocrine, nutritional and metabolic diseases	0.485	0.236, 0.997
Mental, Behavioral and Neurodevelopmental disorders	-	-
Diseases of the nervous system	1.741	0.763, 3.974
Diseases of the eye and adnexa	2.732	1.001, 7.457 *
Diseases of the ear and mastoid process	-	-
Diseases of the circulatory system	0.775	0.191, 3.146
Diseases of the respiratory system	1.214	0.724, 2.037
Diseases of the digestive system	1.315	0.842, 2.054
Diseases of the skin and subcutaneous tissue	0.925	0.340, 2.517
Diseases of the musculoskeletal system and connective tissue	0.844	0.208, 3.426
Diseases of the genitourinary system	0.992	0.403, 2.438

[a] Adjusted for sex

* Statistically significant increased risks

For oldest children group, AORs and 95% CI of children aged 13-15 years are shown in **Table 4.10**. Positive association can be seen in 6 diseases. Two of six showed AORs with statistically significant increased risks in diseases of the genitourinary system (AOR [95%CI] = 2.743 [1.214, 6.199]) and diseases of the digestive system (AOR [95%CI] = 2.051 [1.110, 3.789]). We only observed an increased AOR for diseases of the respiratory system in these oldest children group although the AOR was not statistically significant. This estimated AOR was still consistent with other study that Zeng et al. 2016 investigated the association between heavy metals in $PM_{2.5}$ and in blood and children's respiratory symptoms and asthma from an e-waste recycling area in Guiyu. The study found positive association of children who have a home near an e-waste recycling site and wheeze (AOR = 1.97, 0.92-4.25), dyspnea (AOR = 1.91, 0.58-6.36), cough (AOR = 1.05, 0.63-1.76) and phlegm (AOR = 1.24, 0.71-2.18). However, as no case in the exposed area, we cannot estimate AORs of mental, behavioral and neurodevelopmental disorders, diseases of the nervous system, diseases of the eye and adnexa, diseases of the ear and mastoid process, diseases of the skin and subcutaneous tissue and diseases of the musculoskeletal system and connective tissue.

Table 4.10 Adjusted odd ratio of diseases (13 - 15 years)

Disease	**Adjusted Odd Ratio[a]**	**95% CI**
Certain infectious and parasitic diseases	0.603	0.256, 1.421
Neoplasms	1.471	0.202, 10.710
Diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism	1.132	0.507, 2.526
Endocrine, nutritional and metabolic diseases	0.420	0.151, 1.169
Mental, Behavioral and Neurodevelopmental disorders	-	-
Diseases of the nervous system	-	-
Diseases of the eye and adnexa	-	-
Diseases of the ear and mastoid process	-	-
Diseases of the circulatory system	2.173	0.673, 7.020
Diseases of the respiratory system	1.182	0.467, 2.990
Diseases of the digestive system	2.051	1.110, 3.789 *
Diseases of the skin and subcutaneous tissue	-	-
Diseases of the musculoskeletal system and connective tissue	-	-
Diseases of the genitourinary system	2.743	1.214, 6.199 *

[a] Adjusted for sex

* Statistically significant increased risks

These significant AORs findings confirmed that children who lived in the e-waste recycling area had more chance to be exposed to more toxic substances and developed many e-waste associated diseases. Greater significant increased risks were observed in the youngest children group (0-6 years old) with 6 diseases. Significant AOR of diseases of the eye and adnexa were pronounced in both youngest and middle age groups. Diseases of the genitourinary system showed the significant increased AOR in the youngest and the oldest children groups.

E-waste education and management to reduce exposure at home workplace must be arranged to reduce those risks for specific subgroups. Implementing proper rules to prevent contamination from e-waste separators to children by mandatory wearing protective masks and gloves and safety glass is recommended when dismantling. The youngest group were at a priority to be taken care well by their parents and health officials to stop exposure through skin absorption, inhalation and digestion as the youngest group was spending almost 24 hours in home as an e-waste workplace. Extra budget support is also needed for the local hospitals for those found e-waste associated diseases.

CHAPTER V

CONCLUSIONS

This work is the first epidemiological study of e-waste related health effects in Buriram province, Thailand. It analyzed 125,823 children inpatient records from the Buriram Hospital between 2007 to 2018. There were a small number of children living in the exposed zone comparing to the reference zone. Characteristics of children were not different between the exposed zone and reference zone except age. We found statistically higher prevalence in 5 diseases in children living in those 2 e-waste subdistricts for neoplasms, diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism, diseases of the nervous system, and diseases of the eye and adnexa. and diseases of the genitourinary system. For living in e-waste area and disease association, the results presented children, who lived in Ban Pao and Daeng Yai sub-districts, an e-waste recycling area in Buriram, could be exposed to toxic substances from e-waste activities and had statistically greater risk than those living in the reference area for neoplasms (AOR [95%CI] = 3.150 [1.722, 5.761]), diseases of the eye and adnexa (AOR [95%CI] = 3.001 [1.596, 5.643]), diseases of the nervous system (AOR [95%CI] = 2.033 [1.320, 3.132]), diseases of the genitourinary system (AOR [95%CI] = 1.728 [1.149, 2.599]) and diseases of the blood and blood-forming organs and certain disorders involving the immune mechanism (AOR [95%CI] = 1.723 [1.303, 2.279]). For age-specific AORs, significant increased risk was observed in the young children group (0-6 years old) with 6 diseases, in in the middle age children group (7-12 years old) with 2 diseases and in the old children group (13-15 years old) with 2 diseases.

The study had several limitations. Firstly, there were small exposed population in this study. We suggest that future research should include children inpatient records from more hospitals around the exposed zone. Secondly, there were other confounder factors that could influence on e-waste associated diseases so the future study should account

for more confounder factors such as height, weight, education and smoking habit of parents. Moreover, this study did not include chemical exposure and other source contaminants in study area such as air pollution from traffic, crematorium, farming pesticide through air, water and soil.

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APPENDIX

The FREQ Procedure

Frequency Percent Row Pct Col Pct	Table of aged by area		
	area		
aged	0	1	Total
1	80647 64.10 99.75 64.28	206 0.16 0.25 56.28	80853 64.26
2	28682 22.80 99.61 22.86	112 0.09 0.39 30.60	28794 22.88
3	16128 12.82 99.70 12.86	48 0.04 0.30 13.11	16176 12.86

Total	125457	366	125823
	99.71	0.29	100.00

Statistics for Table of aged by area

Statistic	DF	Value	Prob
Chi-Square	2	13.2034	0.0014
Likelihood Ratio Chi-Square	2	12.4434	0.0020
Mantel-Haenszel Chi-Square	1	4.9090	0.0267
Phi Coefficient		0.0102	
Contingency Coefficient		0.0102	
Cramer's V		0.0102	

Sample Size = 125823

The LOGISTIC Procedure

Model Information	
Data Set	WORK.SUB0_4
Response Variable	area
Number of Response Levels	2

Number of Observations Read	68580
Number of Observations Used	68580

Model Information	
Model	binary logit
Optimization Technique	Fisher's scoring

Response Profile		
Ordered Value	area	Total Frequency
1	0	68415
2	1	165

Probability modeled is area='1'.

Class Level Information		
Class	Value	Design Variables
ICD10	0	1
	1	0

Model Convergence Status
Convergence criterion (GCONV=1E-8) satisfied.

Model Fit Statistics		
Criterion	Intercept Only	Intercept and Covariates
AIC	2321.440	2304.021
SC	2330.576	2340.564
-2 Log L	2319.440	2296.021

Testing Global Null Hypothesis: BETA=0			
Test	Chi-Square	DF	Pr > ChiSq
Likelihood Ratio	23.4191	3	<.0001
Score	20.0396	3	0.0002
Wald	18.6326	3	0.0003

Type 3 Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
ICD10	1	15.4614	<.0001
age	1	2.1500	0.1426

Type 3 Analysis of Effects			
Effect	DF	Wald Chi-Square	Pr > ChiSq
sex	1	1.4200	0.2334

Analysis of Maximum Likelihood Estimates						
Parameter		DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept		1	-7.0199	0.3490	404.6341	<.0001
ICD10	0	1	1.0349	0.2632	15.4614	<.0001
age		1	-0.0938	0.0639	2.1500	0.1426
sex		1	0.1872	0.1571	1.4200	0.2334

Odds Ratio Estimates			
Effect	Point Estimate	95% Wald Confidence Limits	
ICD10 0 vs 1	2.815	1.680	4.715
age	0.910	0.803	1.032
sex	1.206	0.886	1.641

Association of Predicted Probabilities and Observed Responses			
Percent Concordant	55.3	Somers' D	0.189
Percent Discordant	36.4	Gamma	0.206
Percent Tied	8.3	Tau-a	0.001
Pairs	11288475	c	0.594

BIOGRAPHY

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