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MATERNAL AND INFANT HEALTH OF IMMIGRANTS IN THE CAPITAL TRI-COUNTY AREA IN MICHIGAN

By

Yu-Ying Chu

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ABSTRACT

MATERNAL AND INFANT HEALTH OF IMMIGRANT IN THE CAPITAL TRI-COUNTY AREA IN MICHIGAN

By

Yu-Ying Chu

Previous studies have shown that many groups of immigrant mothers have improved birth outcomes compared to mothers born in the United States, which is referred to as the *epidemiological paradox*. This thesis research was designed to study how individual- and neighborhood-level risk factors affect the adverse birth outcomes of U.S.-born and foreign-born mothers in the capital tri-county area in Michigan from the year 1995 to 2007. There were 73,682 women in total, including 67,515 U.S.-born and 5,628 foreign-born mothers. The results indicated that foreign-born women were less likely to contribute to both low birth weight and preterm birth than U.S.-born women, and the birth outcomes varied considerably within different foreign-born groups of mothers. I also found that neighborhood-level risk factors affect U.S.-born women more while individual-level risk factors were more important for foreign-born women.

Keywords: immigrants, epidemiological paradox, low birth weight, preterm birth, Michigan

This thesis is dedicated to my family

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1.0 Introduction

The World Health Organization (WHO) adopted in 1950 the standard of less than 2,500 grams (or 5 pounds, 8 ounces) as a universal definition of low birth weight and this threshold has been used in studies of the subject in the decades since (WHO, 1950). According to Paneth (1995) both low birth weight and its major antecedent, preterm birth (referring to the delivery of infants prior to 37 completed weeks of gestation), are more common in the United States than in most Western European nations. Low birth weight is also the most important predictor of neonatal mortality (deaths that occur in the first week of life) in the United States.

According to the U.S. Census Bureau, the term *foreign born* refers to anyone who is not a U.S. citizen at birth. This includes naturalized U.S. citizens, lawful permanent residents (immigrants), temporary migrants (such as foreign students), humanitarian migrants (such as refugees), and people illegally present in the United States.

Over the last three decades in the United States the neonatal mortality rate has declined primarily due to the increase in available neonatal care facilities, yet the incidence of low birth weight has continued to rise. While there are many known maternal and environmental risk factors for low birth weight, these still do not completely explain why the overall incidence is increasing. This increase in incidence however, is not seen across all populations. Previous research has shown that the

incidence of low birth weight is increasing among U.S.-born mothers, while the rate for immigrant mothers is still relatively low (Gould et al., 2003; Madan et al., 2006; El Reda et al., 2007). This phenomenon of immigrant mothers having improved birth outcomes compared to U.S.-born mothers is referred to in the literature as the "epidemiological paradox" (Gould et al., 2003).

The *epidemiological paradox* was first observed in the U.S. Latino population in the 1970s (Markidas and Coreil, 1986) and was characterized by favorable birth outcomes among Latino mothers compared to other mothers of similar low socioeconomic status (SES) (Acevedo-Garcia et al., 2003). A large number of studies have subsequently evaluated the association between immigrant status, SES, health behaviors, birth outcomes and other types of morbidity and mortality (Palloni and Morenoff, 2001; Peak and Weeks, 2002; Gould et al., 2003). For instance, unlike other socioeconomically disadvantaged minority groups, Mexican Americans were found to have very low rates of psychiatric service utilization compared to other ethnic groups (Markides and Coreil, 1986). Furthermore, the concept of *epidemiological paradox* applies to health behaviors such as smoking as Acevedo-Garcia et al (2004) reported that rates of tobacco use were lower among certain foreign-born groups than among their U.S.-born ethnic counterparts, controlling for socioeconomic position. Also, Singh and Siahpush (2002) used data

from the National Longitudinal Mortality Study (1979-1989) and found that compared with U.S.-born Caucasians of equivalent socioeconomic and demographic background, foreign-born African Americans had a 48% lower risk of mortality. Similar findings were also observed for foreign-born Hispanics (-45%), foreign-born Asians/Pacific Islanders (APIs) (-43%), U.S.-born Hispanics (-26%), U.S.-born APIs (-32%) and foreign-born Caucasians (-16%). While American Indians did not differ significantly from U.S.-born Caucasians, U.S.-born African Americans had an 8% higher mortality risk. African American and Hispanic immigrants experienced, respectively, 52% and 26% lower mortality risks than their U.S.-born counterparts.

The purpose of this thesis research is to improve our understanding of the geography of the *epidemiological paradox* by studying the incidence of low birth weight and preterm birth across and within different groups of foreign-born mothers living in the capital tri-county area in Michigan (Ingham, Eaton, and Clinton). I studied the likelihood that foreign-born mothers would have fewer low birth weight and preterm birth babies compared to U.S.-born mothers who are also living in the capital tri-county area. I tried to explain the population-geographic disparities in low birth weight and preterm birth rates by studying the individual characteristics of mothers, including age, education level, marital status, medical risk factors and origin of birth as well as the neighborhood environment in which mothers live and

infants are born. This thesis would draw on theoretical and methodological approaches from the fields of population and medical geography to answer these important and timely questions.

This study took place in the capital tri-county area in Michigan where there are a large number of foreign-born mothers of reproductive age. From 2002 to 2008 immigrants have comprised approximately 7.8% (range, 7.2% to 9.7%) of the population in Ingham county, 3.3% (range, 2.8% to 4.4%) of the population in Eaton county, and 1.6% (range, 1.3% to 1.8%) of the population in Clinton county (U.S. Bureau of the Census). Therefore, the capital tri-county area is an ideal place to study maternal differences in low birth weight by origin of birth. Over the last three decades the United States has also received a substantial number of immigrants and there have been few studies to-date that have attempted to understand the role of origin of birth in the rising incidence of low birth weight in the capital tri-county area. The findings from this study will also help to inform similar trends in the United States.

The objectives in this thesis research are:

(1) To assess whether foreign-born groups of mothers living in the capital tri-county area have lower rates of low birth weight and preterm birth compared to U.S.-born mothers also living in this area (i.e., to see if an *epidemiological paradox* exists in the capital tri-county area);

(2) To determine the variation in incidence of low birth weight and preterm birth among different foreign-born groups of mothers to see if the *epidemiological paradox* is stronger among some groups compared to others;

(3) To describe the individual and neighborhood level characteristics of foreign-born groups and U.S.-born mothers in the capital tri-county area neighborhoods; and

(4) To identify differences in individual and neighborhood level risk factors for low birth weight and preterm birth incidence in different foreign-born groups and U.S.-born mothers to better understand underlying factors that may contribute to the *epidemiological paradox*.

2.0 Literature Review

The following literature review examines known individual and neighborhood level risk factors for low birth weight.

2.1 Individual Level Risk Factors for Adverse Birth Outcomes

Several determinants influence birth outcomes. The following are the main individual characteristics of mothers that may contribute to low birth weight and preterm birth as indicated in previous research.

2.1.1 Age

Valero de Bernbé et al (2004) indicated the incidence of low birth weight increases in the young and old extremes of women's reproductive life; that is, between 15 and 19 years and between 35 and 40 years of age. Reichman and Pagnini (1997) showed that both African American and white mothers in their 30s were significantly more likely to deliver a low birth weight baby than women aged 25 to 29 years of age of the same race. However, other studies have found that even though older maternal age is associated with increased risk of low birth weight among singleton births, this effect was significant for African American women only (Collins and David, 1990; Starfield et al., 1991). Rauh et al (2001) further found that the extreme age-related effects observed for African American women in relation to low birth weight were largely concentrated among poor women.

2.1.2 Education

Previous studies have found a powerful connection between health and education. Education and knowledge of appropriate health behaviors are important determinants of health and the education of a child's mother is an important predictor of the health of a child (Skilnik, 2008). One study conducted in the Philippines illustrated how higher educated mothers were able to keep their children healthy, even in locations without a safe water supply (Glewwe, 1997).

Auger et al (2008) indicated that among Canadian-born mothers, all levels of education less than university were associated with a greater likelihood of all three adverse birth outcomes. The strongest associations were seen for mothers having "no high school diploma" relative to "university" education, for small for gestational age births (infants born below the 10% percentile of a standard population) odds ratio (OR) = 2.03 (95% CI 1.84 to 2.22), low birth weight OR = 2.03 (95% CI 2.61 to 3.91), and preterm birth OR = 1.67 (95% CI 1.49 to 1.87).

However, these results were reversed for foreign-born mothers. For these mothers all levels of education lower than university education were less strongly associated with small for gestational age birth and preterm birth and not significantly associated with low birth weight. For example, mothers having no high school diploma relative to university-educated mothers had a higher likelihood of small for gestational age

OR = 1.26 (95% CI 1.07 to 1.49) , an OR substantially smaller than the equivalent OR for Canadian-born mothers OR = 2.03 (95% CI 1.84 to 2.22). The two educational levels "no high school diploma" versus university-education OR = 1.36 (95% CI 1.11 to 1.66) and "high school diploma" versus university-education OR = 1.37 (95% CI 1.11 to 1.70) were associated with preterm birth among foreign-born mothers but these associations were not substantially different from those of Canadian-born mothers. Auger et al (2008) therefore concluded that the "healthy migrant" effect may be present in mothers with lower education but not in other educational categories.

This finding was disputed however, by other researchers who studied only higher educated women. The mechanisms by which higher educated foreign-born mothers are more likely to experience adverse birth outcomes than Canadian-born highly educated women are stress and psychosocial factors (Dejin-Karlsson and Ostergren, 2004; Frank, 2005). After entry into Canada, immigrant women of higher education could conceivably experience greater stress adapting to a new living environment. For example, the challenge of finding employment comparable to what they may have had in their own countries was considered very stressful.

2.1.3 Marital Status

Holt et al (1997) found that women who were married during their first pregnancy had a lower incidence of low birth weight than single mothers but if they

were separated during the second pregnancy, the relative risk (RR) of low birth weight increased RR = 1.4 in comparison to those who remained married. Conversely, among women whose marital status changed from single to married between pregnancies, the risk of low birth weight decreased RR = 0.8. Also, Madan et al (2006) found that a household with less familial and social support may contribute to poorer perinatal outcomes. Further, Nothnagle et al (2000) pointed out that more women in the late care group (women who received care only in the third trimester) reported being unmarried, or having no supportive person available during pregnancy than did women with earlier care.

2.1.4 Socioeconomic Status

Socioeconomic status level is one of the factors most closely related with the health status of populations, and it is shown that unfavorable socioeconomic conditions increases the incidence of low birth weight (Valero de Bernbé et al., 2004). Other studies have consistently shown that racial or socioeconomic differences in morbidity and mortality are most pronounced in young and middle-aged adults (House et al., 1990; Elo and Preston, 1996).

Nevertheless, Madan et al (2006) illustrated that foreign-born Asian-Indian women have a low-risk sociodemographic profile but a paradoxically higher incidence of prematurity, low birth weight, and small for gestational age birth infants.

The odds of low birth weight compared with white women were significantly higher in both foreign-born, OR = 2.37 (95% CI 2.3 to 2.4) and U.S.-born, OR = 2.18 (95% CI 1.95 to 2.18) Indian women. Markides and Coreil (1986) also concluded that the health status of Hispanics in the Southwest is much more similar to the health status of other Caucasians than that of African Americans although socioeconomically, the status of Hispanics is closer to that of African Americans. These authors suggest that the extended family support that Hispanics receive may protect them from stress-related morbidity.

Moreover, Uretsky and Mathiesen (2007) had a different perspective toward socioeconomic status among foreign-born populations. These authors showed that advances in educational attainment, economic status, and English proficiency were all significantly related to improved health, but this effect was muted among the foreign-born as the number of years living in the United States increased. This result suggests that along with improvement in key socioeconomic factors there is a deterioration of some unmeasured indicators that appear to have an overwhelming and negative influence on immigrant health.

2.1.5 Personal Behaviors

Maternal smoking, alcohol, caffeine, and drug consumption are the main behavioral risk factors that may contribute to having low birth weight babies.

(McFarlane et al., 1996; Smeriglio and Wilcox, 1999). Even though the relationship between caffeine consumption and low birth weight remains a subject of some debate, Wilborg et al (1996) observed the risk of preterm birth in women who consumed large doses of caffeine (> 400 mg per day) and also smoked was three times higher than that of women who did not consume caffeine. Furthermore, the consumption of illicit drugs had been associated with a lower birth weight, and it is estimated that up to 25 to 30% of women who consume cocaine during pregnancy will give birth to a small for gestational age birth infant (Valero de Bernbé et al., 2004). Kliegman et al (1994) also indentified cocaine as the drug with the strongest association with preterm birth and low birth weight.

2.1.6 Medical Risks

A variety of diseases may relate to adverse birth outcomes. Madan et al (2006) pointed out that diabetes, depending on the type and severity, may increase the risk of adverse birth outcomes including, macrosomatia (exceptionally large baby at birth), low birth weight, prematurity, congenital anomalies and fetal death. In general, more severe stages of diabetes are associated with vascular compromise and smaller than expected birth weights. However, treatment of a diabetic pregnant woman with insulin and diet decreases prenatal mortality and the incidence of macrosomy in the infant, but may also increases the frequency of growth retardation due to iatrogenic

hyperinsulinism (an above normal level of insulin in the blood of a person or animal) and excessive caloric reduction (Valero de Bernbé et al., 2004).

Valero de Bernbé et al (2004) also described that chronic hypertension may provoke alterations in fetal growth as a result of reduced uteroplacetal fluid. Moreover, hypertension, induced by pregnancy is defined as the development of blood pressure values higher than 140/90 mm/Hg after the 20^{th} week of pregnancy, leads to an increased risk of preterm birth and of low birth weight (Leung et al., 1998; Zeitlin et al., 2001). Plus, lupus is the most frequent autoimmune disease in the pregnant woman. Lupus increases the frequency of low birth weight and preterm birth 30 to 50%, especially when the disease involves the kidneys and hypertension (Valero de Bernbé et al., 2004).

2.1.7 Parity

Parity refers to the number of times a woman has giving birth. Short intervals between births constitute one of the main risk factors for prematurity and low birth weight, although researchers are still debating about this (Valero de Bernbé et al., 2004). Ferraz et al (1988) showed that short birth intervals, varying from 3 to 6 months in developing countries and from 1 to 2 years in developed countries may lead to an increased tendency toward low birth weight and prematurity in subsequent pregnancies.

Also, Roth et al (1998) indicated that second and third children weigh more than the first because of improved intrauterine conditions, such as uterine structures and vascular structures, which permit greater placental development, and consequently, improved fetal nutrition (Valero de Bernbé et al., 2004). However, the risk of low birth weight will increase again with the fourth and subsequent child (Silva et al., 1998). Further, a history of low birth weight in previous pregnancies is also an important predictor of risk in the current pregnancy (Bratton et al., 1996).

2.1.8 Prenatal Care

Prenatal care has long been endorsed as a mean to identify mothers at risk of delivering a preterm or growth-retarded infant while also providing them with an array of available medical, nutritional, and educational interventions to reduce the risks associated with low birth weight and other adverse pregnancy conditions and outcomes (Alexander and Korenbrot, 1995). Hence, adequacy of prenatal care use could be an indicator of a myriad of health-enhancing maternal attitudes and behaviors as well as a measure of the prenatal care received.

The most targets for prenatal interventions to prevent low birth weight, according to Kramer (1990), are "(1) smoking (aimed at reduction or cessation); (2) nutrition (aimed at increasing pre-pregnancy weight and/ or ensuring adequate weight gain during pregnancy); and (3) medical care (aimed at reducing overall morbidity).

Nevertheless, the determinants of prenatal care use are varied and range from obvious financial, geographic, and support barriers to more subtle cultural and attitudinal characteristics." Those who received the least prenatal care cited finances as the most important reason for not having prenatal care earlier in the pregnancy or more often during the pregnancy (Alexander and Korenbrot, 1995).

Nothnagle et al (2000) had the same observation in California. These authors found that a higher percentage of women in the late and no care groups had income under the poverty line compared with women in the earlier care group. In addition, although the majority of women in each group (earlier care, late care, and no care) had Medi-Cal as their primary insurance during pregnancy, over two-fifths (41.5%) of women who received no prenatal care were uninsured throughout pregnancy, compared with only about 1% of women in the earlier care and late care groups; women in the late care and no care groups appeared less likely to have private insurance than women in the earlier care group.

Moreover, Gavin et al (2004) indicated the racial and ethnic disparities relate to the use of a range of prenatal care among Medicaid-covered women as well. Compared with white non-Hispanic women, minority women were less likely to receive health services that the woman initiates, discretionary services, and services potentially requiring specialized follow-up care, whereas they were more likely to

receive screening tests for diseases related to high-risk behaviors. The authors also proposed that these results may be explained by the markedly different composition of the Hispanic and Asian/Pacific Islander populations with respect to country of origin and hence cultural beliefs and practices.

2.1.9 Mother's Birthplace

Mother's birthplace has also been highlighted as an important predictor of birth outcomes among immigrant subgroups in either Europe (Vahratian et al., 2004) or the United States (El Reda et al., 2007). Urquia et al (2009) pointed out that the risk of low birth weight varied considerably according to the region of origin of the immigrant mother; the country of origin appears to be a much more important factor in low birth weight among children of recent immigrants than the neighborhood in which they currently live. For example, infants of North African immigrants, compared to infants of Belgian women, were less likely to be born preterm, despite their lower socioeconomic status. Also, foreign-born Hispanic women, despite a high-risk demographic and socioeconomic profile, experienced birth outcomes superior to those of their U.S.-born counterparts (Crump et al., 1999). Another observation was among foreign-born Asian and Asian-born Indian women. Despite the fact that they have a better socioeconomic status profile, foreign-born Asian and Asian-born Indian women experienced a higher incidence of low birth weight and

preterm birth than their U.S.-born counterparts (Acevedo-Garcia et al., 2003; Gould et al., 2003; Tore et al., 2006).

One similar trend has also been observed in Michigan, which is home to about 490,000 persons of Arab ancestry, one of the largest populations of Arab immigrants outside of the Middle East (Arab American Institute Foundation, 2003). El Reda et al (2007) reported that even though foreign-born Arab women in Michigan have a higher-risk maternal demographic profile and being at a considerable socioeconomic disadvantage (having less education, being more likely to report Medicaid as the expected payer source, and more likely to receive no prenatal care) than that of their U.S.-born white counterparts, their prevalence of preterm birth is significantly lower, which is consistent with the *epidemiologic paradox* reported among foreign-born Hispanic women.

2.1.10 Duration of Residence

Previous studies indicate that the favorable birth and health outcomes of foreign-born migrant women might be explained by the "health migrant effect" and by the relatively healthy life styles that they maintained from the country of origin. However, a change to an unhealthier life style could contribute to the decreased health outcomes of native-born migrants and migrants with longer residence duration (Tore et al., 2006).

Crump et al (1999) shared the same observation. Their study of Mexican Americans found that longer residence in the United States resulted in increased risk of preterm birth among foreign-born Americans, indicating that acculturation plays a major role in reversing the effects of traditionally protective social and cultural factors.

Kearns (1993) illustrated that what occurs in a place (in terms of the relations between people and elements of their environment) has profound importance to health. Previous research also suggested that birth outcomes may either improve or deteriorate with length of residence among first-generation immigrants, depending on the migrant group or the receiving environment or a combination of both (Urquia et al., 2009).

Some studies have shown that immigrants generally arrive in the U.S. healthier than the general population, but as time passes their health status converges towards the levels found in the U.S. (Singh and Miller, 2001; Singh and Siahpush, 2002). Importantly, Uretsky and Mathiesen (2007) showed that foreign-born populations with improved health seem to decrease uniformly with years living in the U.S. and after about 10 years immigrant health becomes roughly equal to the level found among the U.S.-born population.

2.1.11 Acculturation

Culture assimilation, or acculturation, is usually the first and the easiest in the series of stages of assimilation by which immigrants become theoretically integrated into U.S. society (Gordon, 1964). Acculturation is also a multidimensional phenomenon by which language components, dietary intake and smoking are important indicators of birth outcomes (Tore et al., 2006).

As a matter of fact, active smoking is highly associated with birth outcomes; maternal smoking during pregnancy increases the relative risk of low birth weight considerably. Dejmek et al (2002) found that mothers who smoked moderately had a higher risk of low birth weight OR = 2.81 (95% CI 2.21 to 3.71) than mothers who did not smoke and mothers who smoked heavily had a significantly higher risk of having low birth weight babies compared to mothers who did not smoke OR = 4.95 (95% CI 4.95 to 8.06). Also, the association between birth weight and maternal smoking was weaker when they used data about smoking during early pregnancy, stronger with data characterizing smoking habits in the first trimester, and even stronger if based in smoking in the second and third trimester. If the mothers continue to smoke even during the second trimester, the adjusted weight reduction for infants was -152 grams (95% CI -117 grams to -185 grams) in moderate and -259 grams (95% CI -175 grams to -342 grams) in heavy active smoking mothers.

Research in The Netherlands showed that higher infant mortality of Turkish

migrants who are more integrated into Dutch society (i.e. Dutch-born and Turkish migrants with younger age at immigration) might be due to adoption of unhealthy western life styles. This suggestion is supported by a Dutch report showing a rising trend of tobacco use especially among younger Turkish women. Meanwhile, the opposite trend was observed among Surinamese mothers, in which infant mortality risk decreased with younger age at immigration. This result implies that increased acculturation and social integration could result in improving health outcomes of their children as well (Tore et al., 2006).

El Reda et al (2007) also mentioned that behaviors of Arab women are being altered by residing in the United States, as evidenced by the higher rates of selected characteristics among U.S.-born Arabs than among their foreign-born counterparts. Specifically, more U.S.-born Arab mothers than foreign-born Arab mothers report tobacco use during pregnancy and list only one named parent on their infants' birth certificate. It is very likely that this higher tobacco use among U.S.-born Arabs is due to acculturation because previous studies have documented that smoking rates among Arab women are significantly lower than those of non-Arabs in Michigan (Akbar, 1994).

2.2 Neighborhood Level Risk Factors for Adverse Birth Outcomes

Women's health is influenced not only by behavior and culture, but also by the

social, economic, and political contexts in which women live: "people's health both shapes and is shaped by the places in which their lives unfold" (McLafferty and Tempalski, 1995; Dyck and Kearns, 1995). The neighborhood or community context, according to McLafferty and Tempalski (1995), encompasses the "local social networks of neighbors and friends, geographical access to jobs and services, housing, and environmental quality." For example, because women often use prenatal care service in their neighborhoods, the locations of services and transportation can be important determinants of birth outcome (Hoagberg et al., 1990).

The following are some neighborhood characteristics which may increase the risk of adverse birth outcomes for mothers.

2.2.1 Income Inequality

O'regan and Wiseman (1990) suggested that low-income neighborhoods consistently have high rates of infant mortality and low birth weight, with rates often several times higher than those in affluent neighborhoods. Also, poverty and unemployment emerge as important predictors of infant health. Huynh et al (2005) reported an adverse influence of income inequality on preterm birth in a study of U.S. counties, and found that the influence of income inequality depends on race. Moreover, another study on cumulative exposure to income inequality reported an association with preterm birth for Hispanic but not African American or Caucasian

ethnicity (Reagan and Salsberry, 2005).

Auger et al (2009) tried to examine the association between birth outcomes and area income and income inequality across social makers in Québec, Canada. These authors found that both preterm birth and small gestational for age birth were positively related to area poverty and inversely related to income inequality. However, high area poverty was associated with preterm birth among Canadian-born, adjusted OR = 1.07 (95% CI 1.00 to 1.14), but not foreign-born mothers, adjusted OR = 0.95 (95% CI 0.83 to 1.09). There was a strong association between high area poverty and small gestational age birth among Canadian-born OR = 1.13 (95% CI 1.06 to 1.20), but the association was not significant among foreign-born mothers, adjusted OR = 1.00 (95% CI 0.88 to 1.13). These authors concluded that income inequality might be a pathway through which "area" exerts its effects on birth outcomes. Also, income inequality could be a proxy for other unrelated neighborhood factors favorably associated with birth outcomes.

2.2.2 Immigrant Density

Besides examining the relationship between birth outcomes and income inequality, Auger et al (2009) also had the observation that low immigrant density was associated with preterm birth in the fully adjusted model for Canadian-born mothers OR = 1.14 (95% CI 1.07 to 1.21), and the association between preterm birth and

foreign-born mothers was OR = 0.79 (95% CI 0.63 to 1.00). That is, high immigrant density was protective against preterm birth for Canadian-born mothers, but unfavorably associated with preterm birth for foreign-born mothers. These authors also suggested that high immigrant density may be associated with conditions that reduce stress in native-born mothers, but increase stress in foreign-born mothers. Such conditions might arise if, for instance, employment opportunities were greater for native- than for foreign-born individuals due to prejudice or network integration. Several other studies confirm this point of view by addressing the result that the psychosocial stress associated with balancing home and work heightens the risk of ill health and low birth weight for some women (Pritchard and Teo Mpfan, 1993; Elliott, 1995).

2.2.3 Housing

Besides using different individual-level risk factors as indicators of low birth weight, Shiono et al (1997) introduced the concept of level of living as well. It includes housing density (had two or more people per room during pregnancy), stable housing (lived three or more years in current residence), moved (moved two or more times in the past year), and housing problems (had two or more major housing problems in need of repair during pregnancy). After controlling for level of poverty and the other known correlates of birth, they found out that living in public housing

was associated with an 83-gram decrease in birth weight. Nevertheless, having a stable residence was associated with a 76-gram increase in birth weight. Importantly, these authors concluded that living in public housing had an independent negative relationship with birth weight while having a stable residence was positively related to birth weight.

2.3 Societal Level Risk Factors for Adverse Birth Outcomes

Societal (the broadest scale) processes "influence the allocation and quality of goods and services, the distribution of wealth, and legal and institutional constrains" (McLafferty and Tempalski, 1995). Sidel (1992) mentioned that the social, economic, and political context in which people live strongly influences the health of both individuals and of populations. The research done by McLafferty and Tempalski (1995) showed that in New York City "changing political, social, and economic relations have profoundly affected the urban landscape, with corresponding impacts on women's reproductive health."

Furthermore, Dyck (1990) illustrated that although women play an active role in shaping communities, some elements are beyond individual control. Those processes that operate beyond the community scale have distinct impacts on individuals and places. For example, Fisher et al (1995) showed a deterioration of birth outcomes during periods of recession and high unemployment.

These studies highlight the different risk factors for low birth weight and preterm birth. Among all the risk factors listed above and the birth data that I am available for, I will select mother's birthplace, maternal race, maternal age, maternal education, marital status, personal behavior (tobacco use during pregnancy), parity, numbers of prenatal care visits, and payment of insurance as individual-level risk factors for low birth weight and preterm birth. As for neighborhood-level risk factors, in addition to using immigrant density in this research, I will study local racial residential segregation in order to understand the clustering of racial groups. Also, I will use the two economic measures of income inequality and area-level poverty to understand the socioeconomic status of the neighborhoods in which mothers live and infants are born. Societal- level risk factor will not be analyzed in this research on neighborhood impacts on birth outcomes.

2.4 Thesis Significance

With the higher percentage of immigrants in the United States year by year, more studies have been focusing on immigrant mothers and their birth outcomes. However, previous studies were mainly conducted in areas with higher immigrant density, such as California and Toronto, Canada. As a matter of fact, the capital tri-county area in Michigan receives a substantial number of immigrants each year from many different countries of the world, yet to-date there have been no studies on

the maternal and infant health of immigrants mothers and children in this area. Therefore, there is a need for more studies that focus on immigrant health in general and maternal and infant health of immigrants in particular to better understand if an *epidemiological paradox* exists in Michigan and how it is different from the *epidemiological paradox* in other regions of the world.

2.4.1 Goal

The goals of my thesis are to compare the incidence of low birth weight and preterm birth in foreign-born and U.S.-born mothers to determine if an *epidemiological paradox* exists in the capital tri-county area in Michigan and to explore both individual- and neighborhood- level risk factors that may contribute to these differences.

2.4.2 Objectives

The objectives of this thesis are (1) to assess whether immigrant groups of mothers living in the capital tri-county area have lower rates of low birth weight and preterm birth compared to U.S.-born mothers also living in this area (i.e., to see if an *epidemiological paradox* exists in the capital tri-county area); (2) to determine the variation in incidence of low birth weight and preterm birth among different immigrant groups of mothers to see if the *epidemiological paradox* is stronger among some groups compared to others; (3) to describe the individual and neighborhood

level characteristics of immigrant groups and U.S.-born mothers in the capital tri-county area neighborhoods; and (4) to identify differences in individual and neighborhood level risk factors for low birth weight and preterm birth incidence in different immigrant groups and U.S.-born mothers to better understand underlying factors that may contribute to the *epidemiological paradox.*

2.4.3 Hypothesis

Following the objectives, I hypothesize that:

a. Foreign-born mothers will have a lower incidence of low birth weight births and preterm birth than U.S.-born mothers;

b. The incidence of low birth weight and preterm birth will differ from different groups of foreign-born mothers;

c. Individual-level risk factors for low birth weight and preterm birth will be more important for foreign-born mothers compared to U.S.-born mothers;

d. Neighborhood-level risk factors have stronger affect on U.S.-born mothers than foreign-born mothers.

3.0. Data and Methods

The following section describes the data and methods that I used in my thesis research to address the goal and objectives and to test the hypotheses.

3.1 Data

3.1.1 Birth Data

The data of all live singleton births in the capital tri-county area were obtained from the Vital Statistics Office at the Michigan Department of Community Health for the years 1995-2007. Vital statistics data include information taken directly off the birth certificate that is routinely collected on all live births in Michigan. All U.S.-born and foreign-born women who gave birth in the capital tri-county area during this period were included in the study population. There were 73,682 women in total, including 67,515 U.S.-born, 5,628 foreign-born, and 529 missing data.

All of the maternal-level variables used in this research were from the vital statistics birth data set. There were 9 independent variables in total. These variables were selected because they have been previously shown to be related to adverse birth outcomes as mentioned at the end of my Literature Review Section. These variables and the form in which they were analyzed included origin of birth (ORIGIN), U.S.-born = 0 and foreign-born = 1; racial/ ethnic group (RACE), African American = 1 and others = 0, Asian = 1 and others = 0, American Indian = 1 and others = 0,

Hispanic = 1 and others = 0, and Hawaiian/ Pacific Islanders = 1 and others = 0; maternal age (MAGE) in years, less than 20 = 1 and others = 0, and greater than 34 = 1 and others = 0; educational level (EDU), no high school diploma = 1 and others = 0, and some college or more = 1 and others = 0, representing less than 12 and 16+ years of education; marital status (MARITAL), one parent (single) = 1 and others = 0, and acknowledgment of paternity = 1 and others = 0; insurance converge (INSURE), Medicaid = 1 and others = 0, and self pay and other = 1 and others = 0; parity (PARITY), 0 = 1 and > 1 = 0; trimester of prenatal care (CARE), none = 1 and others = 0, second = 1 and others = 0, and third = 1 and others = 0; and smoking during pregnancy (SMOKE), yes = 1 and no = 0.

Overall statistical models included U.S.-born and foreign-born and more specific models included U.S.-born and foreign-born by origin of birth. Foreign-born mothers and infants were grouped by origin of birth after exploring the birth data and determining an adequate and similar N for each group. Also, I aimed to group those foreign-born populations by geographical proximity and cultural similarity. These groups represented Eastern Europe (N = 263), Western Europe (N = 551), North Africa (N = 114), Sub-Saharan Africa (N = 407), Canada (N = 229), Mexico (N = 528), Central/ South America (N = 569), Eastern Asia (N = 1029), South Asia (N = 461), Southeast Asia/ Oceania (N = 904), and Central Asia/ Middle East (N = 522).

Infant-level risk factors included birth weight (birth weight < 2,500 grams = 1 and birth weight >= 2,500 grams = 0; birth weight continuous, grams), preterm birth (gestation < 37 weeks = 1 and gestation >=37 weeks = 0; gestation, continuous, weeks).

3.1.2 Neighborhood-level Data

All the neighborhood-level variables used in this research were obtained from the U.S. Bureau of the Census, SF1 and SF3 data files at the census tract level and included median household income (INCOME), used as an indicator of neighborhood poverty and economic deprivation; ratio of income to poverty threshold by household type (POVERTY), used to describe the poverty level of households of immigrants; immigrant density by census tract (DENSITY), used to understand the density of immigrant populations in the neighborhoods; and Anselin's local Moran's I (LMiZscore) was used to measure the clustering of racial groups as an indicator of local racial residential segregation (Anselin, 1995).

3.2 Methods

3.2.1 Join Tables

In order to visualize the spatial patterns of both individual- and neighborhood-level risk factors and analyze the effect of these risk factors on adverse birth outcomes for U.S.-born and foreign-born mothers and infants these data were

joined to county boundary files for the capital tri-county area using the common identifier "GEO_ID" in GIS analysis. There were 117 census tracks in the capital tri-county area.

3.2.2 Descriptive Statistics

To assess the individual- and neighborhood-level risk factors and adverse birth outcomes for U.S.-born and foreign-born mothers and infants, these data were first explored for missing values and general descriptive statistics such as frequencies and summary statistics were estimated. The rate of low birth weight and preterm birth were also calculated to compare the birth outcomes of U.S.-born and foreign-born women. These rates represented the number of low birth weight or preterm birth per 1,000 live births.

Moreover, in order to compare the adverse birth outcomes of U.S.-born mothers in the capital tri-county area and the state of Michigan, I calculated the standardized rates. The standardized rates were obtained by multiplying the rate of low birth weight (8.4%) and preterm birth (12.5%) of the state of Michigan in the year 2006 to estimate the expected number of U.S.-born births. Then I divided the estimated numbers by the observed numbers of low birth weight and preterm birth infants of U.S.-born mothers for each census tract to calculate standardized morbidity ratios (SMR) by census tract. Three different standardized morbidity ratios could be observed: SMR >1 meaning

that the observed numbers of low birth weight or preterm birth was greater than expected, SMR=1 meaning that the observed and the expected numbers were relatively equal; or SMR <1 meaning that the observed numbers of low birth weight or preterm births were less than expected.

3.2.3 Spatial Statistics Analyses

Due to the rapid development of Geographic Information Systems (GIS) in recent years, spatial data analysis has received considerable attention and played an important role in social science. Spatial means that each individual record has a geographical reference that is important in understanding the local environment in which mothers and infants are exposed. Using spatial statistics, I was able to identify where clusters of immigrant populations reside in the capital tri-county area in order to better integrate individual- and neighborhood-level risk factors.

To calculate the racial residential segregation indices I used Anselin's local Moran's I (Anselin, 1995). This index measures the level of spatial autocorrelation for each census tract. I used the hot spot analysis to calculate the Getis-Ord Gi* statistics (Getis and Ord, 1992), another measure of spatial autocorrelation to map the clusters of adverse birth outcomes, poverty, and different racial/ethnic groups in the capital tri-county area. The G-statistic showed whether features with high values or features with low values tend to cluster in my study area. If a feature's value is high, and the

values for all of the neighborhood features are also high; it is a part of the hot spots.

Furthermore, in order to understand how individual- and neighborhood-level risk factors affect the adverse birth outcomes for U.S.-born and foreign-born mothers, I estimated logistic regression models and geographically weighted regression (GWR) models. The logistic regression models were estimated in SPSS (v 17) (SPSS, 2009) and the GWR models were estimated using the GWR function in the Spatial Statistics tool in ArcGIS (v 9.3.1) (ESRI, 2009).

In both of these analyses the dependent variables were the low birth weight and preterm birth rates and the independent variables included maternal- and infant-level variables and/or neighborhood-level variables as described in the previous sections. Binary logistic regression models were used to estimate the association between the dependent variable(s) and each independent variable separately. The GWR models were estimated to examine geographical differences in individual- and neighborhood-level risk factors for low birth weight and preterm birth and where those differences are for U.S-born and foreign-born mothers and infants. All analyses were performed using the software ArcGIS (v 9.3.1) (ESRI, 2009) and SPSS (v 17) (SPSS, 2009).

An example of these models may include but are not limited to:

$$P_i = \alpha_0 + \alpha_1 \text{MAGE} + \alpha_2 \text{MARTIAL} + \alpha_3 \text{EDU} + \alpha_4 \textit{ORIGIN} + \alpha_5 \text{INSURE} + \alpha_6 \text{CARE} + \alpha_7 \text{SMOKE} + \alpha_8 \text{INCOME} + \alpha_9 \text{POVERTY} + \alpha_{10} \text{DENSITY} + \varepsilon_i$$

where P_i is the adverse birth outcome under the hypothesis that individual-level

risk factors, such as maternal age (MAGE), marital status (MARITAL), education level (EDU), mother's country of origin (ORIGIN), insurance coverage (INSURE), trimester of prenatal care (CARE), smoke during pregnancy (SMOKE), neighborhood-level risk factors, including median household income (INCOME), ratio of income to poverty threshold by household type (POVERTY), and immigrant density (DENSITY), and an error term may in part affect birth outcomes.

4.0 Results

There were 73,143 valid data in this thesis research. The total number of births of U.S.-born mothers was 67,515 while 5,120 (7.6%) counted as low birth weight and 6,675 (9.9%) counted as preterm birth. As for foreign-born mothers, the total population was 5,628, and 408 (6.6%) births were low birth weight and 486 (7.8%) were preterm births.

4.1 Individual and Neighborhood Level Risk Factor

4.1.1 Frequencies

Table 1 presents the basic characteristics of the populations in the capital tri-county area in Michigan on the individual and neighborhood levels. At the individual level, I found a higher percentage of U.S.-born mothers being pregnant before the ages 20 while the percentage of maternal age greater than 34 years was higher among foreign-born mothers. This observation somehow could be explained by the distribution of maternal education that more foreign-born mothers had higher education compared to U.S.-born mothers (59.6% vs. 49.0%).

Marital status made a great difference between U.S.-born and foreign-born in my study. The percentage of single foreign-born mothers was 5.1% compared to 13.3% of single U.S.-born mothers; however, the percentage of acknowledgment of paternity was only 8.1% in foreign-born but 22.4% in U.S-born mothers. And the percentage of

tobacco use during pregnancy was significant as well: 11.4% in U.S.-born and 1.8% in foreign-born mothers. As for prenatal care, the numbers were mainly the same for the U.S-born and foreign-born mothers: less than 1% of the population did not receive prenatal care at all while more than 85% of the population started the prenatal care from the first trimester.

On the neighborhood level, I found that more foreign-born mothers lived in highly-segregated neighborhoods compared to U.S.-born mothers (35.4% vs. 10.4%). The percentage of foreign-born living in poverty level was 25.5% while it was 10.3% for U.S.-born women. As for immigrant density, more than 70% of the U.S.-born women lived in low immigrant density neighborhoods, whereas the foreign-born women were relatively evenly distributed into low (38.5%), medium (24.4%), and high (37.0%) immigrant density neighborhoods.

4.1.2 Spatial Distribution

Figure 1 is the map of the study area for this research. It is called the capital tri-county area in Michigan. The county to the north is Clinton County; to the southeast is Ingham County, and to the southwest is Eaton County. Michigan's capital city is Lansing, which is comprised and surrounded by all three counties but it primarily in Ingham County.

Figures 2 and 3 show the poverty level in the capital tri-county area. It is

significant that the central capital and the campus areas were poor areas while the areas northwestern and southeastern of the capital were regarded as rich areas. Figure 4 indicates that the median household income of the capital area was only $6,250 to $20,271 compared to the suburban areas, where there were more extremely rich populations clustered and the median household income were above $44,667.

Figure 5 shows the distribution of immigrant density, and I noticed that the percentage of immigrant density in most of the areas outside of the capital was fairly low whereas a range of immigrant density from low to high was found in the capital area. Also, the percentage of immigrant density was much higher in the eastern and northern areas of Michigan State University.

4.1.3 Spatial Statistics – Hot Spot Analyses

Figures 6 to 13 show the areas where different U.S.-born and foreign-born racial/ ethnic groups tend to cluster more in the capital tri-county area in Michigan. It is significant that U.S.-born Caucasians were more likely to live in the south of capital tri-county area while the capital area was a significant cold spot for them to live. Foreign-born Caucasians, on the other hand, were found living closer to the areas of Michigan State University more. U.S.-born African Americans were more likely to live in the southwestern parts of the capital area and some of the foreign-born African Americans were observed to live in those areas as well. However, other foreign-born

African Americans lived closer to the campus too.

As for U.S.-born Asians, they were most likely to live in Ingham County and lived closer to campus and the result was similar for foreign-born Asians. For U.S.-born Hispanic, it was significant that the areas north of Michigan State University were the cold spots, whereas they were more likely to live in the southwestern parts of the capital area. There were some overlapped areas for U.S.-born African Americans and U.S.-born Hispanic, but apparently the latter groups spread their clustered neighborhoods toward the direction of west and south more. The result of foreign-born Hispanic was similar to the result of both U.S.-born and foreign-born Asians that they were found living closer to the campus.

4.1.4 Spatial Statistics – Geographically Weighted Regressions

Figures 14 to 17 indicate how the predicted adverse birth outcomes and the residuals distributed for U.S.-born and foreign-born mothers in the capital tri-county area by using the geographically weighted regression method after adjusting for some individual- (percentage of African Americans, percentage of no prenatal care, percentage of no high school etc.) and neighborhood-level characteristics such as LMiZscore and percentage of poverty. I found that the capital area was predicted to have higher incidence of low birth weight and preterm birth for U.S.-born mothers. The suburban areas were estimated to have lower percentage of the birth outcomes.

Compared to the residual map, I also found this model explained fairly well in the suburban area and most of the central capital area.

On the contrast, foreign-born mothers were predicted to have higher low birth weight in the west side of Eaton County and some areas of the capital area. Also, foreign-born mothers were estimated to have lower preterm birth in the capital area and the areas east and south of the capital. However, the results of foreign-born mothers were not explained as well as the one of U.S.-born mothers in this model.

4.2 Adverse Birth Outcomes

4.2.1 Frequencies

Table 2 shows the mean infant birth weight of U.S.-born mothers was slightly higher than that of foreign-born mothers; however, the percentage of low birth weight of U.S.-born mothers was also higher. On the other hand, the mean gestation of U.S.-born mothers was 0.2 weeks shorter and the percentage of preterm birth was close to 2% more compared to foreign-born mothers.

Table 3 describes the birth outcomes of the different groups among foreign-born mothers in the capital tri-county area in more detail. Immigrants from Asian countries especially Eastern Asia (Korea, China, Taiwan, Japan, and Hong Kong) had the largest portion of births, followed by women from Central/ South America and Western Europe. I found the difference of low birth weight and preterm birth varied

significantly by world regions of the mother's country of origin. For example, mothers from Eastern Asia and Mexico had lower percentages of low birth weight and South Asian mothers had the highest percentage of low birth weight. As for preterm birth, Canadian mothers had the lowest percentage while the highest percentage fell into the Western Europe group of mothers.

4.2.2 Spatial Distribution

Figures 18 and 19 show the hot spots where more low birth weight and preterm birth were observed in both U.S.-born and foreign-born women. I found that the places where there were more low birth weight and preterm birth were overlapped in the capital area, however, more cases of low birth weight were reported in the western of the capital and spread out to one area of Eaton County while there was one hot spot of preterm birth closed to the area of Michigan State University.

Figures 20 and 21 indicate how the percentages of low birth weight and preterm birth were distributed in the U.S.-born women. I found many areas were overlapped of both low birth weight and preterm birth and the percentages were relatively low in the north part of Clinton County. The capital area was the area with higher percentage of both low birth weight and preterm birth as well.

Moreover, figures 22 and 23 show the results from the comparison of the percentage of low birth weight and preterm birth of U.S.-born women to the

percentage of state-level incidence in the year 2006. I found that two areas had the same number of low birth weight as the state of Michigan, whereas many places in the capital area and also the Michigan State University area had more observed cases of low birth weight than estimated. The result of preterm birth was mainly the same; however, less observed cases were found in the capital area and one area had the observed numbers equal to the estimated numbers.

Figures 24 to 34 show the absolute numbers of low birth weight and preterm birth within different foreign-born group of mothers in the capital tri-county area. There were more cases of low birth weight and preterm birth observed in the southeastern and the eastern parts of the capital area among the foreign-born mothers from Eastern Europe while mothers from Western Europe were found more cases in the east side of Ingham County, northwest side of the Eaton County and some in the capital area. As for the mothers from North Africa, they were found more low birth weight and preterm birth southern of the capital area, and more cases were found in the capital area for the women from Sub Sahara.

Foreign-born Mexican mothers had higher numbers of low birth weight and preterm birth in the southeastern part of Ingham County and northern parts of Eaton County. On the contrary, more cases could be found in the capital area and the northern part of Clinton County for foreign-born mothers from Canada. Higher

numbers of low birth weight of preterm birth of mothers from Central/South America were in the capital area and the southwestern part of that.

South Asian mothers were more likely to have low birth weight and preterm birth close to the Michigan State University area and the part west of the capital area, whereas more cases were found of the foreign-born mothers from Southeast Asia and Oceania in the west side of Eaton County, the capital area, and the eastern parts of Ingham County. Women from Eastern Asia were observed to have higher numbers of low birth weight and preterm birth in the areas east of the Michigan State University but the areas with the highest number were west of the campus. For the mothers from Central Asia and Middle East, more cases were found in the eastern and western part of the capital area.

4.3 Epidemiological Paradox

Table 4 shows the results of the logistic regressions of independent risk factors for low birth weight in singleton live births in both U.S.-born and foreign-born mothers and tables 5 and 6 show the results of U.S.-born and foreign-born separately.

Foreign-born mothers were less likely to have low birth weight compared to U.S.-born mothers OR = 0.87 (95% CI 0.76 to 1.00) and the result was statistically significant (p-value = 0.04). As for individual- level risk factors, I found maternal age greater than 34 years was significant in both U.S.-born OR = 1.51 (95% CI 1.39 to

1.65) and foreign-born mother groups OR =1.66 (95% CI 1.28 to 2.15), whereas some college maternal education was less likely to result in low birth weight in only U.S.-born mothers OR = 0.89 (95% CI 0.83 to 0.96).

U.S.-born African Americans were more likely to have low birth weight OR = 1.82 (95% CI 1.08 to 1.97) than other U.S.-born racial groups while foreign-born Hawaiians and Pacific Islanders had higher risk of low birth weight OR = 1.36 (95% CI 1.08 to 1.70) compared to other foreign-born mother groups. Having single (one parent) listed as marital status was highly related to low birth weight in both U.S.-born OR = 1.48 (95% CI 1.35 to 1.63) and foreign-born mothers OR = 1.91 (95% CI 1.29 to 2.81), whereas acknowledgment of paternity marital status was only significant in U.S.-born mothers OR = 1.25 (95% CI 1.16 to 1.36). Parity was significant merely in U.S.-born mothers as for the second birth OR = 0.86 (95% CI 0.80 to 0.93); however, the odds of low birth weight (versus non low birth weight) increased from the second birth to the fourth or more birth in both U.S.-born and foreign-born women even though they were not statistically significant.

Also, whether the source of payment was Medicaid or not made a significant difference in U.S.-born mothers OR = 1.12 (95% CI 1.05 to 1.20) but was not statistically significant in foreign-born women (p-value = 0.99). Moreover, the initiations of prenatal care were all predictive of low birth weight in U.S.-born

mothers particularly the category no prenatal care OR = 1.84 (95% CI 1.48 to 2.29); however, only the second trimester initiation of prenatal care was more significant to contribute to low birth weight in foreign-born mothers OR = 0.50 (95% CI 0.31 to 0.80). Tobacco use during pregnancy was more likely to result in low birth weight in U.S.-born mothers OR = 1.06 (95% CI 1.03 to 1.09) and was significant in foreign-born mothers as well (p-value = 0.04).

Table 7 shows the results of the logistic regressions of independent risk factors for preterm birth in singleton live births in both U.S.-born and foreign-born mothers and tables 8 and 9 indicate the results of U.S.-born and foreign-born separately.

Foreign-born mothers were significantly less likely to have preterm birth compared to U.S.-born mothers OR = 0.81 (95% CI 0.72 to 0.92). On the individual level, maternal age greater than 34 years was predictive to preterm birth in both U.S.-born OR = 1.32 (95% CI 1.22 to 1.43) and foreign-born women OR = 1.46 (95% CI 1.15 to 1.87), whereas a no high school maternal education was more likely to result in preterm birth in only U.S.-born mothers OR = 1.12 (95% CI 1.04 to 1.20).

Compared to other U.S.-born racial groups of mothers, U.S.-born African Americans had higher risk of preterm birth OR = 1.42 (95% CI 1.32 to 1.53) while U.S.-born Hawaiians and Pacific Inlanders were less likely to have preterm birth OR = 0.58 (95% CI 0.39 to 0.87). However, no significant result that contributed to

preterm birth was observed in the foreign-born racial groups. Also, marital status made a significant difference in U.S.-born mothers; both single and acknowledgment of paternity were at higher risk of preterm birth, OR = 1.21 (95% CI 1.11 to 1.32) and OR = 1.13 (95% CI 1.05 to 1.22) respectively. Only single marital status was statistically significant in foreign-born mothers (p-value = 0.02).

As for parity, the risk of preterm birth gradually increased from the second birth to the fourth or more birth in U.S.-born mothers, and the results were significant in the second birth OR = 0.90 (95% CI 0.84 to 0.96) and the fourth or more birth OR = 1.27 (95% CI 1.16 to 1.39). On the contrary, in foreign-born mothers the third birth was more likely to contribute to preterm birth but the result was not significant either (p-value = 0.48). Similar to the result from low birth weight, having Medicaid as source of payment was only predictive in U.S.-born mothers OR = 1.09 (95% CI 1.02 to 1.15).

The initiations of prenatal care were all significant of preterm birth in U.S.-born women especially the category no prenatal care OR = 2.08 (95% CI 1.70 to 2.55). In foreign-born mothers, having no prenatal care was more likely to result in preterm birth OR = 1.36 but was not statistically significant (p-value = 0.53). No significant differences contributing to preterm birth were observed in U.S.-born and foreign-born mothers in terms of maternal tobacco use.

Table 10 shows the result of how individual- and neighborhood-level characteristics contribute to low birth weight of both U.S.-born and foreign-born mothers in the capital tri-county area in Michigan by using logistic regressions, and tables 11 and 12 represent the separate outcomes of U.S.-born and foreign-born mothers.

After removing other relatively non-significant maternal-level variables, I found that foreign-born women were still less likely to have low birth weight and it was still statistically significant (p-value = 0.04). As for neighborhood-level characteristics, poverty level contributed to low birth weight more OR = 1.12 (95% CI 1.03 to 1.21), but the level of segregation was not significant. Moreover, the poverty level made a great difference in low birth weight between U.S.-born and foreign-born mothers that U.S.-born mothers were affected more by the higher level of poverty (p-value = 0.02).

Table 13 indicates the result of the logistic regressions of individual- and neighborhood-level characteristics for preterm birth in singleton live births in both U.S.-born and foreign-born mothers, and tables 14 and 15 show the results of U.S.-born and foreign-born separately.

Unlike the result of low birth weight from table 10, poverty level did not crucially predict preterm birth; however, it was significant that medium-level immigrant density was less likely to result in preterm birth OR = 0.86 (95% CI 0.77 to

0.96). Comparing the results separately from two groups of mothers, I found that medium-level immigrant density was more predictive to contribute to less preterm births in U.S.-born OR = 0.88 (95% CI 0.78 to 0.99) (p-value = 0.03) than that in foreign-born mothers (p-value = 0.06).

Tables 16 and 17 present how neighborhood-level characteristics affect the birth outcomes of low birth weight and preterm birth among different foreign-born mother groups. For the foreign-born mothers from Eastern Asia, even though 67.4% of low birth weight mothers lived in the highly-segregated neighborhoods, they had the lowest percentage (4.2%) of low birth weight, whereas the mothers from South Asia and Central/South America, who lived in the highly-segregated neighborhoods as well, had the highest (10.2%) and second highest percentage (8.4%) of low birth weight. Foreign-born mothers from Western Europe shared the similar characteristic of U.S.-born mothers in that they lived in the neighborhoods where the level of segregation was lower; however, they still had fairly high percentage of low birth weight (8.2%).

Foreign-born mothers from North Africa and Sub Sahara had higher percentage of low birth weight and lived in the neighborhoods with the highest (44.0%) and the second highest (41.9%) poverty level compared to other foreign-born groups in the capital tri-county area in Michigan. Similarly, mothers from Canada, Eastern Europe,

and Mexico lived in a lower level of poverty neighborhoods and had relatively less percentage of low birth weight. Again, having similar characteristic of the U.S.-born mothers, foreign-born mothers from Western Europe, despite the fact that 84.4% of the low birth weight women lived in low poverty neighborhood, they had higher percentage of low birth weight.

As for the level of immigrant density, the result is varied among groups again. 62.8% of the low birth weight foreign-born mothers from Eastern Asia lived in the high immigrant density neighborhoods and had the lowest percentage of low birth weight while 55.6% of low birth weight mothers from North Africa lived in a high immigrant density neighborhoods but the percentage of low birth weight was fairly high (7.9%). On the other hand, 83.3% of the low birth weight foreign-born mothers from Canada lived in the low immigrant density neighborhoods and had relatively good birth outcome of low birth weight while the mothers from Western Europe, who lived in the lower immigrant density neighborhoods as well, had a higher percentage of low birth weight (8.2%).

The result of how the neighborhood-level characteristics affect the birth outcome of preterm birth within different foreign-born groups and in the U.S.-born mothers is similar to the result of low birth weight. Despite the fact that 67.2% of the preterm birth foreign-born mothers from Eastern Asia lived in the highly-segregated

neighborhoods; the percentage of preterm birth was lower (6.5%). On the contrary, foreign-born mothers from Canada had the lowest percentage of preterm birth (5.7%) but 84.6% of the preterm birth women lived in the neighborhoods where the level of segregation was lower.

The mothers from Canada, Eastern Europe, and Mexico had relatively low percentages of preterm birth and lived in the lower poverty level neighborhoods, while 38.8% of the preterm birth mothers from Central/South America lived in the higher poverty level neighborhoods and had the second highest percentage of preterm birth (9.0%). On the other hand, 50% of the preterm birth mothers from North Africa lived in the high poverty level neighborhoods, the percentage of preterm birth was relatively low (7.0%).

As for the level of immigrant density, 84.6% of the preterm birth Canadian mothers lived in the lower immigrant density neighborhoods and had the best birth outcome of preterm birth, whereas the mothers from Eastern Asia, who had the second lowest percentage of preterm birth, were more likely to live in the higher immigrant density neighborhoods. The foreign-born mothers from North Africa shared the similar characteristic as mothers from Eastern Asia; the percentage of preterm birth was 7.0% while 50% of the preterm birth North African mothers lived in the higher immigrant density neighborhoods.

5.0. Discussion

Previous research has shown that the incidence of low birth weight is increasing among U.S.-born mothers, while the rate for immigrant mothers is still relatively low (Gould et al., 2003; Madan et al., 2006; El Reda et al., 2007). This phenomenon of immigrant mothers having improved birth outcomes compared to U.S.-born mothers is referred to in the literature as the *epidemiological paradox* (Gould et al., 2003). And the goals of my thesis are to compare the incidence of low birth weight and preterm birth in U.S.-born and foreign-born mothers to determine if an *epidemiological paradox* exists in the capital tri-county area in Michigan and to explore both individual- and neighborhood- level risk factors that may contribute to these differences.

The first hypothesis that foreign-born mothers will have a lower incidence of low birth weight births and preterm births than U.S- born mothers was supported. Even though the mean infant weight of foreign-born mothers was 44.6 g less compared to U.S.-born mothers, foreign-born mothers had lower rate of low birth weight. The difference of the rates of preterm birth between U.S.-born and foreign-born mothers was more crucial. In summary, the result of the current analysis demonstrated that migrant selectivity and the protective factors that have given the foreign-born a health advantage in national or state studies have similar influence among the foreign-born

mothers in the capital tri-county area in Michigan.

The test of my second hypothesis that the incidences of low birth weight and preterm birth will differ from different groups of foreign-born mothers was supported as well. The result was in agreement to the findings from Madan et al (2006) that foreign-born Mexican mothers had better birth outcomes while foreign-born Asian-Indian had a paradoxically higher incidence of low birth weight and preterm birth. Nevertheless, compared to the result from Urquia et al (2009) that migrants from Eastern Europe and Central Asia had better birth outcomes than migrants from others regions of the world, I found that foreign-born mothers from Eastern Asia, Mexico, and Canada had lower percentage of low birth weight and mothers from Canada, Eastern Asia, and North Africa had lower percentage of preterm birth.

The third and last hypothesis that individual-level risk factors for low birth weight and preterm birth are more important for foreign-born mothers while neighborhood-level risk factors have stronger affect on U.S.-born mothers were observed by Urquia et al (2009) as well. Their study pointed out that the risk of low birth weight varied considerably according to the regions of origin of the immigrant mothers; the country of origin appears to be a much more important factor in low birth weight among children of recent immigrants than the neighborhood in which they currently live.

From the logistic regressions, I found that living in a high poverty level neighborhood was more likely to result in low birth weight in U.S.-born mothers while the result was not significant in foreign-born mothers. Similarly, living in a medium immigrant density neighborhood affected U.S.-born mothers more compared to foreign-born mothers. And the reason was mainly because U.S.-born mothers were exposed to the environment more than foreign-born mothers, who were not yet influenced by their surrounding neighborhoods.

Moreover, Auger et al (2009) had the observation that high immigrant density was protective against preterm birth for Canadian-born mothers, but unfavorably associated with preterm birth for foreign-born mothers. I had the different findings that even though relatively high percentage of low birth weight mother from the foreign-born groups of Eastern Asia and North Africa lived in the high immigrant density neighborhoods, their birth outcomes of preterm birth were better, whereas high immigrant density was not protective against preterm birth for U.S.-born mothers.

This study is subject to limitations. First, the total number of foreign-born mothers from 1995 to 2007 was still relatively small. Second, I was not able to account for alcohol and illicit use during pregnancy, and these risk factors were proven to contribute to significant differences of adverse birth outcomes. Also, I could

only obtain the data from the U.S. Census Bureau of the year 1999, such as immigrant density and median household income, and this may mediate the results of the adverse birth outcomes. Last, there was no information about mother's diet or social support-extended family network systems, which may explain the *epidemiological paradox.*

6.0. Conclusion

This thesis research demonstrates the association between both individual- and neighborhood-level risk factors and adverse birth outcome for U.S.-born and foreign-born mothers in the capital tri-county area in Michigan. The mechanism of *epidemiological paradox*, referring to immigrant mothers having improved birth outcomes compared to U.S.-born mothers, that was found in previous studies was also observed in this thesis research. The country of origins of the foreign-born mothers made big differences in the birth outcomes of low birth weight and preterm birth too. Moreover, while neighborhood-level risk factors such as level of poverty and level of immigrant density had great influences for U.S.-born mother, foreign-born mothers were affected more by the individual-level risk factors such as maternal education and marital status.

Future research can be conducted in other regions where there are greater numbers of immigrants to see if the *epidemiological paradox* persists. Also, more individual- and neighborhood- level risk factors can be included in the future study, such as diets, family support, level of stress of mothers during pregnancy, and type of housing. Interviewing mothers, if possible, can help better understand how personal emotion such as stress may result in adverse birth outcomes. Moreover, instead of having all different foreign-born mothers as study groups, focusing on certain groups

of immigrant may be a good way as well. For example, the research can focus on the adverse birth outcomes of Chinese and Mexican or Indian and Korean.

Finally, this research on the *epidemiological paradox* is important for understanding ethnic differences in birth outcomes by origin of birth. Future research should also investigate the second-generation of immigrant women in the United States to see if their birth advantage changes and drifts more toward that of the U.S.-born mothers and infants. If it does then health care and public health programs and policy must be adjusted to improve the health of mothers and children born in the United States and to maintain the health immigrant mothers and children coming to the United States.

APPENDIX A

Table 1 Characteristics of U.S.-born and foreign-born mothers and infants in the capital tri-county area in Michigan, 1995-2007.

Individual-level characteristic	U.S.-born mothers (N = 67,515) (%)	Foreign-born mothers (N = 5,628) (%)
Maternal age		
< 20 years	10.7	4.2
20 – 34 years	77.7	80.0
> 34 years	11.6	15.8
Maternal education		
No high school	20.7	14.9
High school diploma	29.3	22.9
Some college	49.0	59.6
Marital status		
Single (one parent)	13.3	5.1
Married (two parents)	64.3	86.8
Acknowledgment of paternity	22.4	8.1
Parity		
0	40.2	43.0
1	33.6	34.1
2	16.6	12.6
≥ 3	9.1	9.9
Source of payment		
Private insurance	63.0	57.9
Medicaid	35.6	40.9
Self pay and other	0.6	0.6
Initiation of prenatal care		
None	0.9	0.7
First trimester	87.3	86.5
Second trimester	7.4	7.9
Third trimester	1.4	1.5
Kessner index*		
Adequate	82.9	82.5
Intermediate	9.7	10.3
Inadequate	6.4	6.3

Continue

Table 1 (cont'd)

Substance use		
Tobacco use	11.4	1.8
Neighborhood-level characteristics		
Level of segregation		
Low (LMiZcore < 1.96)	89.6	64.6
High (LMiZcore ≥ 1.96)	10.4	35.4
Level of poverty		
Low (< 30%)	89.7	74.5
High (≥ 30%)	10.3	25.5
Level of immigrant density		
Low (0% - 5%)	72.8	38.5
Medium (5% - 10%)	18.6	24.4
High (10% - 62%)	8.7	37.0

* Kessner index is a classification of prenatal care developed by the Institute of Medicine in 1973 that adjusts the timing and quantity of prenatal care for the length of gestation to determine levels of adequate, inadequate, and intermediate prenatal care.

Source: Women Health Dictionaries http://womenhealth.medical-dictionaries.org/

Table 2 Birth outcomes of U.S.-born and foreign-born mothers and infants in the capital tri-county area in Michigan, 1995-2007.

Birth outcomes	U.S.-born mothers (N = 67,515)	Foreign-born mothers (N = 5,628)
Mean infant birth weight (g)	3340.8	3296.2
	(SD = 629.6)	(SD = 606.9)
% Low birth weight*	7.6	6.6
Mean gestation (weeks)	38.5	38.7
	(SD = 2.1)	(SD = 2.1)
% Prematurity**	9.9	7.8

* Low birth weight = infant birth < 2,500 g

** Prematurity = gestations < 37 weeks

Table 3 Birth outcomes within different foreign-born groups by country/region of origin in the capital tri-county area in Michigan, 1995-2007.

Country/region of origin	Births No. (%)	Mean birth weight (g)	Low birth weight* (%)	Mean gestations (weeks)	Prematurity** (%)
Eastern Europe	263 (4.7)	3493.9 (SD = 615.2)	5.3	38.8 (SD = 1.9)	7.2
Western Europe	551 (9.8)	3355.6 (SD = 619.6)	8.2	38.6 (SD = 1.8)	9.4
North Africa	114 (2.0)	3319.6 (SD = 560.4)	7.9	38.9 (SD = 1.6)	7.0
Sub Sahara	407 (7.2)	3307.0 (SD = 643.4)	7.6	38.6 (SD = 2.3)	8.1
Canada	229 (4.1)	3438.3 (SD = 621.5)	5.2	38.7 (SD = 2.2)	5.7
Mexico	528 (9.4)	3306.3 (SD = 627.8)	4.5	38.6 (SD = 2.2)	7.6
Central/South America	569 (10.1)	3296.7 (SD = 662.6)	6.5	38.5 (SD = 2.6)	9.0
Eastern Asia	1029 (18.3)	3325.2 (SD = 574.4)	4.2	38.8 (SD = 1.9)	6.5
Central Asia/ Middle East	522 (9.3)	3261.6 (SD = 661.0)	8.4	38.6 (SD = 2.2)	7.7
South Asia	461 (8.2)	3163.6 (SD = 561.6)	10.2	38.6 (SD = 1.8)	8.2
Southeast Asia/ Oceania	904 (16.1)	3213.7 (SD = 521.8)	7.1	38.7 (SD = 1.8)	8.4

* Low birth weight = infant birth < 2,500 g

** Prematurity = gestations < 37 weeks

Table 4 Binary logistic regression analyses of low birth weight in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.72	0.04	0.07	<0.01
Maternal age				
< 20 years	-0.05	0.05	0.95 (0.86, 1.05)	0.35
20 – 34 years (ref.)				
> 34 years	0.43	0.04	1.53 (1.41, 1.66)	<0.01
Maternal education				
No high school	0.08	0.04	1.08 (1.00, 1.17)	0.06
High school diploma (ref.)				
Some college	-0.11	0.04	0.89 (0.83, 0.96)	<0.01
Country of origin				
U.S.-born (ref.)				
Foreign-born	-0.14	0.07	0.87 (0.76, 1.00)	0.04
Maternal race				
Caucasian (ref.)				
African American	0.58	0.04	1.79 (1.66, 1.94)	<0.01
American Indian	-0.13	0.25	0.88 (0.54, 1.42)	0.60
Asian	-0.10	0.20	0.91 (0.62, 1.33)	0.62
Hawaiian and Pacific Islander	0.23	0.10	1.26 (1.04, 1.51)	0.02
Marital status				
Single (one parent)	0.41	0.05	1.51 (1.38, 1.66)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.23	0.04	1.25 (1.16, 1.36)	<0.01
Parity				
0 (ref.)				
1	-0.15	0.04	0.87 (0.81, 0.93)	<0.01
2	-0.02	0.04	0.98 (0.90, 1.07)	0.66
≥ 3	0.10	0.05	1.11 (1.00, 1.22)	0.05

Continue

Table 4 (Cont'd)

Source of payment				
Private insurance (ref.)				
Medicaid	0.11	0.03	1.11 (1.05, 1.19)	<0.01
Self pay and other	-0.06	0.19	0.95 (0.65, 1.38)	0.78
Initiation of prenatal care				
None	0.58	0.11	1.78 (1.43, 2.21)	<0.01
First trimester (ref.)				
Second trimester	-0.28	0.06	0.76 (0.68, 0.85)	<0.01
Third trimester	-0.67	0.15	0.51 (0.39, 0.69)	<0.01
Maternal tobacco use				
Non-smoker (ref.)				
Smoker	0.06	0.01	1.06 (1.03, 1.09)	0.18

*Adjusted for all factors listed.

Table 5 Binary logistic regression analyses of low birth weight of U.S.-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.72	0.04	0.07	<0.01
Maternal age				
< 20 years	-0.06	0.05	0.94 (0.85, 1.04)	0.24
20 – 34 years (ref.)				
> 34 years	0.41	0.05	1.51 (1.39, 1.65)	<0.01
Maternal education				
No high school	0.10	0.04	1.11 (1.02, 1.20)	0.01
High school diploma (ref.)				
Some college	-0.11	0.04	0.89 (0.83, 0.96)	<0.01
Maternal race				
Caucasian (ref.)				
African American	0.60	0.04	1.82 (1.08, 1.97)	<0.01
American Indian	-0.06	0.25	0.94 (0.58, 1.53)	0.81
Asian	0.03	0.37	1.03 (0.50, 2.12)	0.94
Hawaiian and Pacific Islander	-0.22	0.20	0.80 (0.54, 1.19)	0.28
Marital status				
Single (one parent)	0.39	0.05	1.48 (1.35, 1.63)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.23	0.04	1.25 (1.16, 1.36)	<0.01
Parity				
0 (ref.)				
1	-0.15	0.04	0.86 (0.80, 0.93)	<0.01
2	-0.01	0.04	1.00 (0.91, 1.08)	0.81
≥ 3	0.12	0.05	1.13 (1.02, 1.25)	0.02
Source of payment				
Private insurance (ref.)				
Medicaid	0.12	0.03	1.12 (1.05, 1.20)	<0.01
Self pay and other	-0.02	0.20	0.98 (0.67, 1.43)	0.90

Continue

Table 5 (Cont'd)

Initiation of prenatal care				
None	0.61	0.11	1.84 (1.48, 2.29)	<0.01
First trimester (ref.)				
Second trimester	-0.25	0.06	0.78 (0.69, 0.87)	<0.01
Third trimester	-0.73	0.12	0.48 (0.35, 0.66)	<0.01
Maternal tobacco use				
Non-smoker (ref.)				
Smoker	0.05	0.02	1.06 (0.13, 1.09)	<0.01

*Adjusted for all factors listed.

Table 6 Binary logistic regression analyses of low birth weight of foreign-born mother group in the tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.67	0.15	0.07	<0.01
Maternal age				
< 20 years	0.05	0.26	1.05 (0.62, 1.76)	0.85
20 – 34 years (ref.)				
> 34 years	0.51	0.13	1.66 (1.28, 2.15)	<0.01
Maternal education				
No high school	-0.23	0.15	0.80 (0.59, 1.08)	0.14
High school diploma (ref.)				
Some college	-0.14	0.13	0.87 (0.67, 1.12)	0.28
Maternal race				
Caucasian (ref.)				
African American	0.28	0.16	1.33 (0.96, 1.83)	0.08
American Indian**	-18.47	7840.11	0.00 (0.00, 0.00)	0.99
Asian	-0.31	0.24	0.74 (0.46, 1.17)	0.20
Hawaiian and Pacific Islander	0.31	0.12	1.36 (1.08, 1.70)	<0.01
Marital status				
Single (one parent)	0.64	0.20	1.91 (1.29, 2.81)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.03	0.20	1.03 (0.70, 1.53)	0.88
Parity				
0 (ref.)				
1	-0.14	0.12	0.87 (0.69, 1.11)	0.26
2	-0.15	0.17	0.86 (0.62, 1.20)	0.38
≥ 3	-0.07	0.19	0.93 (0.64, 1.35)	0.71
Source of payment				
Private insurance (ref.)				
Medicaid	0.00	0.11	1.00 (0.81, 1.24)	0.99
Self pay and other	-0.88	1.02	0.41 (0.06, 3.07)	0.39

Continue

Table 6 (Cont'd)

Initiation of prenatal care				
None	0.22	0.54	1.24 (0.43, 3.57)	0.69
First trimester (ref.)				
Second trimester	-0.70	0.24	0.50 (0.31, 0.80)	<0.01
Third trimester	-0.18	0.43	0.83 (0.36, 1.93)	0.67
Maternal tobacco use				
Non-smoker (ref.)				
Smoker	0.10	0.05	1.10 (1.01, 1.21)	0.04

*Adjusted for all factors listed.

** The total number of foreign-born American Indian was too small (N = 26), and thus the result was not significant in this model.

Table 7 Binary logistic regression analyses of preterm birth in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.27	0.04	0.10	<0.01
Maternal age				
< 20 years	-0.08	0.05	0.93 (0.84, 1.02)	0.11
20 – 34 years (ref.)				
> 34 years	0.29	0.04	1.34 (1.24, 1.44)	<0.01
Maternal education				
No high school	0.08	0.04	1.09 (1.01, 1.17)	0.02
High school diploma (ref.)				
Some college	-0.06	0.03	0.94 (0.89, 1.01)	0.07
Country of origin				
U.S.-born (ref.)				
Foreign-born	-0.02	0.06	0.81 (0.72, 0.92)	<0.01
Maternal race				
Caucasian (ref.)				
African American	0.33	0.04	1.40 (1.30, 1.50)	<0.01
American Indian	-0.19	0.23	0.83 (0.54, 1.29)	0.41
Asian	0.13	0.16	1.14 (0.84, 1.55)	0.40
Hawaiian and Pacific Islander	-0.11	0.09	0.89 (0.75, 1.07)	0.23
Marital status				
Single (one parent)	0.21	0.04	1.23 (1.13, 1.34)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.12	0.04	1.13 (1.05, 1.21)	<0.01
Parity				
0 (ref.)				
1	-0.11	0.03	0.89 (0.84, 0.95)	<0.01
2	0.02	0.04	1.02 (0.95, 1.10)	0.58
≥ 3	0.23	0.05	1.26 (1.15, 1.37)	<0.01

Continue

Table 7 (Cont'd)

Source of payment				
Private insurance (ref.)				
Medicaid	0.09	0.03	1.09 (1.03, 1.15)	<0.01
Self pay and other	-0.26	0.19	0.77 (0.53, 1.11)	0.16
Initiation of prenatal care				
None	0.70	0.10	2.01 (1.64, 2.45)	<0.01
First trimester (ref.)				
Second trimester	-0.27	0.05	0.76 (0.69, 0.84)	<0.01
Third trimester	-0.60	0.14	0.55 (0.42, 0.72)	<0.01
Maternal tobacco use				
Non-smoker (ref.)				
Smoker	0.02	0.01	1.02 (1.00, 1.05)	0.10

*Adjusted for all factors listed.

Table 8 Binary logistic regression analyses of preterm birth of U.S.-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.28	0.04	0.10	<0.01
Maternal age				
< 20 years	-0.10	0.05	0.09 (0.83, 1.01)	0.06
20 – 34 years (ref.)				
> 34 years	-0.28	0.04	1.32 (1.22, 1.43)	<0.01
Maternal education				
No high school	0.11	0.04	1.12 (1.04, 1.20)	<0.01
High school diploma (ref.)				
Some college	-0.05	0.03	0.95 (0.89, 1.01)	0.11
Maternal race				
Caucasian (ref.)				
African American	0.35	0.04	1.42 (1.32, 1.53)	<0.01
American Indian	-0.12	0.23	0.90 (0.58, 1.40)	0.63
Asian	0.16	0.31	1.18 (0.64, 2.16)	0.60
Hawaiian and Pacific Islander	-0.55	0.20	0.58 (0.39, 0.87)	<0.01
Marital status				
Single (one parent)	0.19	0.05	1.21 (1.11, 1.32)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.12	0.04	1.13 (1.05, 1.22)	<0.01
Parity				
0 (ref.)				
1	-0.11	0.03	0.90 (0.84, 0.96)	<0.01
2	0.02	0.04	1.02 (0.94, 1.10)	0.62
≥ 3	0.24	0.05	1.27 (1.16, 1.39)	<0.01
Source of payment				
Private insurance (ref.)				
Medicaid	0.08	0.03	1.09 (1.02, 1.15)	<0.01
Self pay and other	-0.32	0.20	0.73 (0.50, 1.07)	0.11

Continue

Table 8 (Cont'd)

Initiation of prenatal care				
None	0.73	0.10	2.08 (1.70, 2.55)	<0.01
First trimester (ref.)				
Second trimester	-0.27	0.06	0.77 (0.69, 0.85)	<0.01
Third trimester	-0.65	0.14	0.52 (0.40, 0.69)	<0.01
Maternal tobacco use				
Non-smoker (ref.)				
Smoker	0.02	0.02	1.02 (1.00, 1.05)	0.10

*Adjusted for all factors listed.

Table 9 Binary logistic regression analyses of preterm birth of foreign-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.34	0.14	0.10	<0.01
Maternal age				
< 20 years	0.08	0.25	1.09 (0.67, 1.77)	0.74
20 – 34 years (ref.)				
> 34 years	0.38	0.12	1.46 (1.15, 1.87)	<0.01
Maternal education				
No high school	-0.21	0.14	0.81 (0.62, 1.07)	0.14
High school diploma (ref.)				
Some college	-0.16	0.12	0.85 (0.67, 1.08)	0.19
Maternal race				
Caucasian (ref.)				
African American	0.05	0.16	1.05 (0.77, 1.43)	0.75
American Indian**	-18.83	8168.45	0.00 (0.00, 0.00)	0.99
Asian	0.05	0.19	1.05 (0.73, 1.52)	0.78
Hawaiian and Pacific Islander	0.04	0.11	1.04 (0.84, 1.29)	0.72
Marital status				
Single (one parent)	0.45	0.19	1.56 (1.07, 2.29)	0.02
Married (two parents) (ref.)				
Acknowledgment of paternity	-0.00	0.18	1.00 (0.70, 1.43)	0.99
Parity				
0 (ref.)				
1	-0.19	0.11	0.82 (0.67, 1.03)	0.09
2	0.12	0.15	1.11 (0.83, 1.49)	0.48
≥ 3	0.07	0.17	1.08 (0.77, 1.51)	0.67
Source of payment				
Private insurance (ref.)				
Medicaid	0.07	0.10	1.07 (0.87, 1.31)	0.52
Self pay and other	0.23	0.62	1.26 (0.38, 4.21)	0.71

Continue

Table 9 (Cont'd)

Initiation of prenatal care				
None	0.31	0.49	1.36 (0.52, 3.56)	0.53
First trimester (ref.)				
Second trimester	-0.35	0.20	0.71 (0.48, 1.05)	0.08
Third trimester	-0.26	0.43	0.77 (0.33, 1.80)	0.55
Maternal tobacco use				
Non-smoker (ref.)				
Smoker	0.04	0.05	1.05 (0.95, 1.16)	0.39

*Adjusted for all factors listed.

** The total number of foreign-born American Indian was too small (N = 26), and thus the result was not significant in this model.

Table 10 Binary logistic regression analyses of low birth weight of both individual-level and neighborhood-level characteristics in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.72	0.03	0.07	<0.01
Maternal age				
< 20 years	-0.06	0.05	0.95 (0.86, 1.04)	0.24
20 – 34 years (ref.)				
> 34 years	0.45	0.04	1.56 (1.44, 1.70)	<0.01
Maternal education				
No high school	0.09	0.04	1.09 (1.01, 1.18)	0.03
High school diploma (ref.)				
Some college	-0.13	0.04	0.88 (0.82, 0.94)	<0.01
Country of origin				
U.S.-born (ref.)				
Foreign-born	-0.14	0.07	0.87 (0.76, 0.99)	0.04
Maternal race				
Caucasian (ref.)				
African American	0.58	0.04	1.78 (1.65, 1.92)	<0.01
American Indian	-0.12	0.25	0.88 (0.55, 1.43)	0.61
Asian	-0.11	0.20	0.90 (0.61, 1.32)	0.58
Hawaiian and Pacific Islander	0.23	0.10	1.26 (1.05, 1.52)	0.02
Marital status				
Single (one parent)	0.46	0.05	1.58 (1.45, 1.73)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.26	0.04	1.30 (1.21, 1.40)	<0.01
Initiation of prenatal care				
None	0.62	0.11	1.86 (1.50, 2.30)	<0.01
First trimester (ref.)				
Second trimester	-0.26	0.06	0.78 (0.69, 0.87)	<0.01
Third trimester	-0.65	0.15	0.52 (0.39, 0.70)	<0.01

Continue

Table 10 (Cont'd)

Level of segregation				
Low (ref.)				
High	-0.06	0.05	0.95 (0.86, 1.05)	0.28
Level of poverty				
Low (ref.)				
High	0.11	0.04	1.12 (1.03, 1.21)	<0.01

*Adjusted for all factors listed.

Table 11 Binary logistic regression analyses of low birth weight of both individual-level and neighborhood-level characteristics of U.S.-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.72	0.03	0.07	<0.01
Maternal age				
< 20 years	-0.07	0.05	0.93 (0.84, 1.02)	0.13
20 – 34 years (ref.)				
> 34 years	0.44	0.04	1.55 (1.43, 1.69)	<0.01
Maternal education				
No high school	0.11	0.04	1.12 (1.03, 1.21)	<0.01
High school diploma (ref.)				
Some college	-0.14	0.04	0.87 (0.81, 0.94)	<0.01
Maternal race				
Caucasian (ref.)				
African American	0.60	0.04	1.81 (1.65, 1.92)	<0.01
American Indian	-0.05	0.25	0.95 (0.55, 1.43)	0.85
Asian	0.02	0.37	1.02 (0.61, 1.32)	0.95
Hawaiian and Pacific Islander	-0.22	0.20	0.81 (1.05, 1.52)	0.28
Marital status				
Single (one parent)	0.44	0.05	1.56 (1.42, 1.71)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.27	0.04	1.31 (1.21, 1.41)	<0.01
Initiation of prenatal care				
None	0.66	0.11	1.93 (1.56, 2.40)	<0.01
First trimester (ref.)				
Second trimester	-0.23	0.06	0.80 (0.71, 0.89)	<0.01
Third trimester	-0.72	0.16	0.49 (0.36, 0.67)	<0.01
Level of segregation				
Low (ref.)				
High	-0.06	0.06	0.94 (0.84, 1.05)	0.26

Continue

Table 11 (Cont'd)

Level of poverty				
Low (ref.)				
High	0.10	0.05	1.11 (1.02, 1.21)	0.02

*Adjusted for all factors listed.

Table 12 Binary logistic regression analyses of low birth weight of both individual-level and neighborhood-level characteristics of foreign-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.76	0.14	0.06	<0.01
Maternal age				
< 20 years	0.16	0.28	1.17 (0.68, 2.02)	0.56
20 – 34 years (ref.)				
> 34 years	0.34	0.13	1.71 (1.32, 2.22)	<0.01
Maternal education				
No high school	-0.31	0.18	0.73 (0.51, 1.05)	0.09
High school diploma (ref.)				
Some college	-0.12	0.13	0.88 (0.68, 1.15)	0.35
Maternal race				
Caucasian (ref.)				
African American	0.27	0.17	1.31 (0.94, 1.83)	0.12
American Indian**	-18.48	8147.76	0.00 (0.00, 0.00)	0.99
Asian	-0.24	0.24	0.78 (0.49, 1.26)	0.31
Hawaiian and Pacific Islander	0.30	0.12	1.34 (1.06, 1.71)	0.02
Marital status				
Single (one parent)	0.68	0.21	1.98 (1.32, 2.96)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	-0.11	0.22	0.90 (0.58, 1.39)	0.62
Initiation of prenatal care				
None	-0.43	0.74	0.65 (0.15, 2.74)	0.56
First trimester (ref.)				
Second trimester	-0.62	0.25	0.54 (0.33, 0.88)	0.01
Third trimester	-0.01	0.43	1.00 (0.43, 2.32)	0.99
Level of segregation				
Low (ref.)				
High	-0.13	0.13	0.88 (0.68, 1.14)	0.32

Continue

Table 12 (Cont'd)

Level of poverty				
Low (ref.)				
High	-0.18	0.13	1.19 (0.93, 1.54)	0.17

*Adjusted for all factors listed.

** The total number of foreign-born American Indian was too small (N = 26), and thus the result was not significant in this model.

Table 13 Binary logistic regression analyses of preterm birth of both individual-level and neighborhood-level characteristics in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.26	0.03	0.11	<0.01
Maternal age				
< 20 years	-0.11	0.05	0.90 (0.02, 0.98)	0.02
20 – 34 years (ref.)				
> 34 years	0.33	0.04	1.39 (1.29, 1.49)	<0.01
Maternal education				
No high school	0.10	0.04	1.11 (1.03, 1.19)	<0.01
High school diploma (ref.)				
Some college	-0.08	0.03	0.92 (0.87, 0.98)	<0.01
Country of origin				
U.S.-born (ref.)				
Foreign-born	-0.19	0.06	0.83 (0.73, 0.94)	<0.01
Maternal race				
Caucasian (ref.)				
African American	0.36	0.04	1.43 (1.33, 1.54)	<0.01
American Indian	-0.17	0.22	0.85 (0.55, 1.32)	0.46
Asian	0.12	0.16	1.12 (0.82, 1.53)	0.47
Hawaiian and Pacific Islander	-0.10	0.09	0.90 (0.75, 1.08)	0.28
Marital status				
Single (one parent)	0.25	0.04	1.28 (1.18, 1.39)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.15	0.04	1.16 (1.09, 1.24)	<0.01
Initiation of prenatal care				
None	0.74	0.10	2.09 (1.72, 2.55)	<0.01
First trimester (ref.)				
Second trimester	-0.26	0.05	0.78 (0.70, 0.86)	<0.01
Third trimester	-0.59	0.14	0.56 (0.43, 0.72)	<0.01

Continue

Table 13 (Cont'd)

Level of segregation				
Low (ref.)				
High	0.06	0.06	1.06 (0.95, 1.18)	0.31
Level of poverty				
Low (ref.)				
High	0.07	0.04	1.08 (0.99, 1.17)	0.29
Level of immigrant density				
Low (ref.)				
Medium	-0.15	0.06	0.86 (0.77, 0.96)	<0.01
High	0.01	0.03	1.01 (0.95, 1.08)	0.74

*Adjusted for all factors listed.

Table 14 Binary logistic regression analyses of preterm birth of both individual-level and neighborhood-level characteristics of U.S.-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.26	0.03	0.10	<0.01
Maternal age				
< 20 years	-1.13	0.05	0.88 (0.81, 0.97)	<0.01
20 – 34 years (ref.)				
> 34 years	0.32	0.04	1.38 (1.28, 1.49)	<0.01
Maternal education				
No high school	0.13	0.04	1.14 (1.06, 1.22)	<0.01
High school diploma (ref.)				
Some college	-0.08	0.03	0.92 (0.87, 0.99)	0.02
Maternal race				
Caucasian (ref.)				
African American	0.38	0.04	1.46 (1.35, 1.57)	<0.01
American Indian	-0.09	0.23	0.92 (0.59, 1.43)	0.70
Asian	0.15	0.31	1.16 (0.63, 2.13)	0.63
Hawaiian and Pacific Islander	-0.54	0.20	0.58 (0.39, 0.87)	<0.01
Marital status				
Single (one parent)	0.23	0.04	1.26 (1.16, 1.37)	<0.01
Married (two parents) (ref.)				
Acknowledgment of paternity	0.16	0.04	1.17 (1.09, 1.25)	<0.01
Initiation of prenatal care				
None	0.77	0.10	2.17 (1.77, 2.65)	<0.01
First trimester (ref.)				
Second trimester	-0.25	0.05	0.78 (0.70, 0.87)	<0.01
Third trimester	-0.63	0.14	0.53 (0.40, 0.70)	<0.01
Level of segregation				
Low (ref.)				
High	0.06	0.06	1.07 (0.95, 1.20)	0.28

Continue

Table 14 (Cont'd)

Level of poverty				
Low (ref.)				
High	0.06	0.05	1.06 (0.97, 1.16)	0.17
Level of immigrant density				
Low (ref.)				
Medium	-0.13	0.06	0.88 (0.78, 0.99)	0.03
High	0.01	0.04	1.01 (0.95, 1.09)	0.71

*Adjusted for all factors listed.

Table 15 Binary logistic regression analyses of preterm birth of both individual-level and neighborhood-level characteristics of foreign-born mother group in the capital tri-county area in Michigan, 1995-2007.

	β	Standard error	Odds ratio (95% CI)	p-value
Intercept	-2.27	0.13	0.10	<0.01
Maternal age				
< 20 years	0.14	0.26	1.15 (0.69, 1.93)	0.59
20 – 34 years (ref.)				
> 34 years	0.42	0.12	1.52 (1.19, 1.94)	<0.01
Maternal education				
No high school	-0.31	0.17	0.73 (0.53, 1.02)	0.07
High school diploma (ref.)				
Some college	-0.17	0.12	0.84 (0.66, 1.08)	0.17
Maternal race				
Caucasian (ref.)				
African American	0.07	0.16	1.07 (0.78, 1.48)	0.66
American Indian**	-18.82	8539.39	0.00 (0.00, 0.00)	0.99
Asian	0.08	0.19	1.09 (0.75, 1.59)	0.66
Hawaiian and Pacific Islander	-0.01	0.12	0.99 (0.79, 1.24)	0.91
Marital status				
Single (one parent)	0.47	0.20	1.61 (1.08, 2.38)	0.02
Married (two parents) (ref.)				
Acknowledgment of paternity	-0.18	0.21	0.84 (1.56, 1.26)	0.40
Initiation of prenatal care				
None	-0.14	0.61	0.87 (0.26, 2.87)	0.82
First trimester (ref.)				
Second trimester	-0.35	0.21	0.71 (0.47, 1.07)	0.10
Third trimester	-0.08	0.43	0.92 (0.40, 2.16)	0.85
Level of segregation				
Low (ref.)				
High	-0.05	0.17	0.96 (0.68, 1.34)	0.80

Continue

Table 15 (Cont'd)

Level of poverty				
Low (ref.)				
High	0.19	0.13	1.21 (0.94, 1.56)	0.15
Level of immigrant density				
Low (ref.)				
Medium	-0.26	0.19	0.77 (0.54, 1.11)	0.06
High	-0.04	0.13	0.96 (0.74, 1.24)	0.74

*Adjusted for all factors listed.

** The total number of foreign-born American Indian was too small (N = 26), and thus the result was not significant in this model.

Table 16 The correlation between low birth weight and neighborhood-level characteristics among different foreign-born groups of mothers and the U.S.-born mothers in the capital tri-county area in Michigan, 1995-2007.

Country/region of origin	Low birth weight* No. (%)	Level of segregation** (%)		Level of poverty*** (%)		Level of immigrant Density**** (%)		
		Low	High	Low	High	Low	Medium	High
Eastern Europe	14 (5.3)	64.3	35.7	85.7	14.3	57.1	28.6	14.3
Western Europe	45 (8.2)	88.9	11.1	84.4	15.6	68.9	24.4	6.7
North Africa	9 (7.9)	55.6	44.4	55.6	44.0	11.1	33.3	55.6
Sub Sahara	31 (7.6)	71.0	29.0	58.1	41.9	35.5	19.4	45.2
Canada	12 (5.2)	83.3	16.7	100.0	0.0	83.3	16.7	0.0
Mexico	24 (4.5)	83.3	16.7	83.3	16.7	58.3	16.7	25.0
Central/South America	37 (6.5)	78.4	21.6	62.2	37.8	27.0	32.4	40.5
Eastern Asia	43 (4.2)	32.6	67.4	60.5	39.5	23.3	14.0	62.8
Central Asia/ Middle East	44 (8.4)	40.9	59.1	79.5	20.5	29.5	22.7	47.7
South Asia	47(10.2)	51.1	48.9	72.3	27.7	40.4	14.9	44.7
Southeast Asia/ Oceania	64 (7.1)	85.9	14.1	70.0	29.7	32.8	39.1	28.1
U.S.-born	5120 (7.6)	92.7	7.3	86.1	13.9	68.0	22.8	9.2

* Low birth weight = infant birth < 2,500 g

** Low level of segregation = LMiZscore < 1.96; high level of segregation = LMiZscore ≥ 1.96

*** Low level of poverty = percentage of poverty < 30%; high level of poverty = percentage of poverty ≥ 30 %

**** Low level of immigrant density = percentage of foreign-born populations 0% - 5%; medium level of immigrant density = percentage of foreign-born populations 5% - 10%; high immigrant density = percentage of foreign-born populations 10% - 62%

Table 17 The correlation between preterm birth and neighborhood-level characteristics among different foreign-born groups of mothers and the U.S.-born mothers in the capital tri-county area in Michigan, 1995-2007.

Country/region of origin	Low birth weight* No. (%)	Level of segregation** (%)		Level of poverty*** (%)		Level of immigrant density**** (%)		
		Low	High	Low	High	Low	Medium	High
Eastern Europe	19 (7.2)	78.9	21.1	94.7	5.3	47.4	47.4	5.3
Western Europe	52 (9.4)	80.8	19.2	84.6	15.4	59.6	30.8	9.6
North Africa	8 (7.0)	62.5	37.5	50.0	50.0	25.0	25.0	50.0
Sub Sahara	33 (8.1)	75.8	24.2	57.6	42.4	42.4	15.2	42.4
Canada	13 (5.7)	84.6	15.4	100.0	0.0	84.6	15.4	0.0
Mexico	40 (7.6)	87.5	12.5	92.5	7.5	50.0	32.5	17.5
Central/South America	51 (9.0)	80.4	19.6	54.9	45.1	31.4	33.3	35.3
Eastern Asia	67 (6.5)	32.8	67.2	61.2	38.8	26.9	13.4	59.7
Central Asia/ Middle East	40 (7.7)	45.0	55.0	80.0	20.0	32.5	25.0	42.5
South Asia	38 (8.2)	47.4	52.6	81.6	18.4	36.8	15.8	47.4
Southeast Asia/ Oceania	76 (8.4)	85.5	14.5	73.7	26.3	39.4	35.5	25.0
U.S.-born	(6675) 9.9	92.1	7.9	87.9	12.1	70.6	20.9	8.5

* Low birth weight = infant birth < 2,500 g

** Low level of segregation = LMiZscore < 1.96; high level of segregation = LMiZscore ≥ 1.96

*** Low level of poverty = percentage of poverty < 30%; high level of poverty = percentage of poverty ≥ 30 %

**** Low level of immigrant density = percentage of foreign-born populations 0% - 5%; medium level of immigrant density = percentage of foreign-born populations 5% - 10%; high immigrant density = percentage of foreign-born populations 10% - 62%

APPENDIX B

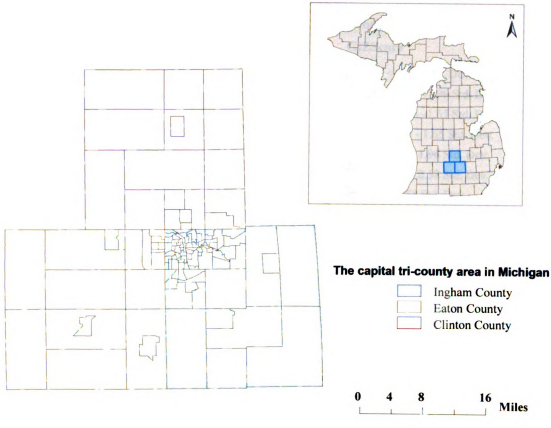
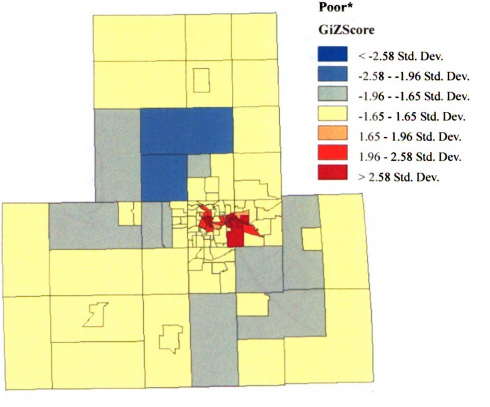
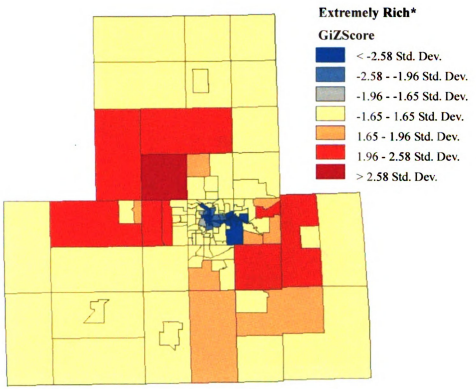


Figure 1 Reference map of the capital tri-county area in Michigan.



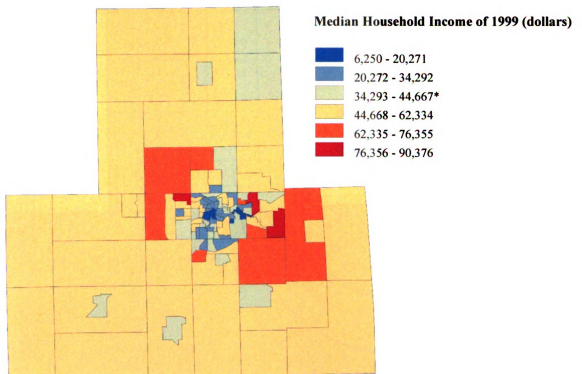
*Poor refers to the poverty threshold that are under 50, 50, 75, and 100.

Figure 2 The hot/cold spots of the percentage of poor in the capital tri-county area in Michigan, 1995-2007.



*Extremely rich refers to the poverty threshold that is greater than 200.

Figure 3 The hot/cold spots of the percentage of extremely rich in the capital tri-county area in Michigan, 1995-2007.



*The median household income of the state of Michigan was $44,667 in 1999.

Figure 4 The spatial distribution of median household income in the capital tri-county area in Michigan, 1995-2007.

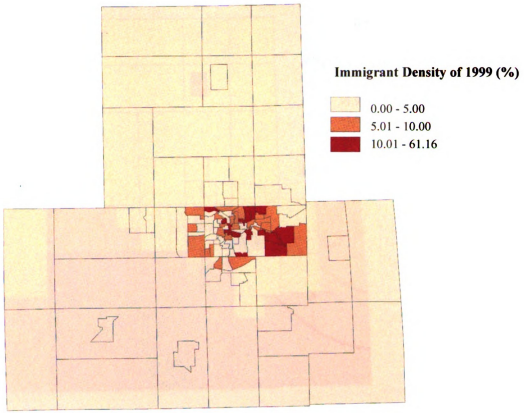


Figure 5 The spatial distribution of the immigrant density in the capital tri-county area in Michigan of 1999.

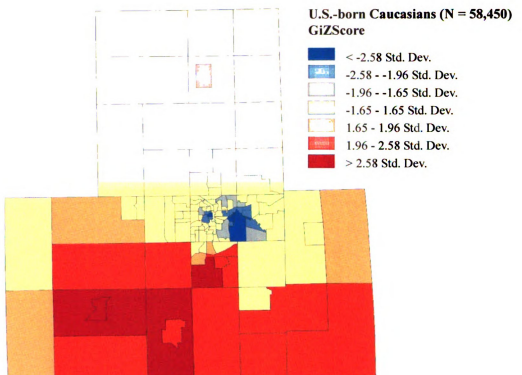


Figure 6 The hot/cold spots of U.S.-born Caucasians in the capital tri-county area in Michigan, 1995-2007

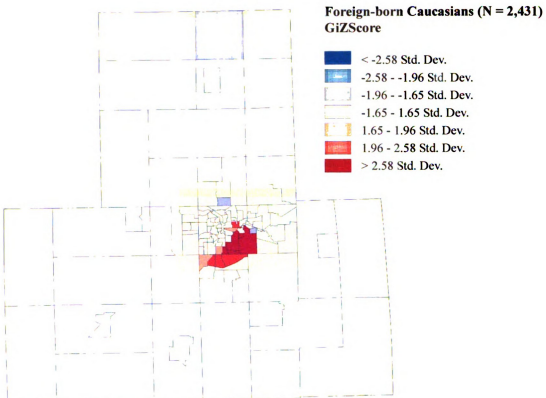


Figure 7 The hot/cold spots of foreign.-born Caucasians in the capital tri-county area in Michigan, 1995-2007.

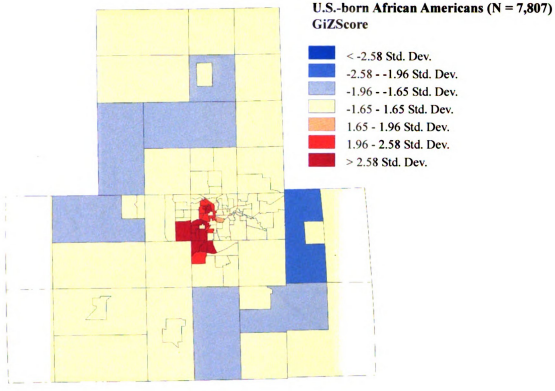


Figure 8 The hot/cold spots of U.S.-born African Americans in the capital tri-county area in Michigan, 1995-2007.

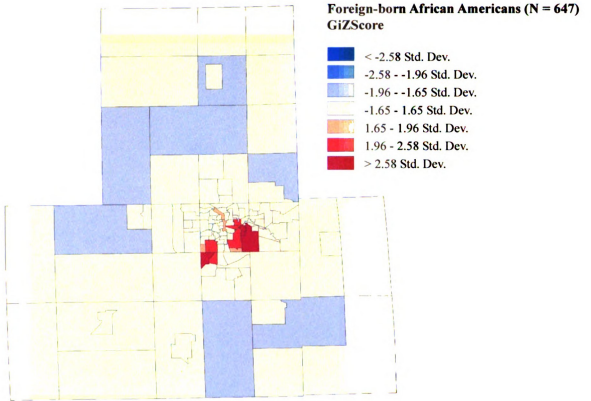


Figure 9 The hot/cold spots of foreign.-born African Americans in the capital tri-county area in Michigan, 1995-2007.

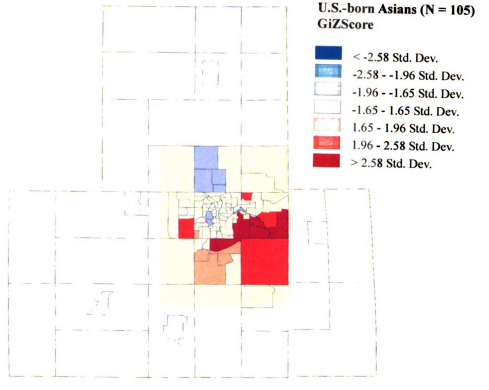


Figure 10 The hot/cold spots of U.S.-born Asians in the capital tri-county area in Michigan, 1995-2007.

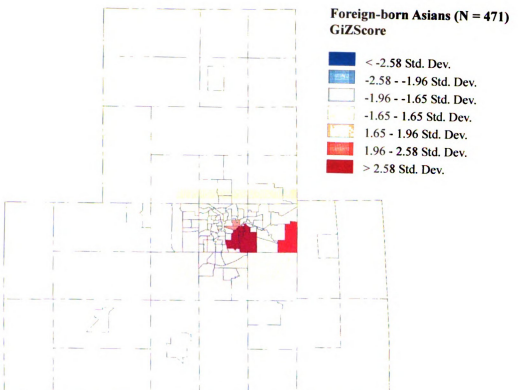


Figure 11 The hot/cold spots of foreign-born Asians in the capital tri-county area in Michigan, 1995-2007.

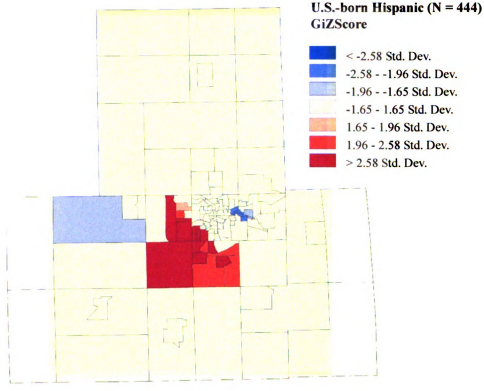


Figure 12 The hot/cold spots of U.S.-born Hispanic in the capital tri-county area in Michigan, 1995-2007.

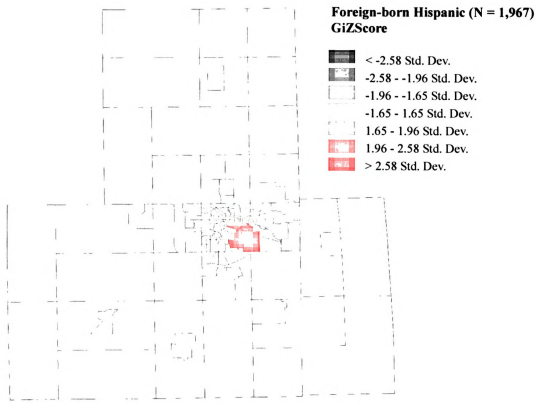


Figure 13 The hot/cold spots of foreign-born Hispanic in the capital tri-county area in Michigan, 1995-2007.

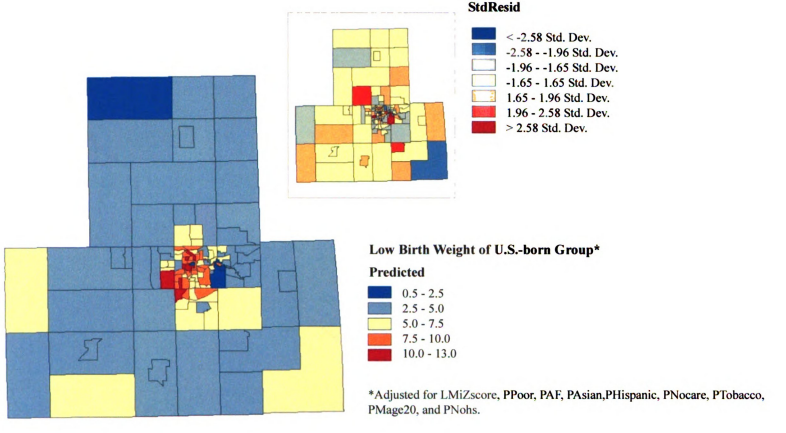


Figure 14 The spatial distribution of predicted low birth weight and its residual of U.S.-born mothers in the capital tri-county area in Michigan, 1995-2007.

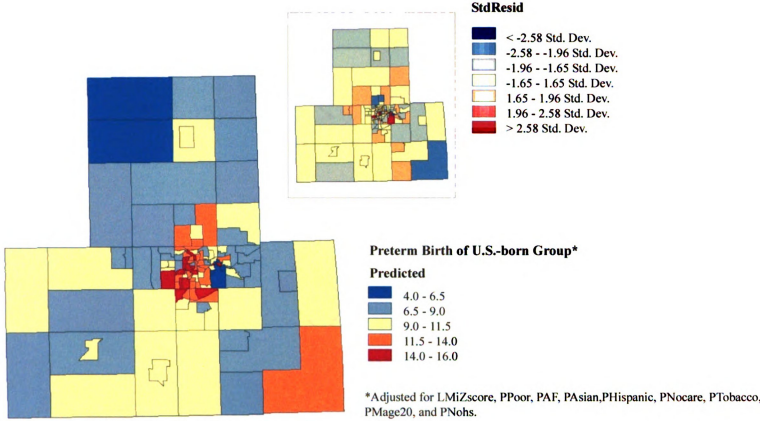


Figure 15 The spatial distribution of predicted preterm birth and its residual of U.S.-born mothers in the capital tri-county area in Michigan, 1995-2007.

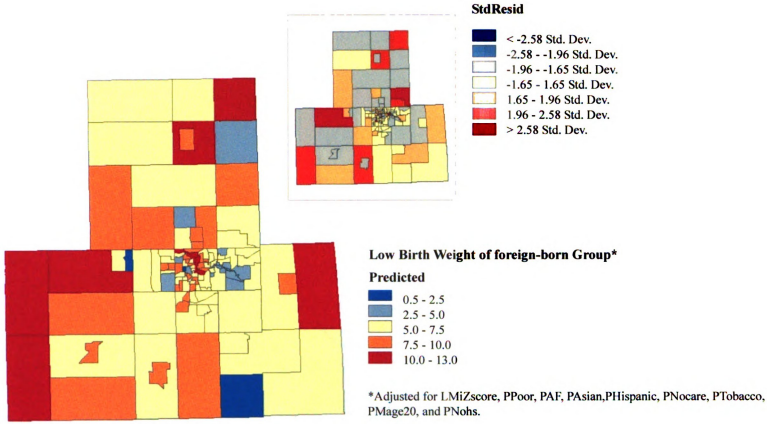


Figure 16 The spatial distribution of predicted low birth weight and its residual of foreign.-born mothers in the capital tri-county area in Michigan, 1995-2007.

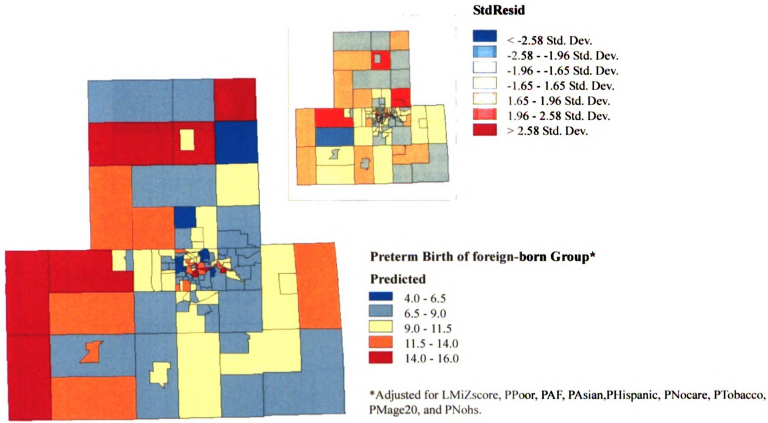


Figure 17 The spatial distribution of predicted preterm birth and its residual of foreign.-born mothers in the capital tri-county area in Michigan, 1995-2007.

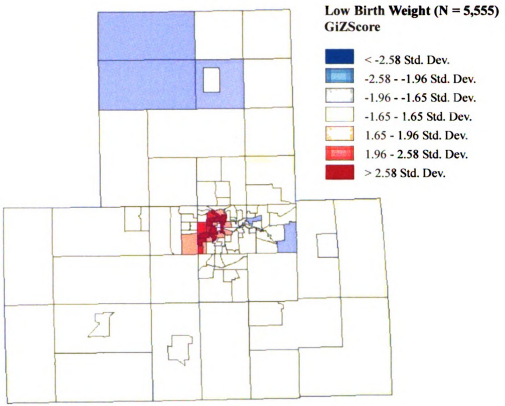


Figure 18 The hot/cold spots of low birth weight of U.S.-born and foreign-born mothers in the capital tri-county area in Michigan, 1995-2007.

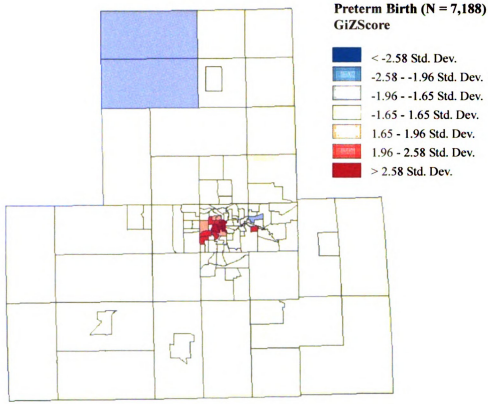


Figure 19 The hot/cold spots of preterm birth of U.S.-born and foreign-born mothers in the capital tri-county area in Michigan, 1995-2007.

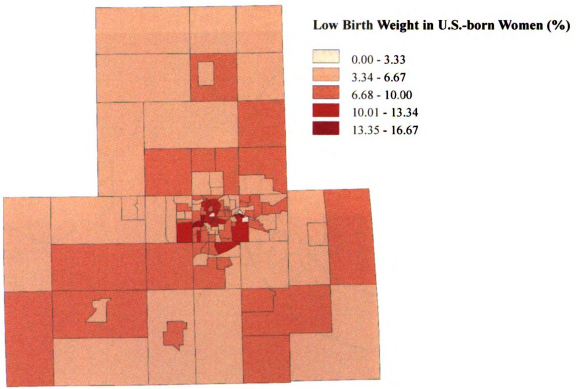


Figure 20 The spatial distribution of the percentage of low birth weight in U.S.-born women in the capital tri-county area in Michigan, 1995-2007.

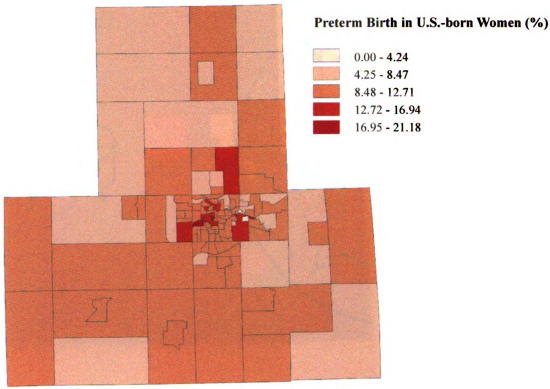


Figure 21 The spatial distribution of the percentage of preterm birth in U.S.-born women in the capital tri-county area in Michigan, 1995-2007.

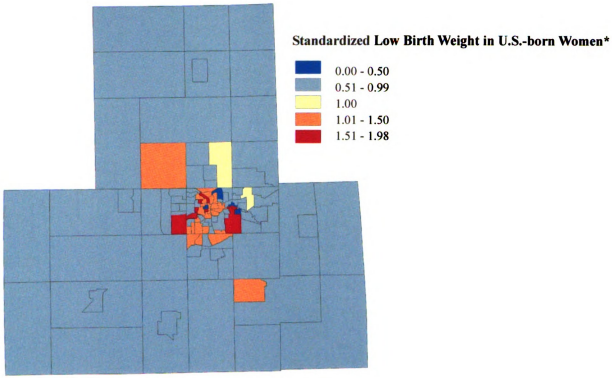


Figure 22 The spatial distribution of the standardized percentage of low birth weight in U.S.-born women in the capital tri-county area in Michigan, 1995-2007.

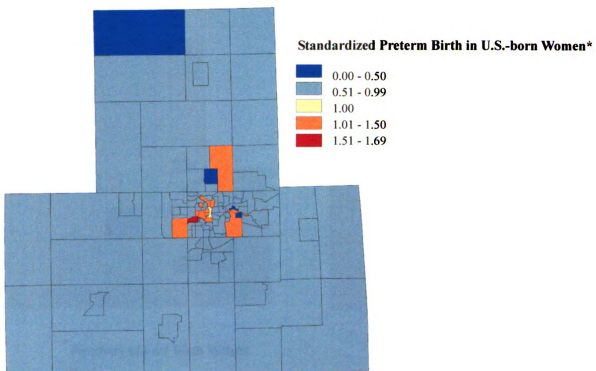


Figure 23 The spatial distribution of the standardized percentage of preterm birth in U.S.-born women in the capital tri-county area in Michigan, 1995-2007.

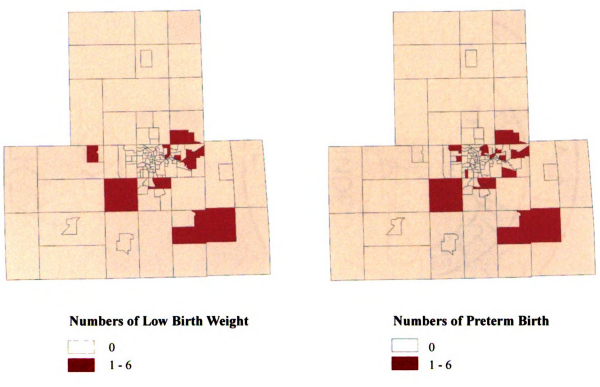


Figure 24 Numbers of low birth weight and preterm birth of the foreign-born women from Eastern Europe in the capital tri-county area in Michigan, 1995-2007.

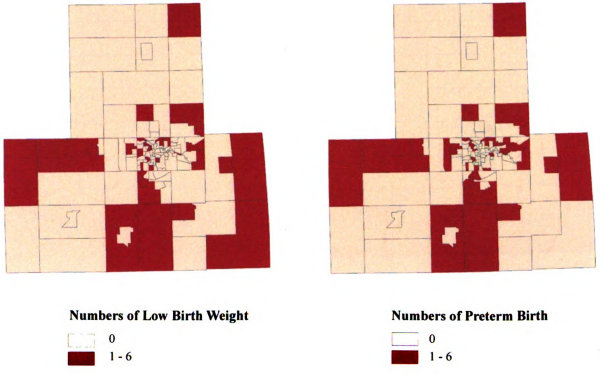


Figure 25 Numbers of low birth weight and preterm birth of the foreign-born women from Western Europe in the capital tri-county area in Michigan, 1995-2007.

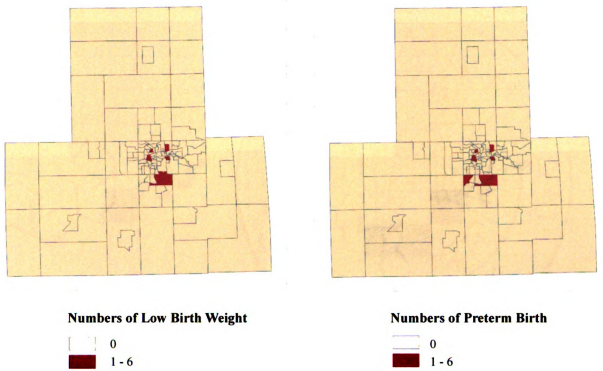


Figure 26 Numbers of low birth weight and preterm birth of the foreign-born women from North Africa in the capital tri-county area in Michigan, 1995-2007.

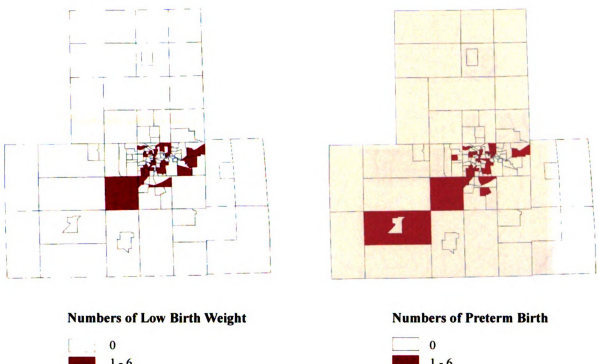


Figure 27 Numbers of low birth weight and preterm birth of the foreign-born women from Sub Sahara in the capital tri-county area in Michigan, 1995-2007.

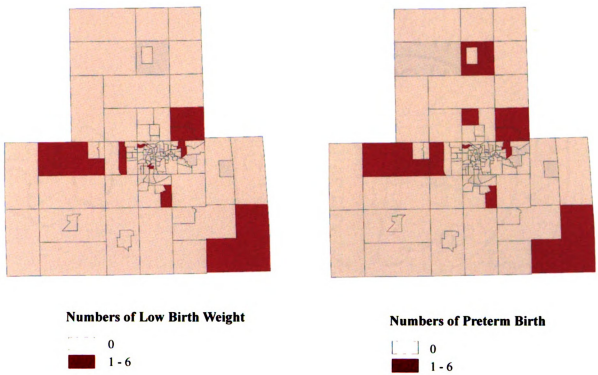


Figure 28 Numbers of low birth weight and preterm birth of the foreign-born women from Canada in the capital tri-county area in Michigan, 1995-2007.

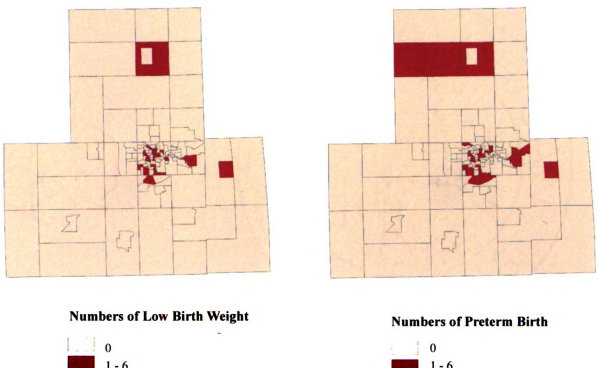


Figure 29 Numbers of low birth weight and preterm birth of the foreign-born women from Mexico in the capital tri-county area in Michigan, 1995-2007.

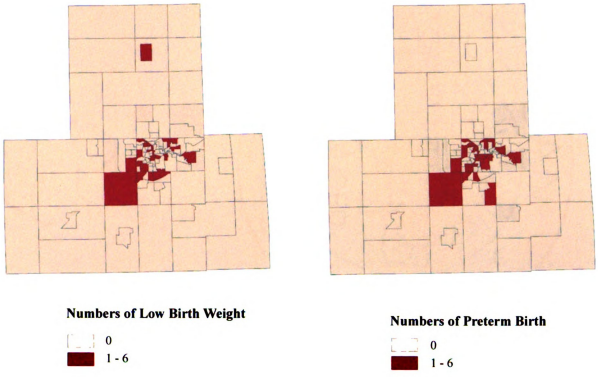


Figure 30 Numbers of low birth weight and preterm birth of the foreign-born women from Central/ South America in the capital tri-county area in Michigan, 1995-2007.

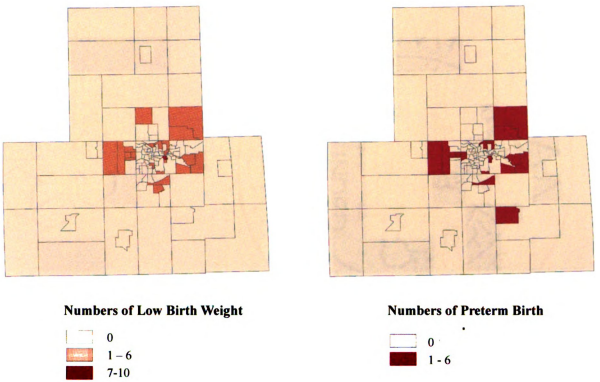


Figure 31 Numbers of low birth weight and preterm birth of the foreign-born women from South Asia in the capital tri-county area in Michigan, 1995-2007.

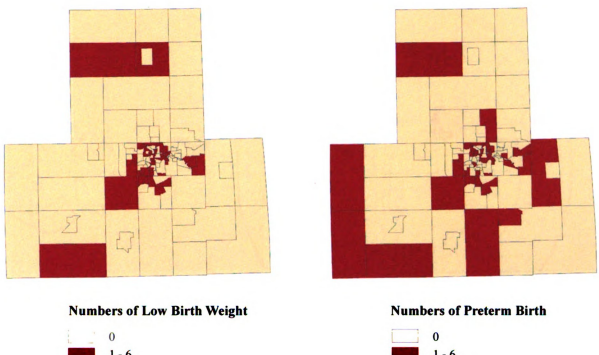


Figure 32 Numbers of low birth weight and preterm birth of the foreign-born women from Southeast Asia/ Oceania in the capital tri-county area in Michigan, 1995-2007

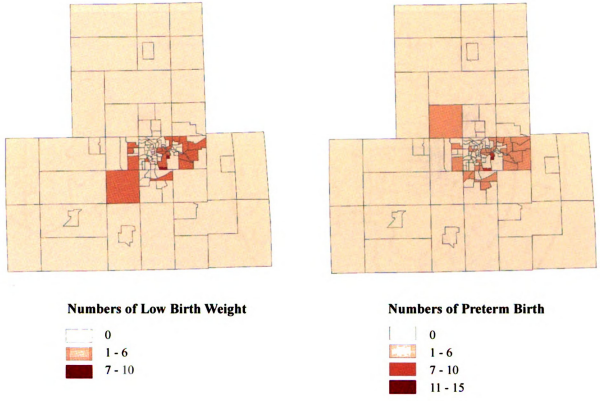


Figure 33 Numbers of low birth weight and preterm birth of the foreign-born women from Eastern Asia in the capital tri-county area in Michigan, 1995-2007

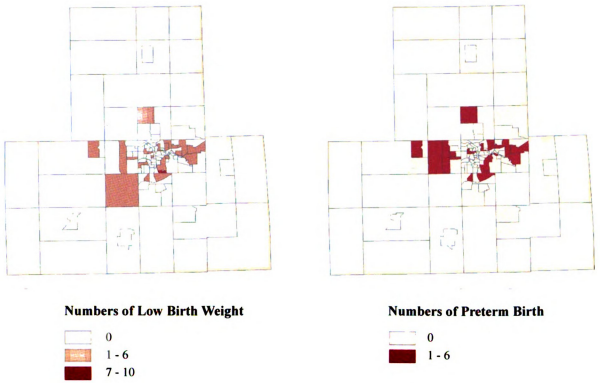


Figure 34 Numbers of low birth weight and preterm birth of the foreign-born women from Central Asia/ Middle East in the capital tri-county area in Michigan, 1995-2007

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