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ชื่อโครงการ	Association between maternal living in e-waste recycling site and adverse birth outcomes in Buriram, Thailand
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Faculty of Science	Department of Environmental Science
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Department of Environmental Science
Faculty of Science, Chulalongkorn University

Association between maternal living in e-waste recycling site and adverse birth outcomes in Buriram, Thailand

Miss Woranan Yeemadarlee

A Senior Project Submitted in Partial Fulfillment of The Requirements
for the Degree of Bachelor of Science
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Accepted by the Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Bachelor's Degree

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หัวเรื่อง	ความสัมพันธ์ระหว่างมารดาที่อาศัยในบริเวณที่มีการรีไซเคิลขยะอิเล็กทรอนิกส์กับความผิดปกติของเด็กแรกเกิดในจังหวัดบุรีรัมย์ ประเทศไทย
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บทคัดย่อ

ในแต่ละปีผลิตภัณฑ์เครื่องใช้ไฟฟ้าอิเล็กทรอนิกส์ถูกทิ้งมากมายและเกิดเป็นขยะอิเล็กทรอนิกส์ โดยตำบลแดงใหญ่ อำเภอบ้านใหม่ไชยพจน์ และตำบลบ้านเป้า อำเภอพุทไธสง จังหวัดบุรีรัมน์ เป็นแหล่งรวบรวมขยะอิเล็กทรอนิกส์ใหญ่สุดในประเทศไทย การรับสัมผัสกิจกรรมการแยกขยะและการเผาขยะอิเล็กทรอนิกส์จะส่งผลกระทบต่อสุขภาพ โดยเฉพาะในกลุ่มประชากรที่มีความไวต่อการรับสัมผัส เช่น สตรีที่กำลังตั้งครรภ์ อาจทำให้เสี่ยงต่อการเกิดความผิดปกติแรกเกิดของทารกในครรภ์ได้ ทั้งนี้ในประเทศยังขาดองค์ความรู้เกี่ยวกับความสัมพันธ์ระหว่างความผิดปกติแรกเกิดและการอาศัยอยู่ในพื้นที่รีไซเคิลขยะอิเล็กทรอนิกส์ การศึกษานี้เป็นการศึกษาระบาดวิทยาแบบย้อนหลังเพื่อทดสอบความสัมพันธ์ระหว่างแม่ที่อาศัยอยู่ในพื้นที่ที่มีการรีไซเคิลขยะอิเล็กทรอนิกส์กับ 6 โรคความผิดปกติแรกเกิดของเด็ก ได้แก่ ทารกเสียชีวิตในครรภ์ (Still birth) ทารกแรกเกิดน้ำหนักน้อยมาก (VLBW) ทารกแรกเกิดน้ำหนักน้อย (LBW) การคลอดก่อนกำหนด (PTB) ภาวะทารกโตช้าในครรภ์ (IUGR) และภาวะความผิดปกติแรกเกิดรวม (ABO) และคำนวณค่า adjusted odd ratio (AOR) ด้วยการวิเคราะห์การถดถอยโลจิสติกพหุคูณด้วยซอฟแวร์ SAS® ประชากรที่ใช้ในการศึกษานี้คือทารกที่คลอด ณ โรงพยาบาลบุรีรัมย์ ในช่วงปี พ.ศ. 2553 ถึง 2562 รวมจำนวน 35,682 ราย ทารกจะถูกแบ่งออกเป็น 2 กลุ่ม คือ กลุ่มที่รับสัมผัส (จำนวน 96 คน) และกลุ่มอ้างอิง (จำนวน 35,682 คน) ซึ่งกลุ่มที่รับได้รับสัมผัส คือกลุ่มของทารกที่แม่อยู่อาศัยอยู่ใน 2 ตำบลที่มีขยะอิเล็กทรอนิกส์ และกลุ่มอ้างอิง คือกลุ่มของเด็กทารกที่แม่อยู่อาศัยอยู่ในตำบลอื่นที่ไม่มีขยะอิเล็กทรอนิกส์ ผลการศึกษาพบลักษณะโดยทั่วไปของแม่และทารก (อายุมารดา, สถานภาพสมรส, อายุครรภ์, ครรภ์ที่, ประวัติการแท้ง) ระหว่าง 2 กลุ่มไม่มีความแตกต่างกัน ยกเว้นสถานณะภาพสมรส พบความชุกของการเกิด 6 ความผิดปกติแรกเกิดของเด็กในพื้นที่ที่ได้รับสัมผัสสูงกว่าพื้นที่อ้างอิง แต่มีเพียงความชุกของ ABO ในพื้นที่รับสัมผัส (27.08%) ที่มากกว่าพื้นที่อ้างอิง (18.08%) อย่างมีนัยสำคัญทางสถิติ พบความสัมพันธ์ระหว่างแม่ที่อยู่อาศัยในพื้นที่ที่มีขยะอิเล็กทรอนิกส์กับทั้ง 6 ความผิดปกติแรกเกิด โดยมีเพียง ABO ที่พบความเสี่ยงเพิ่มขึ้นในพื้นที่ที่ได้รับสัมผัสอย่างมีนัยสำคัญทางสถิติ (AOR=1.67, 95% Cl : 1.05,2.65) ส่วนกลุ่มแม่ที่อายุน้อย (≤20 ปี) ที่อยู่ในพื้นที่ที่มีขยะอิเล็กทรอนิกส์ พบความเสี่ยงของ PTB เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ (AOR = 2.83, 95% Cl: 1.14, 7.06) ส่วนกลุ่มแม่ที่มีสถาณะภาพเป็นโสด พบความเสี่ยงมากขึ้นอย่างมีนัยสำคัญทางสถิติของ LBW (AOR=2.89, 95% Cl: 1.22, 6.84) และ ABO (AOR= 2.87, 95% Cl: 1.34, 6.16) ส่วนกลุ่มแม่ที่ตั้งครรภ์ทารกเพศหญิงที่อาศัยอยู่ในพื้นที่ที่มีขยะอิเล็กทรอนิกส์พบความเสี่ยงมากที่สุดของ LBW ถึง 14.49 เท่า เมื่อเทียบกับพื้นที่อื่นอย่างมีนัยสำคัญทางสถิติ (AOR=14.49, 95% Cl: 1.74, 98.01) ผลการศึกษานี้สามารถนำไปใช้วางแผนสำหรับการจัดสรรงบประมาณและพัฒนาแผนการดูแลสุขภาพและการเฝ้าระวังพิเศษในกลุ่มหญิงตั้งครรภ์ที่อาศัยอยู่ในชุมชนขยะอิเล็กทรอนิกส์ โดยควรให้ความสำคัญเป็นพิเศษกับแม่ที่เป็นโสด แม่อายุน้อย หรือ แม่ที่ตั้งครรภ์ทารกเพศหญิงเพื่อลดความเสี่ยง การศึกษานี้จะสมบูรณ์ยิ่งขึ้นหากมีข้อมูลการรับสัมผัสมลพิษในพื้นที่ศึกษา

คำสำคัญ : ความผิดปกติแรกเกิด, ขยะอิเล็กทรอนิกส์ และการศึกษาระบาดวิทยา

Title Association between maternal living in e-waste recycling site and adverse birth outcomes in Buriram, Thailand

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Project advisor Sitthichok Puangthongtub, Ph.D

Faculty of Science Department of Environmental Science

Academic year **2018**

Abstract

Each year, many electronic products are obsolete or broken resulting in large electronic waste generation. Daeng Yai subdistrict, Ban Mai Chaiyaphot District and Ban Pao subdistrict, Phutthaisong District in Buriram province were a main hub of e-waste recycling in Thailand. Exposure to common e-waste dismantling, recycling and burning could cause adverse health effects in sensitive population like pregnant women. This e-waste recycling exposure may risk them for adverse birth outcomes. In Thailand, the knowledge of relationship between adverse birth outcomes and maternal living in an e-waste recycling site was very limited. This study applied a retrospective epidemiological design to investigate the association between maternal living in e-waste recycling site and 6 adverse birth outcomes of stillbirth, very low birth weight (VLBW), low birth weight (LBW), preterm birth (PTB), intrauterine growth retardation (IUGR) and all adverse birth outcomes (ABO) and estimated adjusted odds ratio (AOR) using multiple logistic regression by SAS®. The studied population were all infants whose mothers had deliverance at the Burirum hospital between 2010-2019. A number of 35,682 birth records were retrieved from the hospital and were geocoded into 2 groups regarding maternal living address: an exposed group (n = 96) in those 2 subdistricts and a reference groups in other districts (n= 35,682). For the results, we noticed that characteristics of mother and infant (maternal age, marital status, gestation age, pregnancy rate, abortion rate and infant's sex) between two groups were not different except the marital status. Prevalences of 6 adverse birth outcomes were greater in the expose zone than those in the reference zone. Only ABO prevalence was statistically higher in the exposure zone (27.08%) than that in the reference zone (18.08%). The association between maternal living in e-waste community and all 6 adverse birth outcomes was observed but ABO was the only effect showed a statistically increased risk (AOR=1.67, 95% Cl: 1.05, 2.65). In young mothers (age ≤ 20), PTB was statistically associated with living in the e-waste site by an increased risk

(AOR = 2.83, 95% CI: 1.14, 7.06). In pregnant women with single status, it showed a statistically significant increased risk in LBW (AOR=2.89, 95% Cl: 1.22, 6.84) and ABO (AOR= 2.87, 95% Cl: 1.34, 6.16). In a group of pregnant women with female infants, living inside e-waste area was considered the greatest risk of LBW as 14.49-fold higher risk than those living outside (AOR=14.49, 95% Cl: 1.74, 98.01). These findings could be used to plan for a financial support and to develop special heath care education and surveillance program to pregnant mothers living in the e-waste community with a priority to those who were single, young or having female infants to alleviate the risks. This work could be improved if exposure monitoring data were available.

Keywords: adverse birth outcomes, e-waste and epidemiological study

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1.1 Problem Statement

E-waste comprises discarded electronic appliances such as television, refrigerator, air converter, notebook, mobile phone, fluorescent, digital camera, media player, printer, and dry-battery. The discarded devices are considered electronic waste (e-waste) and are significantly contributing to levels of pollution around the globe and have deleterious effects on human health (Pascale et al., 2018) because e-waste contains with heavy metals (lead (Pb), mercury (Hg), cadmium (Cd), chromium (Cr), PBDEs, PCBs, PCDD/PCDFs and PAHs) (Xu et al., 2015) and may create environmental contamination during e-waste recycling. The study of the effect of e-waste recycling in Guiyu, China found that determine the hydroxylated PAH (OHPAH) metabolite concentrations in maternal urine in this area were higher than the reference background concentration (Huo et al., 2019) In addition, at the same e-waste recycling area (Song & Li 2014).

The studies in Guiyu, China found that the neonates in e-waste recycling site associated negatively with adverse birth outcomes. The results showed that the neonates in Guiyu had high rate of adverse birth outcomes, lower birth weight and lower Apgar scores (Xu et al., 2012). At the same area, the researchers found the adverse association of child physical growth and development in children who living in exposed area or e-waste recycling site in Guiyu. Those children had negatively associated with height and chest circumference (Xu et al., 2015). In addition, other studies found that the factors of maternal time spent living, parental work involved in e-waste and innovated house as a workshop significantly related with adverse birth outcomes and adverse children's health.

In Thailand, the trend of e-waste generation rate is increasing each year estimated by the Thailand Pollution Control Department (PCD). In 2017 the amount of e-waste generation is slightly increasing to 401,300 tons a year (65% of total hazardous wastes generation) (Pollution Control Department, 2018). The important e-waste recycling community in Thailand is located in "Daeng Yai sub-district, Ban Mai Chaiyaphot District and Ban Pao sub-district, Phutthaisong District in Buriram province" where is the important hub of e-waste recycling in Thailand. There were 383 tons of e-waste per week and e-waste are dismantled by local people at individual work's home (Wittayaarnumas, 2017).

In 2014, PCD studied about the heavy metals contamination in soil samples from e-waste recycling site in Daeng Yai sub-district and Ban Pao sub-district. Their results showed that there were high contamination of Pb in e-waste recycling site (higher than Thai soil standard and the Intervention Value (Netherland soil standard) (Pollution Control Department, 2014). In addition, the e-waste recycling can affect adversely to human health according to adverse birth outcomes in infant and child physical growth and development in children.

The e-waste generation rate in Thailand is continually rising but there were few epidemiological studies about adverse birth outcomes associated with e-waste recycling in Thailand. Therefore, the aims of this study are determining the association between the e-waste recycling and adverse birth outcomes.

1.2 Research objectives

- To compare the characteristics of infants and their mothers in exposed maternal living area and referent maternal living area
- To determine the prevalence of adverse birth outcomes related to maternal living in exposed maternal living area and referent maternal living area
- To investigate the association between maternal living in e-waste recycling site and adverse birth outcomes using epidemiological study (case-control study).

1.3 Scope of the research

- This study was a retrospective study.
- The e-waste recycling site was located in Daeng Yai sub-district, Ban Mai Chaiyaphot District and Ban Pao sub-district, Phutthaisong District in Buriram province.
- E-waste recycling method was primitive methods.
- The studied population were infants whose mother delivered in Burirum hospitals during 2010 - 2018.
- The studied diseases were adverse birth outcomes, included stillbirth, low birth weight (LBW), very low birth weight (VLBW), preterm birth (PTW) and intrauterine growth retardation (IUGR).

1.4 Expected benefits

- This study provided the distribution of demographical characteristic between exposed maternal living area and referent maternal living area.
- The study could investigate if the association between maternal living in an e-waste recycling site and adverse birth outcomes in Buriram exists.
- The results of statistically significant variables can be used to manage the regarding factors e.g. raising the awareness of e-waste recycling activities, planning of the maternal health, care during pregnancy, avoidance for living in e-waste recycling site during pregnancy.

Chapter II

Literature Review

2.1 Definition of e-waste

"E-waste is a term used to cover all items of electrical and electronic equipment (EEE) and its parts that have been discarded by its owner as waste without the intent of reuse" (Step Initiative., 2014). It is also referred to as WEEE (Waste Electrical and Electronic Equipment), electronic waste or e-scrap, that have completed its useful life and are discarded such as television, refrigerator, air converter, notebook, mobile phone, fluorescent, digital camera, media player, printer, and dry-battery. In most common materials found in e-waste is ferrous metals as iron and steel, representing 60.2% of e-waste (by weight). Plastics and metal-plastic mixture are the second largest component by weight, representing ~21% of e-waste. The other materials found in e-waste representing in (**Fig.2.1**) (Widmer et al., 2005).

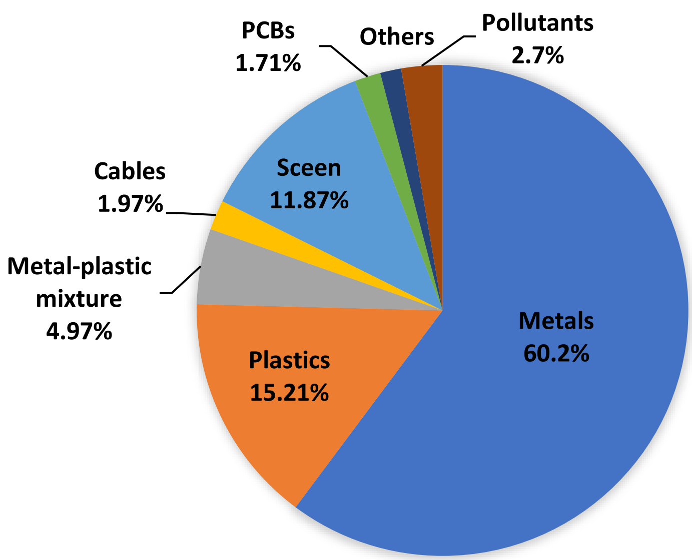

Fig 2.1 Generalised material composition in e-waste.

2.2 Hazardous and Toxic Constituents of E-Waste

E-waste is a source of useful as well as toxic materials. Circuit boards and other components can contain arsenic, cadmium, mercury, lead flame retardants containing halide substances etc., some of which become biologically active (Mihai, 2016). These hazardous materials are potential serious environmental and health threat. If burnt, some materials release toxic halogen gases, dioxins and furan. The leaching of heavy metals toxicity and spillage of chronic chemical pollutants contaminating soil, water, and organics into the air is dangerous to the environmental sustainability that can be lethal to the biota, as described in Table 2.1 (Pathak et al., 2019).

Table 2.1 Toxicity and their impact.

E-waste Components	Toxic Metals	Limit (ppm)	Disease Caused by the Exposure to Above Permissible Limit
Ceramic capacitors, switches, batteries	Ag	5.0	Excessive amount causing blue pigments on body, damages brain, lung, liver, kidney
Gallium arsenide is used in light emitting	As	5.0	Chronic effect and causes skin disease and lung cancer and impaired nerve signaling
Electron tube, lubricant, fluorescent lamp, CRT gun	Ba	<100	Causes brain swelling, muscle weakness, damage to the heart
Power supply boxes, motherboards	Be	0.75	Causes lung cancer, berylliosis, skin disease, carcinogens
PCBs, casing, PVC cables	Br	0.1	thyroid gland damage, hormonal issues, skin disorder, DNA damages, hearing loss
PCBs, battery, CRTs, semiconductors, infrared detectors, printer ink, toners	Cd	1.0	Pose a risk of irreversible impacts on human health particularly the kidney
Printed circuit boards	CN	< 0.5	Cyanide poisoning, >2.5 ppm may cause to coma and death

E-waste Components	**Toxic Metals**	**Limit (ppm)**	**Disease Caused by the Exposure to Above Permissible Limit**
Plastic computer hosing, cabling, hard discs, as a colorant in pigments	Cr	5.0	Toxic in the environment, causing DNA damage and permanent eye impairment
Batteries, LCD, switches, backlight bulbs or lamps	Hg	0.2	Damages brain, kidney and fetuses
Mobile, telephone, batteries	Li	< 10	Diarrhea, vomiting, drowsiness, muscular weakness
Batteries, semiconductor, CRT, PCB	Ni	20.0	Causes allergic reaction, bronchitis, reduces lung function, lung cancers
Transistor, LED lead-acid battery, solder, CRT, PCBs, florescent tubes	Pb	5.0	Damages brain, nervous system, kidney, and reproductive system causes acute and chronic effects on human health
CRT glass, plastic computer housing and a solder alloy	Sb	<0.5	Carcinogen, causing stomach pain, vomiting, diarrhea and stomach ulcer
Fax machine, photoelectric cells	Se	1.0	High concentration causes selenosis
CRT, batteries	Sr	1.5	Somatic as well the genetic changes due to this cancer in bone, nose, lungs, skin
Batteries, luminous substances	Zn	250.0	Nausea, vomiting, pain, cramps, and diarrhea
Cooling units and insulation foam	CFCs	< 1.0 for 8 h/day	Impacts on the ozone layer which can lead to greater incidence of skin cancer
Transformer, capacitor, condensers	PCBs	5.0	PCB causes cancer in animals and can lead to liver damage in humans
Monitors, keyboard, cabling, and plastic computer housing	PVC	0.03	Hazardous and toxic air contaminants, release of HCl causes respiratory problems

2.3 Environments contaminated by e-waste

Heavy metals could penetrate the soils where vegetables and crops are grown by contaminating irrigation water and through direct deposition by air. Plants can take up these metals from soil by their roots, transport them upwards to their shoots, and finally accumulate them inside their tissues (Luo et al., 2014). Soil contamination was widely spread across the country in China. High levels of several heavy metals and polychlorinated biphenyls were found in soil, which, later, entered the food chain such as rice. Eastern China, Taizhou (Zhejiang province) revealed concentrations of Pb and Cd in polished rice to be 2–4 times in excess of 0.2 mg/kg, the maximum allowable concentrations of these elements in foodstuffs in China (Fu et al., 2008). In the same town, measured elevated levels (up to 18 ng/g) of PBDEs in chicken tissues and concluded that these toxins may pose a threat to humans and ecosystems (Liang et al., 2008). Rice paddy soils adjacent to e-waste recycling areas in the Zhejiang province were shown to reduce the germination rate of rice (Wang et al., 2011).

Water contaminants can enter aquatic systems by leaching from dumpsites where processed or unprocessed e-waste may have been deposited. (Shi et al., 2009) found brominated flame retardants other than PBDE, namely 1,2-bis (2,4,6 tribromophenoxy) ethane, decabromodiphenyl ethane and tetrabromobisphenol A bis (2,3-dibromopropyl) ether, are widespread in various biota of the Pearl River Delta, downstream from e-waste recycling towns. (Robinson, 2009) found Pb up to 0.4 mg/L in river water downstream of a recycling plant in Guiyu, some 8 times higher than the local drinking water standard (0.05 mg/L) and elevated concentrations of Ag, Cr, Li, Mo, Sb and Se in the nearby Lianjiang river. All the contaminated area should be avoided and considered uninhabitable due to an increase in concentration of toxin in higher food chain as mentioned above.

Many e-waste contaminants are spread into the air dust. This is a major exposure pathway for humans through ingestion, inhalation and skin absorption (Mielke & Reagan, 1998). High levels of heavy metals in the air will impose serious environmental and biological problems (Song & Li 2014). Increased risks of mortality and morbidity have been associated with elevated levels of total suspended particles (TSP) in ambient air, especially for fine particles with aerodynamic diameter less than 2.5 mm (PM2.5) (Deng et al., 2006).

2.4 Pregnant women impact of e-waste

Guiyu town in China, is one of the largest e-waste destinations and recycling areas in the world. E-waste recycling in Guiyu is home-based and family-run with highly insufficient occupational hygienic conditions. Due to these informal activities, amount of chemicals including toxic heavy metals and persistent organic pollutants (POPs) such as lead, chromium, cadmium, polychlorinated biphenyls (PCBs), polybrominated diphenyl ethers (PBDEs) and polycyclic aromatic hydrocarbons (PAHs) are released to the environment, can pose a threat to the local people, especially to children. (Xu et al., 2015) Pregnant women are more susceptible to toxic that may affect to children. The research study in Guiyu found that the significantly higher rate of adverse birth outcomes in term of stillbirth (4.72% vs 1.03%), low birth weight (6.12% vs 4.12%), term low birth weight (3.40% vs 1.57%) and also lower Apgar scores (9.6 vs 9.9) showed in Guiyu when compared with the lowest air pollution city in China. (Xu et al., 2012). Another study was to investigate whether exposure to cadmium (Cd) during pregnancy is associated with an increased risk of adverse birth outcomes in a sex-dependent manner, that found significant inverse associations between U-Cd concentrations and birth anthropometry (birth weight, birth length, head circumference and apgar scores with 1 min and 5 mins) in female neonates (Zhang et al, 2018).

The studies another country study associated prenatal or postnatal exposure to PAHs with harmful physiological effects, such as global alteration of DNA methylation in cord blood, lower birth weight, smaller head circumference and preterm birth only a limited number of studies have examined the effects of PAH exposure and their impact on the developing fetus during pregnancy . (Xu et al., 2015). This study determines the urinary hydroxylated PAH metabolites in healthy mothers at delivery, and links maternal urinary levels with neonatal birth outcomes in an e-waste pollution area (Song & Li, 2014).

2.5 E-waste in Buriram, Thailand

Daeng Yai sub-district, Ban Mai Chaiyaphot District and Ban Pao sub-district, Phutthaisong District in Buriram province where were the largest hubs of e-waste recycling in Thailand. The Regional Environmental Office 11 (Nakornrachasima) and Pollution Control Department took underground water and soil samples. They found high contamination levels of lead and Pb. The Health Promotion Center Region 5 (Nakornrachasima) also examined tap water found high levels of nitrates (Wittayaarnumas, 2017). These were evidences of e-waste related heavy metals and chemical contaminants reported in the e-wasted community.

2.6 Epidemiological study

Epidemiological study is the study of the distribution and determinants of health-related states or events in specified populations. Its goal is to control of health problem. This study regressions the hospital record to analyses the effects of e-waste and influencing factors on mother and infants in Buriram province, Thailand. However, processing a massive data could lead to loss of data effects on pregnancy are usually caused by several variables, so adjusted confuse, provides a valid result by accounting the effect due to the confounding variables included in the analysis.

Chapter III

Methodology

3.1 E-waste recycling site

The studied area of e-waste recycling site were located in Daeng Yai sub-district, Ban Mai Chaiyaphot District and Ban Pao sub-district, Phutthaisong District in Buriram province. Their total area is 505 km^2. The population in Daeng Yai sub-district were 2,315 people for male and 2,360 people for female accordingly. The population in Ban Pao sub-district were 2,737 people for male and 2,874 people for female accordingly. The main occupation of people was agriculture and part-time jobs were textile and e-waste dismantling. There were 383 tons of e-waste per week coming to these 2 sub-districts.

3.2 Study design

This study is a cross-sectional study using epidemiologic data of birth records from the Buriram hospital where biggest hospitals in this province. The birth records were obtained for all pregnant women who delivered births during 2010 to 2019. The pregnant women were divided into 2 group using their living address as an exposed group and a reference group (living in recycling subdistricts and living in other subdistricts respectively)

• **Exposed maternal living area** refers to Daeng Yai sub-district, Ban Mai Chaiyaphot District and Ban Pao sub-district, Phutthaisong District in Buriram province where were the 2 largest e-waste recycling sites in Buriram. (the exposed zone)

• **Reference maternal living area** refers another sub-district and district in Buriram province where is far away for recycling site. (the reference zone)

• **Adverse birth outcomes**

This study used the birth records based on the codes of International Classification of Diseases version 10 (ICD-10). All the codes of ICD-10 that we focused on adverse birth outcomes shown in **Table 3.1**

Table 3.1 Definition of adverse birth outcome with ICD 10 codes

Adverse birth outcomes	**Definition**	**ICD 10 code**
Stillbirth	fetal death before complete expulsion or extraction from the mother at > 20 weeks of gestation	**Z37.1** Single stillbirth **Z37.4** Twin both stillborn **Z37.7** Multiple births, all stillborn
Very Low birth weight (VLBM)	an infant who had weight less than 1,000 grams.	**P07.0** Extremely low birth weight
Low birth weight (LBM)	A baby who are born weighing 1,000 to 2,499 grams	**P07.1** Other low birth weight
Preterm birth (PTB)	A baby who are born before 37 weeks of pregnancy	**P07.3** Other preterm infants
Intrauterine growth retardation (IUGR)	A baby who are born > 37 weeks of pregnancy and weighing < 2,500 grams	**P05.1** Small for gestational age
All adverse birth outcome (ABO)	the combination of above adverse birth outcomes consisted of stillbirth, VLBW, LBW, PTB and IUGR.	

3.3 Variables

Maternal characteristics included maternal living address (at least consisting of sub-district, district and province), maternal age, marital status, gestational age, pregnancy rate and abortion rate which were adequate for statistical analysis. Infant characteristics included sex and birth weight.

3.4 Statistical analysis

The birth records were analyzed with statistical software. The SAS® software, university edition which was chosen for using in this study to analyze the data for descriptive and inferential statistics. Chi-square tests was used to compare the differences of maternal and infant characteristics between a e-waste recycling subdistricts and reference subdistricts and to compare the prevalence of adverse birth outcomes between sites.

The obtained number of pregnant women were grouped into 4 groups showing in **Table 3.2** Then, crude odds ratio (COR) and 95% confidence intervals (95%CI) was computed for determining the association between adverse birth outcomes and maternal living in e-waste recycling site. The crude ratio shows and standard error (SE), and 95%CI shown in Equation **(1)**, **(2)** and **(3)** respectively.

Table 3.2 The number of infants with/without an adverse birth outcome and maternal living within a exposed site or reference site

Maternal living area	Adverse birth outcome	Non-adverse birth outcome
Exposed zone	A	B
Reference zone	C	D

Where A = the number of infants with adverse birth outcomes in recycling site

B = the number of infants without adverse birth outcomes in recycling site

C = the number of infants with adverse birth outcomes in control site

D = the number of infants without adverse birth outcomes in control site

$$\text{Crude odd ratio (OR)} = \frac{A/B}{C/D} = \frac{AD}{BC} \qquad (1)$$

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

Where SE = Standard error

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

Adjusted odd ratio (AOR) was then analyzed by logistic regression model which was used for controlling confounding factors such as maternal age and marital status. These confounding factors can increase a variance of consequence. The logistic regression model is shown below in **Equation (4)** and the computed AOR is shown in **Equation (5).**

$$\text{Prob (adverse birth outcome)} = \frac{1^{e^{z}}}{1+e^{z}}\ ;\ Z = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n \quad (4)$$

$$\text{Adjusted odds ratio} = \frac{\text{Prob (adverse birth outcome)}}{\text{Prob (non-adverse birth outcome)}} = e^{\beta 0 + \beta 1X1 + \beta 2X2 + \ldots + \beta nXn} \quad (5)$$

where $Z = \text{Logit}(\text{Prob}_{\text{adverse birth outcome}})$

X_1 = Maternal living area

X_2 to X_n = Confounding variables (maternal age and marital status)

β_0 = Constant coefficient

β_n = Coefficient of X_n

An interpretation of AOR, when AOR is less than 1.0, it describes a negative relationship. The negative relationship indicates that an interested adverse birth outcomes are associated decreasingly with the maternal living in e-waste recycling site after controlling for confounding factors. In the case of AOR is greater than 1.0, it means a positive relationship. The positive relationship indicates that an interested adverse birth outcome is associated increasingly with the maternal living in e-waste recycling site. If AOR lower bound of 95%CI range is greater than 1.0 so there is a confirmed statistically significant association between maternal living in e-waste recycling site and an adverse birth outcome with p-value < 0.05.

Chapter IV

Results and Discussion

A total of 35,682 birth records from Buriram Hospital from 2010 to 2019 were read. Each birth record consisted of variables of mothers and their infants, such as mother's address, maternal age, marital status, gestational age, pregnancy rate, abortion rate, infant sex, weight birth, but some variables might be missing.

Regarding to mother's living address recorded at the hospital, it can be observed that total number of 35,682 birth records shown in **Table 4.1** Most mothers were living in the reference zone (99.73%) while a very small number of mothers were living in the exposure zone (0.27%). It can be assumed that a large number of newborns were developed in the reference zone.

Table 4.1 Distribution of mothers according to analysis zone.

Mothernal living zone	**Number of mothers (N)**	**Number of mothers (%)**
Exposed zone	96	0.27
Reference zone	35,586	99.73
Total	35,682	100.00

4.1 Whole population analysis.

The characteristics of mothers and infants in the expose and the reference zone are shown in **Table 4.2**. Mothers and infants had a ratio of one to one regarding the birth records provided as each birth delivery was an independent event for each mother so mother characteristics may be duplicated for her other birth deliveries. The maternal age was categorized into 3 groups, ≤ 20, $21 - 35$, and > 35. We found that distribution of maternal age among these 3 subgroups were quite similar between 2 zones. For marital status which was classified into 3 groups as single, married and widowed or divorced or separated. More mothers were married in the exposed zone (65.53%) comparing with those in the reference zone (52.08%) and less mother were single in the exposed zone (29.17%) comparing with those in the reference zone (45.09%). The maternal characteristic were statistically different between zones (p-value < 0.01). For other characteristics, gestation age, pregnancy rate, abortion rate and infant sex were not statistically different between the expose and reference. These variables would be self controlled for their confounding effects to cause adverse birth outcomes.

Table 4.2 The characteristics of mothers and infants in exposed and reference zone.

Characteristics	Exposed zone (N=96)		Reference zone (N=35586)		Total (Missing)	p value
	N	%	N	%		
Maternal characteristics						
Maternal age (years)						
≤ 20	23	23.96	7652	21.50	35682	0.78
21-35	61	63.54	22843	64.19	(0)	
> 35	12	12.50	5091	14.31		
Marital status						
Single	28	29.17	16044	45.09	34719	0.01*
Married	63	65.63	18534	52.08	(963)	
Widowed, divorced or separated	0	0	50	0.14		
Gestation age (weeks)						
< 37	16	16.67	4783	13.44	35682	0.32
≤ 39	63	65.63	25799	72.50	(0)	
> 39	17	17.71	5004	14.06		
Previous pregnancies						
0	0	0	14	0.04	34211	0.56
1	45	49.45	13885	40.69	(1471)	
2	28	30.77	12144	35.59		
≥3	18	19.78	8077	23.67		
Abortion Rate						
0	76	83.52	27966	81.99	34200	0.79
1	14	15.58	5180	15.19	(1482)	
≥2	1	1.1	963	2.82		
Infant characteristics						
Infant sex						
Female	43	47.25	16490	48.34	34205	0.84
Male	48	52.75	17624	51.66	(1477)	

*Statistically significant difference at p-value < 0.05

The prevalence of interested adverse birth outcomes between the exposed and reference zone are shown in **Table 4.3.** The prevalence of adverse birth outcomes in the exposed zone was estimated for stillbirth (5.21 %), very low birth weight (6.25 %), low birth weight (15.63 %), preterm birth (16.67 %) and IUGR (7.52%) and ABO (27.08%). It can be observed that all 6 adverse birth outcomes showed greater prevalence in the exposed zone than those in the reference zone. The only statistically higher prevalence was observed for ABO ($p < 0.05$) when compared between zones. Our result shows consistency with other work that adverse birth outcomes in the exposed zone was higher than those the reference zone such that a research study in Guiyu (exposed zone) found higher rate of adverse birth outcomes in term of stillbirth, low birth weight, term low birth weight compared with Xiamen (reference zone) (Xu et al., 2012). This prevalence finding suggests that mothers living in the exposed area could experience all 6 adverse birth outcomes.

Table 4.3 Prevalence (%) of adverse birth outcomes in exposed and reference zone

Adverse birth outcomes	Exposed zone		Reference zone		p value
	N	%	N	%	
Stillbirth	5	5.21	1459	4.10	0.58
VLBW	6	6.25	1523	4.28	0.34
LBW	15	15.63	3624	10.18	0.08
PTB	16	16.67	4783	13.44	0.35
IUGR	5	5.21	1089	3.06	0.22
ABO	26	27.08	6542	18.38	0.03*

*Statistically significant difference at p-value < 0.05

In Table 4.4, the crude and adjusted odds ratio with 95%Cl are used to represent the association between adverse birth outcomes and maternal living in the e-waste activity exposure zones. The result of crude odds of adverse birth outcomes were estimated and showed the positive association in all 6 adverse birth outcomes. ABO was the only effect whose risk (COR=1.65, 95% Cl : 1.05,2.59) was statistically significant as its lower bound of 95% Cl is greater than 1. After adjusted for potential confounders of maternal age and marital status, the ABO effect had still remained robust as for a statistically increased risk. (AOR=1.67, 95% Cl : 1.05,2.65). This finding confirmed that mothers living in e-waste site had significant increased risk of ABO resulting for a risk of their infant survival. This statistical analysis confirmed that the infants whose mother living in e-waste exposure zones showed the positive association in all 6 adverse birth outcomes. In the other similar studies, they also reported in this agreement. In Guiyu where the biggest destination of informal e-waste recycling site in China. Its study found that the Guiyu births whose mothers living in this area had the statistically significant association with LBW and IUGR when compared with control site and also their finding showed maternal lead level in cord blood in Guiyu higher than control site (Xu et al., 2012). Heavy metal from e-waste such as Lead, Cadmium and Mercury resulted in birth outcomes. In the same site, that the mothers in Guiyu exposed to the higher levels of PFOA (perfluorooctanoic acid) which it was widely used in electronic industry and when compared with the control site and their adverse birth outcomes such as PTB, LBW and IUGR were significantly difference when compared with normal birth (Wu et al., 2012).The study from Saudi Arabian found that the levels of lead, cadmium and mercury were measured and found in umbilical cord blood, maternal blood and the placenta along with the risk of being small-for-gestational age (SGA) and Cadmium was the most prominent effect on several measures of birth outcome (Al-Saleh et al., 2014).

Table 4.4 Crude and adjusted odds ratio of adverse birth outcomes with 95% confidence intervals in exposed zone.

Adverse birth outcomes	Crude Odd Ratio	95 % CI		Adjusted Odd Ratio	95 % CI	
		Lower	Upper		Lower	Upper
Stillbirth	1.29	0.52	3.17	1.37	0.55	3.37
VLBW	1.49	0.65	3.41	1.59	0.69	3.64
LBW	1.63	0.94	2.84	1.73	0.99	3.01
PTB	1.29	0.75	2.21	1.25	0.72	2.19
IUGR	1.74	0.71	4.29	1.83	0.74	4.53
ABO	1.65*	1.05	2.59	1.67*	1.05	2.65

* $p < 0.05$,

Adjusted for maternal age and marital status

4.2 Subgroup population analysis

COR and AOR were further analyzed for specific subgroups by maternal age, maternal status and infant sex. Those risk estimates could be used to detect an increased risk in particular sensitive subgroups of mother population.

Maternal age was categorized into three groups: ≤ 20, 21–35, and > 35 years. The result of crude odds ratio of adverse birth outcomes with 95% confidence intervals in exposed zone categorized by age groups are shown in **Table 4.5-4.6.** For young mothers (age ≤ 20), living in the exposed zone showed 5 positive association with Stillbirth, VLBW, LBW, PTB and ABO. Only PTB was statistically associated with the young mothers living in the e-waste site by an increased risk (AOR = 2.83, 95% CI: 1.14, 7.06). Other work has also investigated that being young itself in mothers aged <20 years, compared to those who were 25–29 years old, had a 6.63-fold increased risk of preterm birth (Jiang et al., 2018). It implied that young mothers already had an additional risk of PTB as a background. For middle-age mothers (aged 21–35), living in the e-waste community showed 5 positive association with Stillbirth, VLBW, LBW, IUGR and ABO but their increased AORs were not statistically significant. For older mothers (aged >35), living in the e-waste area showed 3 positive association with LBW, IUGR and ABO while they experienced the statistically greatest risk to LBW (AOR = 4.36, 95% CI: 1.09, 17.52). These older mother in the e-waste sub-districts could be taken care well for less exposure to e-waste activities or be moved out from the e-waste community during their pregnancy period.

Table 4.5 Subgroup maternal age for crude odds ratio of adverse birth outcomes with 95% confidence intervals in exposed zone.

Adverse birth outcomes	<= 20			21 - 35			> 35		
	COR	Lower	Upper	COR	Lower	Upper	COR	Lower	Upper
Stillbirth	1.88	0.44	8.05	1.54	0.48	4.92	-	-	-
VLBW	1.79	0.42	7.65	1.99	0.72	5.50	-	-	-
LBW	1.66	0.61	4.47	1.29	0.59	2.83	3.78	0.97	14.69
PTB	2.81*	1.19	6.64	0.94	0.43	2.06	0.48	0.06	3.81
IUGR	0.93	0.12	6.89	1.89	0.59	6.06	3.73	0.47	29.70
ABO	2.17	0.94	5.01	1.49	0.82	2.70	1.39	0.36	5.39

* $p < 0.05$

Table 4.6 Subgroup maternal age for Adjusted odds ratio of adverse birth outcomes with 95% confidence intervals in exposed zone.

Adverse birth outcomes	<= 20			21 - 35			> 35		
	AOR	Lower	Upper	AOR	Lower	Upper	AOR	Lower	Upper
Stillbirth	2.50	0.57	10.99	1.58	0.49	5.01	-	-	-
VLBW	2.38	0.54	10.42	2.05	0.74	5.66	-	-	-
LBW	1.88	0.69	5.14	1.33	0.61	2.93	4.36*	1.09	17.52
PTB	2.83*	1.14	7.06	0.95	0.43	2.10	0.52	0.07	4.20
IUGR	1.01	0.14	7.58	1.97	0.62	6.32	4.23	0.52	34.15
ABO	2.18	0.90	5.27	1.54	0.85	2.80	1.58	0.39	6.34

* $p < 0.05$,

Adjusted for marital status.

The COR and AOR results of subgroup analysis for marital status stratified in 2 groups as single and married status show that being single pregnant mothers were positively associated with all 6 adverse birth outcomes while being married pregnant mothers were positively associated with 5 adverse birth outcomes (see **Table 4.7**). For only single mother subgroup, we noticed the statistically significant increased risk after adjusted for maternal age in LBW (AOR=2.89, 95% Cl : 1.22, 6.84) and ABO (AOR= 2.87, 95% Cl : 1.34, 6.16). These AORs remains remained statistically robust similar to their CORs which can confirm that maternal living in e-waste site caused the increased risk of LBW and ABO specifically in pregnant mothers who were single. This finding could be used to develop special heath care education and surveillance program to those single pregnant mothers in the exposed zone. There were evidences in other 2 non-pollution studies that showed single pregnant women were already at greater risk of some adverse birth outcomes. In Canada population , marital status may be the cause of adverse pregnancy outcomes especially in lone maternal status (mothers who were neither married nor in common-law relationship) which was considered having significant positive association for LBW (Luo et al., 2004). Other similar study found that marital status as single compared with married showed the positive association with adverse birth outcomes of stillbirth, infant mortality, PTB, SGA birth, and LGA birth (Shapiro et al., 2018). With our AORs finding in the exposed zone together with others' AOR findings in non-toxicant studies, it can imply that e-waste activities can impose additional risk on the top of a background risk of adverse birth outcomes to those being single pregnant women.

Table 4.7 Subgroup maternal status for crude odds and adjusted odd ratio of adverse birth outcomes with 95% confidence intervals in exposed zone.

Adverse birth outcomes	Single						Married					
	COR	Lower	Upper	AOR	Lower	Upper	COR	Lower	Upper	AOR	Lower	Upper
Stillbirth	2.71	0.82	8.99	2.65	0.79	8.82	0.80	0.19	3.26	0.84	0.20	3.48
VLBW	2.60	0.78	8.63	2.55	0.77	8.49	1.16	0.36	3.71	1.23	0.38	3.97
LBW	2.94*	1.25	6.92	2.89*^	1.22	6.84	1.30	0.62	2.73	1.31	0.62	2.75
PTB	1.80	0.73	4.45	1.77	0.72	4.39	1.06	0.52	2.14	1.09	0.54	2.22
IUGR	1.15	0.16	8.49	1.12	0.15	8.30	2.21	0.80	6.11	2.21	0.80	6.12
ABO	2.91*	1.36	6.22	2.87*	1.34	6.16	1.27	0.70	2.29	1.30	0.72	2.36

* $p < 0.05$,

Adjusted for maternal age

For subgroup analysis by infant sex, it was stratified into 2 groups as male and female. However, there were only 5 stillbirth records in the exposed zone and none was identified for sex. For LBW, there were only female infants. With these limitations, OR for stillbirth can not be determined and OR for LBW in male infants can also not be estimated. **Table 4.8** shows CORs and AORs that pregnant women having female infants were positively associated with VLBW, LBW, PTB, IUGR and ABO while pregnant women having male infants were positively associated with LBW, PTB, IUGR and ABO. We only observed a statistically significant positive association between female infant and VLBW (AOR=14.49, 95% Cl: 1.74,98.01), adjusted for maternal age and marital status. After adjusted, VLBW was variance because infants had less disease (not enough data). This was considered the great risk of e-waste living pregnant women with female infants as 14.49 fold-higher risk than those living outside the e-waste subdistricts. We hope that this finding could advise special measure to take care well this pregnant mother group especially with those with female infants.

Table 4.8 Infant subgroup for crude odds and adjusted odd ratio of adverse birth outcomes with 95% confidence intervals in exposed zone.

Adverse birth outcomes	Female infants						Male infants					
	COR	**Lower**	**Upper**	**AOR**	**Lower**	**Upper**	**COR**	**Lower**	**Upper**	**AOR**	**Lower**	**Upper**
Stillbirth	-	-	-	-	-	-	-	-	-	-	-	-
VLBW	13.06*	1.74	98.01	14.49*	1.91	109.87	-	-	-	-	-	-
LBW	1.51	0.67	3.40	1.78	0.78	4.06	1.83	0.86	3.92	1.85	0.86	3.98
PTB	1.58	0.66	3.74	1.45	0.57	3.72	1.04	0.41	2.62	1.05	0.42	2.66
IUGR	1.91	0.59	6.18	2.22	0.68	7.24	1.61	0.39	6.64	1.62	0.39	6.71
ABO	1.66	0.82	3.36	1.69	0.80	3.58	1.78	0.91	3.49	1.82	0.92	3.58

* $p < 0.05$,

Adjusted for maternal age and marital status.

Chapter V
Conclusions and Suggestions

In Buriram province where the one of the important provinces in Northeast is the largest e-waste site in Thailand. In this study, there were 35,682 birth records from the Burirum hospital involved in this research. The prevalence of adverse birth outcomes found in an ascending order was PTB, LBW, VLBW, IUGR and stillbirth respectively. Prevalence of all six adverse birth outcomes were found higher in the exposed zone than the reference zone.

For statistically significant increased risks, we found that in whole population analysis after adjusted for potential confounders of maternal age and marital status, the ABO effect had still remained robust as for a statistically increased risk. For young mothers (age <20 years old), only PTB was statistically associated with living in the e-waste site by an increased risk. For single mother subgroup, we noticed the statistically significant increased risk after adjusted for maternal age in LBW and ABO which can confirm that maternal living in e-waste site caused the increased risk of LBW and ABO especially in pregnant mothers who were single. These findings could be used to plan for a financial support and to develop special heath care education and surveillance program to those pregnant mothers living in the e-waste community with a priority to pregnant women with single, young or having female infants.

Suggestions for future work

- The birth records were registered between August 2010 and January 2019 that provided a few mothers in some adverse birth outcomes as stillbirth and IUGR. We suggested that more years of birth will give the better results.
- The recycling site is located far from Buriram hospital that some mothers in this area might be admitted in others hospital. Then, we suggested that more birth records from adjacent hospitals might give more accurate results.
- This study also lacks of pollution monitoring information such as in air and soil or maternal exposure to toxicants. These pollutant data can improve and better our risk results.

Measures and recommendations to government agencies

- For the government, e-waste sites need extra financial support and special health care to control and maintenance quality of e-waste activities to alleviate adverse birth outcomes in specific sensitive population especially those pregnant women with single, young and/or having female infant status. Moreover, controlling or segregating e-waste site far away from living area or not accumulating e-waste in the living area could reduce access risk.
- For public health, knowledge of e-waste pollution and confirmed risks of adverse birth outcome effects and living in e-waste site shall be communicated to e-waste communities. So, people living in e-waste subdistricts can apply it to protect themselves.
- For a local authority, pollutants in and around e-waste sites and communities shall be monitored and alternative occupations could be encouraged to people living in e-waste area.

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APPENDIX

The FREQ Procedure

area	Frequency	Percent	Cumulative Frequency	Cumulative Percent
exp	96	0.27	96	0.27
ref	35586	99.73	35682	100.00

The FREQ Procedure

Frequency Percent Row Pct Col Pct

Table of age_mom by area			
	area		
age_mom	exp	ref	Total
1	23 0.06 0.30 23.96	7652 21.44 99.70 21.50	7675 21.51
2	61 0.17 0.27 63.54	22843 64.02 99.73 64.19	22904 64.19
3	12 0.03 0.24 12.50	5091 14.27 99.76 14.31	5103 14.30
Total	96 0.27	35586 99.73	35682 100.00

Statistics for Table of age_mom by area

Statistic	DF	Value	Prob
Chi-Square	2	0.4931	0.7815
Likelihood Ratio Chi-Square	2	0.4932	0.7814
Mantel-Haenszel Chi-Square	1	0.4927	0.4827
Phi Coefficient		0.0037	
Contingency Coefficient		0.0037	
Cramer's V		0.0037	

Sample Size = 35682

The FREQ Procedure

Frequency Percent Row Pct Col Pct

Table of status_mom by area

status_mom	area: exp	area: ref	Total
1	28 0.08 0.17 29.17	16044 44.96 99.83 45.09	16072 45.04
2	63 0.18 0.34 65.63	18534 51.94 99.66 52.08	18597 52.12
3	0 0.00 0.00 0.00	50 0.14 100.00 0.14	50 0.14
4	5 0.01 0.52 5.21	958 2.68 99.48 2.69	963 2.70
Total	96 0.27	35586 99.73	35682 100.00

Statistics for Table of status_mom by area

Statistic	DF	Value	Prob
Chi-Square	3	11.1364	0.0110
Likelihood Ratio Chi-Square	3	11.3026	0.0102
Mantel-Haenszel Chi-Square	1	10.2701	0.0014
Phi Coefficient		0.0177	
Contingency Coefficient		0.0177	
Cramer's V		0.0177	
WARNING: 25% of the cells have expected counts less than 5. Chi-Square may not be a valid test.			

Sample Size = 35682

The FREQ Procedure

Frequency Percent Row Pct Col Pct

Table of week_mom by area

	area		
week_mom	exp	ref	Total
1	5 0.01 0.34 5.21	1459 4.09 99.66 4.10	1464 4.10
2	7 0.02 0.36 7.29	1958 5.49 99.64 5.50	1965 5.51
3	84 0.24 0.26 87.50	32169 90.15 99.74 90.40	32253 90.39
Total	96 0.27	35586 99.73	35682 100.00

Statistics for Table of week_mom by area

Statistic	DF	Value	Prob
Chi-Square	2	0.9324	0.6274
Likelihood Ratio Chi-Square	2	0.8588	0.6509
Mantel-Haenszel Chi-Square	1	0.7669	0.3812
Phi Coefficient		0.0051	
Contingency Coefficient		0.0051	
Cramer's V		0.0051	

Sample Size = 35682

The FREQ Procedure

Frequency Percent Row Pct Col Pct

Table of preg_no by area			
	area		
preg_no	exp	ref	Total
0	0 0.00 0.00 0.00	14 0.04 100.00 0.04	14 0.04
1	45 0.13 0.32 49.45	13885 40.59 99.68 40.69	13930 40.72
2	28 0.08 0.23 30.77	12144 35.50 99.77 35.59	12172 35.58
3	12 0.04 0.21 13.19	5575 16.30 99.79 16.34	5587 16.33
4	6 0.02 0.24 6.59	2502 7.31 99.76 7.33	2508 7.33
Total	91 0.27	34120 99.73	34211 100.00
Frequency Missing = 1471			

Statistics for Table of preg_no by area

Statistic	DF	Value	Prob
Chi-Square	4	2.9596	0.5646
Likelihood Ratio Chi-Square	4	2.9568	0.5651
Mantel-Haenszel Chi-Square	1	1.8775	0.1706
Phi Coefficient		0.0093	
Contingency Coefficient		0.0093	
Cramer's V		0.0093	

Sample Size = 34211
Frequency Missing = 1471

The FREQ Procedure

Frequency
Percent
Row Pct
Col Pct

Table of babystill by area			
	area		
babystill	exp	ref	Total
0	76 0.22 0.27 83.52	27966 81.77 99.73 81.99	28042 81.99
1	14 0.04 0.27 15.38	5180 15.15 99.73 15.19	5194 15.19
2	1 0.00 0.12 1.10	812 2.37 99.88 2.38	813 2.38
3	0 0.00 0.00 0.00	151 0.44 100.00 0.44	151 0.44
Total	91 0.27	34109 99.73	34200 100.00
Frequency Missing = 1482			

Statistics for Table of babystill by area

Statistic	DF	Value	Prob
Chi-Square	3	1.0582	0.7872
Likelihood Ratio Chi-Square	3	1.6175	0.6554
Mantel-Haenszel Chi-Square	1	0.5127	0.4740
Phi Coefficient		0.0056	
Contingency Coefficient		0.0056	
Cramer's V		0.0056	
WARNING: 25% of the cells have expected counts less than 5. Chi-Square may not be a valid test.			

Sample Size = 34200
Frequency Missing = 1482

The FREQ Procedure

Frequency Percent Row Pct Col Pct

Table of baby_sex by area

baby_sex	area: exp	area: ref	Total
1	43 0.13 0.26 47.25	16490 48.21 99.74 48.34	16533 48.34
2	48 0.14 0.27 52.75	17624 51.52 99.73 51.66	17672 51.66
Total	91 0.27	34114 99.73	34205 100.00

Frequency Missing = 1477

Statistics for Table of baby_sex by area

Statistic	DF	Value	Prob
Chi-Square	1	0.0428	0.8361
Likelihood Ratio Chi-Square	1	0.0428	0.8361
Continuity Adj. Chi-Square	1	0.0104	0.9189
Mantel-Haenszel Chi-Square	1	0.0428	0.8361
Phi Coefficient		-0.0011	
Contingency Coefficient		0.0011	
Cramer's V		-0.0011	

Fisher's Exact Test	
Cell (1,1) Frequency (F)	43
Left-sided Pr <= F	0.4599
Right-sided Pr >= F	0.6219
Table Probability (P)	0.0819
Two-sided Pr <= P	0.9164

Sample Size = 34205
Frequency Missing = 1477

Adverse birth outcomes	Crude Odd Ratio	95 % CI		Adjusted Odd Ratio	95 % CI	
		Lower	Upper		Lower	Upper
Stillbirth	1.29	0.52	3.17	1.37	0.55	3.37
LBW	1.66*	1.02	2.69	1.77*	1.08	2.89
PTB	1.29	0.75	2.21	1.25	0.72	2.19
IUGR	1.74	0.71	4.29	1.83	0.74	4.53
ABO	1.65*	1.05	2.59	1.67*	1.05	2.65

LBW = baby who are born weighing < 2500 gram

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