Beyond the dichotomy of "immigrant disadvantage" and "healthy immigrant paradox": heterogeneities of prevalence, socioeconomic determinants and spatial patterns of low birthweight among natives and immigrant subgroups in Hong Kong

by

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This is to certify that I have examined the above MPhil thesis
and have found that it is complete and satisfactory in all respects,
and that any and all revisions required by
the thesis examination committee have been made.

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Abstract

Low birthweight (LBW), defined as newborns with a birthweight below 2,500g, is associated with high infant mortality and various morbidities. Certain immigrant groups were found to have higher risks of LBW (i.e., “immigrant disadvantage”), while others may have fewer LBW events (i.e., “healthy immigrant paradox”). This population-based study examines which notion applies to Hong Kong. Using 2006-2020 singleton live birth data in Hong Kong, I examined the prevalence, socioeconomic determinants, and spatial patterns of LBW among natives and immigrant subgroups in Hong Kong. Results showed an increasing trend of LBW events from approximately 4.75% in 2006 to approximately 5.75% in 2020. Compared with the average LBW prevalence among Hong Kong natives (5.76%), South/Southeast Asians had the highest LBW prevalence (6.19%). Substantively lower LBW events were observed among the mothers from Mainland China who conducted maternity migration (i.e., traveling to Hong Kong solely to give birth) (3.23%) and mothers from non-Asian high-income territories (3.26%). The socioeconomic determinants of LBW among natives and immigrant subgroups are heterogeneous, with LBW risks of natives being the most vulnerable to socioeconomic disadvantages. Interestingly, South/Southeast Asian mothers were mostly not prone to the effect of socioeconomic disadvantages on LBW risks. The spatial patterns of LBW across the study groups are heterogeneous, with LBW more clustered only among mothers from Mainland China, East Asian high-income territories and South/Southeast Asian territories. Local clusters are observed in distinct areas across the study groups. The findings suggest that instead of building a universal approach to explain LBW events, moving beyond the dichotomy of “immigrant disadvantage” and “immigrant health paradox” and consideration of the compositions of immigrants in evaluating the epidemiology of LBW are necessary and warranted. Location-specific health intervention should be targeted to the vulnerable population subgroups to mitigate the increasing trend of LBW events in Hong Kong.

1. Introduction

Low birthweight (LBW) refers to newborns with a birthweight below 2,500g regardless of gestational age and typically applies to live births only (Blencowe et al., 2019). Birthweight is an important marker of perinatal, neonatal, and postneonatal health (Doherty & Kinney, 2019). LBW remains a pivotal global public health issue associated with high infant mortality, higher risk of morbidity, childhood stunting, developmental disabilities, and long-term adult-onset chronic diseases (e.g., obesity and diabetes) (Blencowe et al., 2019; Boulet et al., 2011; Jornayvaz et al., 2016; Schieve et al., 2016).

Reduction and surveillance of LBW, especially targeting vulnerable populations, have become a global public health priority detailed in the Sustainable Development Goal (World Health Organization, 2012). While a growing literature focused on immigrants' birth outcomes, the links between immigrant status and birthweight showed inconsistent results (Racape et al., 2016). In some countries, immigrants were found to be the vulnerable group that may have higher risks of LBW (Stanek et al., 2020; Urquia et al., 2010). This phenomenon was commonly coined as "immigrant disadvantage" (Štípková, 2016). For instance, in Spain, the birthweight was significantly lower for newborns to mothers from Asian non-high-income countries, compared with newborns to mothers from non-high-income European countries, African countries, and Latin American countries (Stanek et al., 2020). Meanwhile, the "healthy immigrant paradox" was uncovered, whereby immigrant mothers enjoyed better birth outcomes than native mothers despite their lower socioeconomic status (Janevic et al., 2011; Racape et al., 2016; Urquia et al., 2012). For instance, in the U.S., immigrant groups such as Mexican-born mothers enjoyed better pregnancy outcomes than would be expected despite being socioeconomically disadvantaged (Kane et al., 2018).

Understanding the plausible explanations of the "immigrant disadvantage" and "healthy immigrant paradox" is crucial in the reduction and surveillance of LBW among immigrants. The notion of "immigrant disadvantage" suggests that "newcomers" in industrialized societies are normally the ones with socioeconomic disadvantages and generally suffer from barriers to accessing health care (Derose et al., 2009; Park & Myers, 2010). This is particularly applicable to those who migrate from low-income countries to high-income host countries (Stanek et al., 2020). For "healthy immigrant paradox", one explanation is the immigrant selectivity hypothesis, which suggests that immigrants are not a random sample of the home country populations and their intention to migrate is based on their perception of being different from the people in their home country, whereby their choices to migrate are based on considerable observable and unobservable attributes such as socioeconomic characteristics (Riosmena et al., 2017; Stanek et al., 2020). Another explanation is the ethnic maintenance hypothesis, which suggests that immigrant groups may develop certain socio-cultural behavioral traits that shape positive birth outcomes. For instance, certain immigrant groups would exhibit protective health behaviors (e.g., healthy diets, limited smoking and drinking, and strong family bonds with support) that are well practiced through internal social norms and social ties among their ethnic communities despite their socioeconomic conditions (Almeida et al., 2009; Stanek et al., 2020; Zolitschka et al., 2019).

To further explore the complexity behind the two notions: "immigrant disadvantage" versus "healthy immigrant paradox", scholars identified that the gradient in low birthweight risks between immigrant subgroups highly depends on their specific socioeconomic characteristics (Racape et al., 2016; Urquia et al., 2010). These characteristics may include maternal age, marital status, educational attainment, occupations, housing conditions, and permanent residency (Stanek et al., 2020; Verropoulou & Basten, 2014). For instance, evidence showed significant differences in the effect of maternal age on LBW risk across people of different race/ethnicity. Caucasian and Hispanic teenage mothers born in the US had significantly higher LBW risk than African-American and Hispanic teenage mothers born in non-US countries (Dennis & Mollborn, 2013). Also, there was evidence showing that the educational gradient in LBW varied considerably among mothers from different immigrant subgroups. For instance, the effect of mothers' education status on LBW risk among native Czech and Slovak mothers was much larger compared to all other mothers who are not native in the Czech Republic (Štípková, 2016). These findings suggest that the links between socioeconomic factors and LBW outcomes are heterogeneous among natives and immigrant subgroups, whereby it is flawed to mitigate LBW by relying on the estimates about the associations between socioeconomic characteristics and birthweight at an aggregate population level (Stanek et al., 2020). Understanding the heterogeneity of socioeconomic determinants of LBW among natives and immigrant subgroups can allow precise policy interventions to target the vulnerable population subgroups who suffer from specific socioeconomic disparities in LBW (Shibre & Tamire, 2020).

Apart from understanding socioeconomic determinants of LBW outcomes, examining the spatial patterns of LBW events has been an important epidemiological practice in mitigating LBW (Kirby et al., 2011; Tu et al., 2012). In the perspective of policymaking, only understanding how SES plays a role in exhibiting LBW outcomes is not sufficient because precise locations of LBW clusters can further complement health prevention strategies in addition to population-wide health policies (Insaf & Talbot, 2016). Identifying the problematic zones (clusters) which require specific health interventions is crucial (Banerjee et al., 2020). The application of Exploratory Spatial Data Analysis (ESDA) is a useful approach allowing scholars to identify the spatial patterns and local variations of health data, and provide a starting point to evaluate spatial models (Banerjee et al., 2020; Kihal-Talantikite et al., 2013; Schabenberger & Gotway, 2017; Tu et al., 2012). Identifying clusters of LBW outcomes among natives and immigrant subgroups can help researchers to generate hypotheses and theories that can be further tested in more rigorous research designs (Tu et al., 2012). Understanding the spatial aspect of LBW particularly merits public health experts to locate vulnerable populations who suffer from health disparities in an effective way and conduct epidemiological surveillance in the long run (Banerjee et al., 2020).

Hong Kong is considered one of the East Asian territories with a relatively high LBW prevalence (Blencowe et al., 2019). While Hong Kong is an immigrant society with nearly 40% of the whole population being immigrants dated 2015 and a net migration number of 147,000 from 2015 to 2020, it is particularly important to uncover the potential disparities in LBW among immigrant subgroups for a sustainable and immigrant-inclusive society (MacroTrends, 2021; United Nations, 2019). However, to my knowledge, population-based studies examining LBW in Hong Kong, especially concerning immigrants, are severely limited. The first population-based study examining LBW in Hong Kong was dated 2001, examining the socioeconomic determinants patterns of LBW in Hong Kong using 1984-1997 birth data (Cheung & Yip, 2001). After that, Verropoulou and Basten (2014) examined the associations of sociodemographic factors and immigrant status of parents with LBW in Hong Kong using 1995-2009 birth data. Although this study attempted to uncover the role of immigrant status in LBW risk in Hong Kong by conducting an aggregate-level analysis, it did not account for the heterogeneity of the prevalence, socioeconomic determinants, and spatial patterns of LBW among natives and immigrant subgroups. Since then, to my knowledge, there have been no population-based studies focusing on the epidemiology of LBW in the last decade in Hong Kong, especially concerning newborns to immigrant mothers.

The overarching goal of this population-based study is to examine whether immigrant mothers in Hong Kong suffer from “immigrant disadvantage” or enjoy “immigrant health paradox” in terms of LBW. Specifically, using 2006-2020 singleton live birth data in Hong Kong, I aim to offer three new contributions. First, I assess the overall trend of LBW in Hong Kong from 2006 to 2020 and identify the average prevalence of LBW among natives and immigrant subgroups. Second, I estimate the heterogeneity of socioeconomic determinants of LBW among natives and immigrant subgroups in Hong Kong. Third, I evaluate the heterogeneity of spatial patterns of LBW among natives and immigrant subgroups in Hong Kong. I hypothesize that: i) the overall trend of LBW in Hong Kong is increasing from 2006 to 2020 and the average prevalence of LBW among natives and immigrant subgroups are substantively different, with immigrant subgroups suffering from “immigrant disadvantage” (i.e., higher prevalence of LBW); ii) the socioeconomic determinants of LBW among natives and immigrants subgroups are heterogeneous, with the LBW risks of immigrant subgroups more vulnerable to socioeconomic disadvantages; and iii) the spatial patterns of LBW among natives and immigrant subgroups are heterogeneous, with LBW more clustered among immigrant subgroups.

2. Methods

2.1 Data and Study Area

This study employs the 2006-2020 population-based birth microdata from the vital registration system of Hong Kong. The microdata include weight at birth of the newborn, date of birth of the newborn, sex of the newborn, type of birth of the newborn (e.g., single child, child of twin, etc.), maternal age when the child was born, mother’s residence, occupation of mother and father, educational attainment of mother and father, type of housing of mother, marital status of mothers (e.g., married and unmarried), length of stay of mother and father in Hong Kong, and place of the previous residence of mother and father. Weight at birth of the newborn was recorded by the hospital and sent to the government via the “Birth Return” form. The birth registration forms did not include any pregnancy complications (e.g., gestational age, pregnancy-induced hypertension, gestational diabetes and obesity, etc.). From 2006 to 2020, there were 1,019,285 births in Hong Kong. I excluded non-singleton births and observations with missing values in the variables of interest. The birth records have the following entries regarding the “place of the previous residence of mother”: “China (excluding Taiwan)”, “Macau”, “Taiwan”, “Indonesia”, “Malaysia”, “Singapore”, “Philippines”, “Thailand,” “India, Pakistan, Bangladesh and Sri Lanka”, “Hong Kong”, “Vietnam”, “Brunei, Laos and Cambodia”, “Japan”, “Korea”, “Other Asian countries”, “Australia”, “New Zealand”, “United Kingdom”, “France”, “Germany”, “Other European countries”, “Canada”, “USA”, “Other American Countries”, “Other Countries”, and “Unknown”. I excluded the observations with over-general and invalid entries of place of the previous residence such as “Other Asian countries”, “Other European countries”, “Other American countries”, “Other countries” and “Unknown”. Given the special phenomenon of “maternity migration” in Hong Kong (i.e., mothers who come from Mainland China traveling to Hong Kong just to give birth while heavily pregnant), for the observations with the entry “China (excluding Taiwan)”, I followed the practice suggested by Gietel-Basten and Verropoulou (2019) and further classified these typologies based on mothers’ period of residence. If a Mainland mother stays in Hong Kong less than 1 year before the birth, she is considered undergoing “maternity migration”. I classified the observations into six study groups: live births to Hong Kong native mothers (“HK”), live births to Mainland Chinese mothers undergoing “maternity migration” (“MM”), live births to Mainland Chinese mothers who did not undergo “maternity migration” (“N-MM”), live births to mothers from East Asian high-income territories (including Macau, Taiwan, Japan and Korea) (“EA”), live births to mothers from South/Southeast Asian territories (including Indonesia, Malaysia, Singapore, Philippines, Thailand, India, Pakistan, Bangladesh, Sri Lanka, Vietnam, Brunei, Laos, and Cambodia) (“S/SEA”), and live births to mothers from Non-Asian high-income territories (including Australia, New Zealand, the U.K., France, Germany, Canada, and the U.S.) (“NA”). Concerning the classification, a limitation should be noted. This classification follows the data structure provided by the government. It is acknowledged that there are differences between territories within the same classification. For example, in the “S/SEA” group, Singapore may be different from other South/South-East Asian territories in terms of the economy. With this concern, I further considered the number of births and the number of LBW births of each origin within each study group, as detailed in Table 1, to evaluate whether the classification produces severe biases in the analysis. Since the numbers of births and LBW births of the territories with distinct economies (e.g., Singapore) are very few, this study follows the classification as stated above. The final sample size of the analysis is 549,685 singleton live births, with 28,491 LBW births.

The study area is shown in Fig. 1. Hong Kong includes 18 districts in three main regions: New Territories (including North District, Sai Kung District, Sha Tin District, Tai Po District, Islands

District, Kwai Tsing District, Tsuen Wan District, Tuen Mun District, and Yuen Long District), Kowloon (including Sham Shui Po District, Kowloon City District, Kwun Tong District, Wong Tai Sin District, and Yau Tsim Mong District), and Hong Kong Island (Central and Western District, Eastern District, Southern District, and Wan Chai District). The downtown developed areas in Hong Kong are mostly clustered in Kowloon and Hong Kong Islands. This study used the Tertiary Planning Unit (TPU), which is the finest geographic unit provided by the dataset, as the geographic unit of analysis.

<Figure 1 is about here>

2.2 Measures

The outcome variable of interest is LBW, which is defined as newborns with a birthweight below 2,500g (1 = presence of LBW; 0 = absence of LBW). This study follows the guideline of the definition of LBW (a birthweight below 2,500g) from the World Health Organization for global comparison (World Health Organization, 2022). This definition is widely applied to the context of North America, Europe, South/Southeast Asia and East Asia in studies elsewhere, while the immigrants in Hong Kong are mostly from these four main regions (Blencowe et al., 2019; Marete et al., 2020). The independent variables in the analysis included maternal age (1 = 35 or above, 0 = below 35), occupations of mother and father (1 = administrative positions & professionals (including managers and administrators, professionals, and associate professionals), 2 = clerks/service workers (including clerks, service workers and shop sales workers), 3 = elementary workers/economically inactive (including agricultural and fishery workers, craft and related workers, plant and machine operators and assemblers, elementary occupations, armed forces and occupations unidentifiable, and economically inactive), educational attainments of mother and father (1 = tertiary, 0 = secondary or below), type of housing of mother (1 = private housing, 0 = public and aided housing), marital status of parents (1 = married, 0 = unmarried), and permanent residency of father (1 = Yes, 0 = No). The residence of mother was in the form of TPU (N = 291). For adjustment of the regression analysis, I added two covariates: sex of the newborn (M = male, F = Female) and year of birth (2006-2020).

2.3 Analyses

I firstly assessed the overall trend of LBW in Hong Kong from 2006 to 2020 by fitting a non-parametric locally weighted scatterplot smoother (commonly known as LOWESS) to monthly LBW rates data from 2006 to 2020. The fitted line with a 95% confidence interval was presented. LBW rate (%) in this study is given as:

$$\frac{\text{Number of LBW births}}{\text{Total number of births}} \times 100$$

I then presented the descriptive statistics of the average prevalence of LBW and socioeconomic characteristics across natives and immigrant subgroups.

I performed binary logistic regression to identify the socioeconomic determinants of LBW across natives and immigrant subgroups. Unadjusted and adjusted models were fitted. The adjusted covariates were sex and year of birth of the newborn. Robust standard errors were employed in the models. I used variance inflation factor (VIF) to detect the presence of multicollinearity for both models. The VIFs of all variables in both models were below 4, suggesting the absence of multicollinearity issue. Odds ratios with 95% confidence interval, p-values, and VIFs were presented. I conducted the statistical analyses using *R* version 4.2.0.

To identify the heterogeneity of spatial patterns of the LBW outcomes among natives and immigrant subgroups, I followed a three-step analytical process.

Firstly, I mapped the TPU-level average LBW prevalence across natives and immigrant subgroups. Secondly, I performed the spatial autocorrelation (Global Moran's I) analysis of LBW rates across natives and immigrant subgroups. The Global Moran's I measure global spatial autocorrelation based on both feature locations and feature values. It evaluates whether the spatial pattern is clustered, dispersed, or random, where the Moran's I range from -1 (dispersed) to 1 (clustered). I defined the neighbor relationship as Queen's case adjacency, which describes that all TPU boundaries sharing at least a corner are considered neighbors. The Global Moran's I statistics for spatial autocorrelation in my study are given as:

$$I = \frac{N}{S_0}\sum_i \sum_j w_{ij} \frac{(x_i - \mu)(x_j - \mu)}{\sum_i (x_i - \mu)^2}$$

where N is the total number of TPUs, w_{ij} is the element in the spatial-weight matrix corresponding to the samples i and j; and x_i and x_j are LBW rates for areas i and j with the mean μ; and

$$S_0 = \sum_i \sum_j w_{ij}$$

Thirdly, I performed the Anselin's Local Indicator of Spatial Autocorrelation (LISA) analysis of LBW rates across natives and immigrant subgroups. LISA indicates the local spatial association that measures whether the LBW rate for one TPU is closer to the value of a neighboring unit or the average value of the study area. A Monte Carlo permutation approach was used to test whether the associations are statistically significant. The permutation assumes that the likelihood for the LBW rate of the investigated feature is equal at any location under randomization so the observed values are randomly shuffled over the given spatial unit and the LISA is re-computed for each permutation. The algorithm would then determine the statistical significance of the LISA by computing a reference distribution based on a sufficient amount of permutations. In this study, I used the value 999 for the reference distribution. I defined the neighbor relationship as Queen's case adjacency, which describes that all TPU boundaries sharing at least a corner are considered as neighbors. The analysis identifies hot spots, cold spots, and spatial outliers by yielding five categories: 'high-high (HH)', 'low-low (LL)', 'high-low (HL)', 'low-high (LH)', and 'not significant (NS)'. The TPU with HH or LL category indicates clustering of high values or low values of LBW rates. The identification of HH or LL areas can help us understand the problematic zones with exceptionally high LBW rates and also some zones with exceptionally low LBW rates that worth exploring for its potential protective factors of LBW. The TPU with HL category represents high values of LBW rates adjacent to low values of LBW rates, while the TPU with LH category represents low values of LBW rates adjacent to high values. The HL or LH categories offer insights into understanding the local disparities in LBW. The TPU with NS category means that there is no statistically significant spatial autocorrelation.

The Local Moran's I statistic of spatial autocorrelation in this study is given as:

$$I_i = \frac{x_i - \bar{X}}{S_i^2} \sum_{j=1, j \neq 1}^{n} w_{i,j}(x_j - \bar{X})$$

where n is the total number of TPUs, x_i is the LBW rate for feature i, $\bar{X}$ is the mean of the LBW rates, $w_{i,j}$ is the spatial weight between feature i and j, and

$$S_i^2 = \frac{\sum_{j=1, j \neq 1}^{n} (x_j - \bar{X})^2}{n - 1}$$

All spatial analyses were conducted using *ArcGIS Pro* version 2.9.

3. Results

Figure 2 presents the overall trend of LBW rates in Hong Kong from 2006 to 2020. I observed an overall increasing trend of LBW rates in Hong Kong from approximately 4.75% in 2006 to approximately 5.75% in 2020. No signs of decreasing trends of LBW were observed from 2006 to 2020. Table 2 shows the descriptive statistics of the average LBW prevalence of the six study groups by origin. Heterogeneous LBW prevalence is observed across the study groups. Compared with the average LBW prevalence among "HK" (5.76%), higher average LBW prevalence was found among "S/SEA" (6.19%). Lower average prevalence of LBW was found in other groups: "MM" (3.23%), "N-MM" (4.28%), "EA" (5.08%), and "NA" (3.26%), with "MM" and "NA" sharing substantively lower prevalence.

<Figure 2 is about here>

<Table 2 is about here>

Table 3 presents the descriptive statistics for socioeconomic characteristics of the parents with LBW babies across the study groups from 2006 to 2020 in Hong Kong. Substantive variations of the socioeconomic characteristics of the parents with LBW births were identified across the study groups. For maternal age, mothers with LBW births from "HK", "MM", "N-MM", and

"S/SEA" are mostly below 35, ranging from 69% to 73%, while advanced maternal age pregnancy (i.e., pregnancy at 35 years old or above) is more common among mothers with LBW births from "EA" (40.0%) and "NA" (46.3%). For occupation and educational attainment of mothers, most mothers with LBW births from "NA" were professionals/administrative positions (65.2%) and with tertiary education (93.2%). Most mothers from "MM" with LBW births received secondary or below education (74.2%) and were elementary workers/economically inactive (72.0%). Likewise, most mothers from "N-MM" with LBW births received secondary or below education (69.5%) and were elementary workers/economically inactive (48.9%), with a slightly higher proportion of them working as clerks/service workers (31.6%). Most mothers with LBW births from "S/SEA" were elementary workers/economically inactive (65.5%) and received secondary or below education (62.8%). Compared with the occupation and education attainment of mothers with LBW births, those of fathers with LBW births had similar patterns. Notably, fathers with LBW births from "NA" shared a substantively higher proportion of administrative positions & professionals (90.6%) and received tertiary education (92.6%). Fathers with LBW births from "EA" were mostly in administrative positions/professionals (64.1%) and received tertiary education (68.5%) as well. It is worth noting that fathers with LBW births from "S/SEA" were mostly in administrative positions/professionals (40.1%), although most of them received secondary or below education (59.1%). For the type of housing of mothers, mothers with LBW births from "NA" predominantly lived in private housing (96.5%). Similar patterns were observed for mothers with LBW births from "EA" (81.6%), "S/SEA" (75.9%), and "HK" (76.6%). For mothers with LBW births from "MM", they shared the highest proportion of mothers living in public and aided housing (43.8%) among the study groups. For marital status of mothers, around nine out of 10 mothers with LBW births across the study groups were married. For permanent residency of fathers with LBW births, most fathers with LBW births from "NA" did not have permanent residency in Hong Kong (74.9%). Similar patterns were observed for fathers with LBW births from "S/SEA" (69.5%) and "MM" (64.4%). It is worth noting that most fathers with LBW births from "EA" had permanent residency (58.2%).

<Table 3 is about here>

Figure 3 presents the coefficient plots of the associations between socioeconomic determinants and LBW of the study population by origin from 2006 to 2020 with adjusted estimates of odds ratios. Detailed unadjusted and adjusted coefficients with 95% confidence intervals are shown in Table 4. I identified notable heterogeneity of socioeconomic determinants of LBW across the study groups. For maternal age, although advanced maternal age pregnancy had higher odds of having LBW across all groups, the degree of odds ratios are heterogeneous and robust statistically significant associations ($p<0.01$) were observed only among mothers from “HK” (aOR = 1.25, 95%CI: 1.22, 1.28), “N-MM” (aOR = 1.27, 95%CI: 1.22, 1.32), “EA” (aOR = 1.40, 95%CI: 1.17, 1.62), and “NA” (aOR = 1.38, 95%CI: 1.16, 1.60). For occupation of mothers, the associations between being elementary workers/economically inactive and LBW were robustly significant ($p<0.01$) only among mothers from “HK” (aOR =1.06, 95%CI: 1.02, 1.11). Significant associations ($p<0.05$) between being clerks/service workers and LBW were found among mothers from “N-MM” (aOR = 1.10, 95%CI: 1.02, 1.18). For educational attainment of mother, significant associations ($p<0.05$) between secondary or below education and LBW were observed only among mothers from “HK” (aOR = 1.05, 95%CI: 1.01, 1.10). For occupation of father, robust significant associations ($p<0.01$) between being clerks/service workers and LBW were identified among fathers from “HK” (aOR = 1.06, 95%CI: 1.02, 1.11) alone. Meanwhile, significant associations ($p<0.05$) between being elementary workers/economically inactive and LBW were found among fathers from “HK” (aOR = 1.06, 95%CI: 1.02, 1.11), “MM” (aOR = 1.52, 95%CI: 1.15, 1.88), and “N-MM” (aOR = 1.09, 95%CI: 1.02, 1.16). For educational attainment of father, a weak association ($p<0.10$) between being secondary or below and LBW was observed only among fathers from “HK” (aOR = 1.04, 95%CI: 0.99, 1.08). For type of housing of mother, robust significant associations($p<0.01$) between living in public and aided housing and LBW were identified only among mothers from “HK” (aOR = 1.07, 95%CI: 1.03, 1.10) and “N-MM” (aOR = 1.09, 95%CI: 1.04, 1.13). Similarly, for marital status of mother, robust significant associations ($p<0.01$) between being unmarried and LBW were found among mothers from “HK” (aOR = 1.33, 95%CI: 1.27-1.39) and “N-MM” (aOR = 1.21, 95%CI: 1.13, 1.30). For permanent residency of father, robust significant associations ($p<0.01$) between absence of permanent of residency of father and LBW were found among fathers from “HK” (aOR = 0.93, 95%CI: 0.89, 0.97) and “N-MM” (aOR = 0.81, 95%CI: 0.76, 0.85). Meanwhile, significant associations ($p<0.05$) were found among fathers from “MM” (aOR = 1.28, 95%CI: 1.05, 1.52) and “S/SEA” (aOR = 1.18, 95%CI: 1.05, 1.31).

<Figure 3 is about here>

<Table 4 is about here>

Figure 4 presents the TPU-level spatial distribution of the average LBW rate prevalence of the study population by origin from 2006 to 2020. The prevalence of LBW is spatially heterogeneous across the study groups. The results of the spatial autocorrelation (Global Moran's I) analysis of LBW rates of the study population by origin from 2006 to 2020 are shown in Table 5. Robust statistically significant clusters were only observed among mothers from "N-MM" (Moran's I: 0.11, $p<0.01$). Marginally significant clusters were identified among mothers from "EA" (Moran's I: 0.068, $p<0.1$) and "S/SEA" (Moran's I: 0.07, $p<0.1$). Figure 5 illustrates the TPU-level LISA analysis for LBW rate of the study population by origin from 2006 to 2020. Locally, notable spatial patterns of LBW clusters were observed across the study populations. Mothers with LBW births from "HK" were mostly clustered in Yuen Long district, Tuen Mun district, Tai Po district and Sai Kung district. For mothers with LBW births from "MM", a small cluster of LBW was observed in Tuen Mun district. A large cluster of LBW was identified in Yuen Long district for mothers from "N-MM". In addition, a small cluster of LBW was also observed in Southern district as well. For "EA" mothers, a large cluster was observed around the boundary of Kwun Tong district. For "S/SEA" mothers, two clusters were observed in Wan Chai district and Southern district. No clusters of LBW were observed among mothers with LBW births from "NA". In general, New Territories was the major region that showed strong local geographic disparities of LBW across the study groups.

<Figure 4 is about here>

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<Figure 5 is about here>

4. Discussions

To my knowledge, this population-based study is the first to examine the heterogeneity of prevalence, socioeconomic determinants and spatial patterns of LBW among natives and immigrant subgroups in Hong Kong. The overarching goal of this study is to identify whether immigrant mothers in Hong Kong suffer from "immigrant disadvantage" or enjoy "immigrant health paradox" in terms of LBW. Corresponding to my hypotheses, this study had three main findings: 1) the overall trend of LBW in Hong Kong kept increasing from 2006 to 2020 and the average prevalence of LBW among natives and immigrant subgroups are substantively different, with immigrant subgroups having both "immigrant disadvantage" and "healthy immigrant paradox" respectively, 2) the socioeconomic determinants of LBW among natives and immigrants subgroups are heterogeneous, with LBW risks of only natives and certain immigrant subgroups more vulnerable to socioeconomic disadvantages; and 3) the spatial patterns of LBW among natives and immigrant subgroups are heterogeneous, with LBW more clustered only among certain immigrant subgroups and in different areas across the study groups locally. This study uncovers the long-embedded disparities of the prevalence, socioeconomic determinants and spatial patterns of LBW among natives and immigrant subgroups in Hong Kong and adds insights on how to mitigate LBW among high-risk population subgroups effectively.

In accordance with the previous literature about mixed LBW among natives and immigrant subgroups, both "immigrant disadvantage" and "immigrant health paradox" were observed concerning LBW in Hong Kong (Janevic et al., 2011; Kane et al., 2018; Racape et al., 2016; Stanek et al., 2020; Urquia et al., 2012). Immigrant mothers from "MM" and "NA" had substantively low LBW rates across the study population, while immigrant mothers from "S/SEA" had substantively higher LBW rates. These findings add insights to the proposition about the "magnet-effect" from Sørbye et al. (2019) that migrants' birthweights are positively associated with the birthweights of the locals, whereby the birthweight among native-born mothers "pull" the birthweight of migrant groups, no matter the origin of the mother was born. Contrarily, this study confirmed that the origin of the immigrant mothers does matter in terms of LBW events. The phenomenon I observed implies ethnic/racial hierarchy in LBW among immigrants in Hong Kong. Particularly, concerning mothers from "S/SEA" in Hong Kong, migrant domestic worker (MDW) is one of the salient groups of migrant workers from South/South-East Asian territories. Literature suggested that the MDW community in Hong Kong has been subject to structural injustice concerning access to healthcare and social support. For example, in a study exploring premarital pregnancies among the MDW community in Hong Kong in 2010, results showed that 97% of the MDW community had premarital sex and 36% of them were pregnant (Ullah, 2010). During pregnancy, the MDW community may face the predicament of losing jobs, extra expenses for healthcare that are not covered in the contract or the insurance plan, depression, and lack of support from their left-behind families. Even worse, one-third of the MDW community may not be aware of their pregnancy rights in Hong Kong and falsely think that their pregnancy rights are contingent upon their employer's generosity and the presumed morality of their pregnancy (Paul & Neo, 2018). The socio-structural frame that the MDW community bears is perhaps one of the driving factors of the substantively higher LBW rates among immigrant mothers from "S/SEA".

Segmented assimilation was perhaps the driving theory of the ethnic/racial hierarchy in LBW in Hong Kong, where immigrant subgroups in Hong Kong are selectively incorporated into the system of stratification of Hong Kong society based on their ethnic/racial affiliation (Urquia et al., 2010). However, such theory still cannot explain the highly context-specific contrasts of LBW rates between "MM" mothers and "N-MM" mothers. Thus, I suggest that instead of building a universal approach to explain LBW events among immigrant groups, moving beyond the dichotomy of "immigrant disadvantage" and "immigrant health paradox" and consideration of the compositions of immigrants in evaluating the epidemiology of LBW are necessary and warranted (Martinson et al., 2017; Stanek et al., 2020; Villalonga-Olives et al., 2017).

In this study, I found that LBW risks were more vulnerable to socioeconomic disadvantages among Hong Kong native mothers. Specifically, Hong Kong unmarried native mothers who have advanced maternal age pregnancy, are elementary workers/economically inactive, receive secondary or below education, and live in public and aided housing are the vulnerable group that requires extra prenatal care. Fathers of the newborns to Hong Kong native mothers who are not in administrative positions/professionals also share vulnerability to LBW risks. Vulnerable "MM" mothers are those who have advanced maternal age pregnancy and are elementary workers/economically inactive. Similarly, vulnerable "N-MM" mothers are those who have advanced maternal age pregnancy, are clerks/service workers, live in public and aided housing, and are unmarried. Generally, "S/SEA" mothers are mostly not prone to the effect of socioeconomic disadvantages on LBW risks. For "EA" and "NA" mothers, the notable vulnerable groups are those who have advanced maternal age pregnancy. In general, the socioeconomic disadvantages of the fathers are linked with LBW risks among newborns to mothers from "HK", "MM" and "N-MM", except that the absence of permanent residency of the father may be a significant factor of LBW risk among newborns to mothers from "S/SEA". The diverse socioeconomic characteristics of vulnerable LBW high-risk subgroups should be considered in tailored policy interventions in Hong Kong (Stanek et al., 2020).

The spatial analysis of this study also confirms the marked variability of LBW in Hong Kong across the study groups. Spatial clusters of LBW events were observed among mothers from "N-MM", "EA" and "S/SEA". Locally, clusters were observed in heterogeneous areas across the study groups. Regional health inequality of LBW events was notable in New Territories. Tuen Mun district, Yuen Long district, Tai Po district, Kwun Tong district, Wai Chai district, and Southern district were generally the problematic areas that require epidemiological attention. The spatial patterns and clustering of LBW events observed would merit the effective implementation of location-specific health prevention programs to reduce LBW events (Banerjee et al., 2020; Tu et al., 2012). The spatial aspect of LBW prevalence compliments the health policies targeting vulnerable population subgroups, especially when health policies assume spatial homogeneity (Tu et al., 2012). For instance, health promotion programs (e.g., education seminars, advertisement, delivering leaflets, home visits, etc.) can be effectively refined to target high-risk natives and immigrant subgroups in certain geographic areas. It is also worthwhile to further explore areas with low prevalence of LBW to discover geographic protective factors that merit the reduction of LBW (Banerjee et al., 2020; Insaf & Talbot, 2016; Tu et al., 2012). For instance, locations of prenatal healthcare centers may be a determinant of LBW events (Pinzón-Rondón et al., 2015). Presence of green space around home may mitigate LBW events (Torres Toda et al., 2020).

This study has two major limitations. Firstly, due to the lack of details of the birthweight data from the government, the LBW analysed in this study did not adjust for other pregnancy complications. The uncontrolled predictors may include but not limited to pregnancy-related hypertension, gestational diabetes, preterm birth, obesity, infections, nutritional status, exposure to poor environmental conditions, and consumption of alcohol and tobacco (Wartko et al., 2017). These variables are directly linked with LBW events. Nevertheless, the unobserved heterogeneity associated with these uncontrolled predictors may be absorbed by socioeconomic factors such as occupation and educational attainment of mother and father, marital status, permanent residency, and housing (Stanek et al., 2020). Another previous study also showed that even maternal physical and behavioural characteristics (e.g., height, weight, and smoking) were added to the models with the exclusion of mothers with chronic morbidities, differences in birthweight for mothers from different ethnic origins still robustly persisted (Figueras et al., 2008).

Another major limitation is that the record of birthweight in the microdata is rounded to the nearest 100 g, which may result in inaccurate classification of LBW babies. For instance, 2,450g newborn may have been reported as 2,500g and classified as "normal birthweight". Thus, the birthweight data I used are by no means error-free and should be interpreted with scrutiny. Nevertheless, as the birthweight variable is categorical, the misclassification problem at the fringes unlikely causes serious bias in the analysis if it is non-systematic (Verropoulou & Basten, 2014).

To conclude, this population-based study confirms that the origin of the immigrant mothers matters in terms of LBW events. I identified the continuous increase in LBW rates in Hong Kong from 2006 to 2020 and the substantive heterogeneity of the average prevalence of LBW rates among natives and immigrant subgroups. Considering the heterogeneity of the socioeconomic determinants of LBW among natives and immigrant subgroups, public health practitioners should implement tailored health interventions for natives and certain immigrant subgroups that are more vulnerable to specific socioeconomic disadvantages. The identification of marked variability of LBW prevalence as well as the clusters of LBW events across the study groups can complement population-wide health policies that might assume spatial homogeneity. The findings suggest that instead of building a universal approach to explain LBW events among immigrant groups, moving beyond the dichotomy of "immigrant disadvantage" and "immigrant health paradox" and consideration of the compositions of immigrants in evaluating the epidemiology of LBW are necessary and warranted. Further empirical research to examine the mechanisms underlying the heterogeneous prevalence, socioeconomic determinants and spatial patterns of LBW among natives and immigrant subgroups are warranted to better inform short-term and long-term health intervention and prevention to mitigate LBW in Hong Kong.

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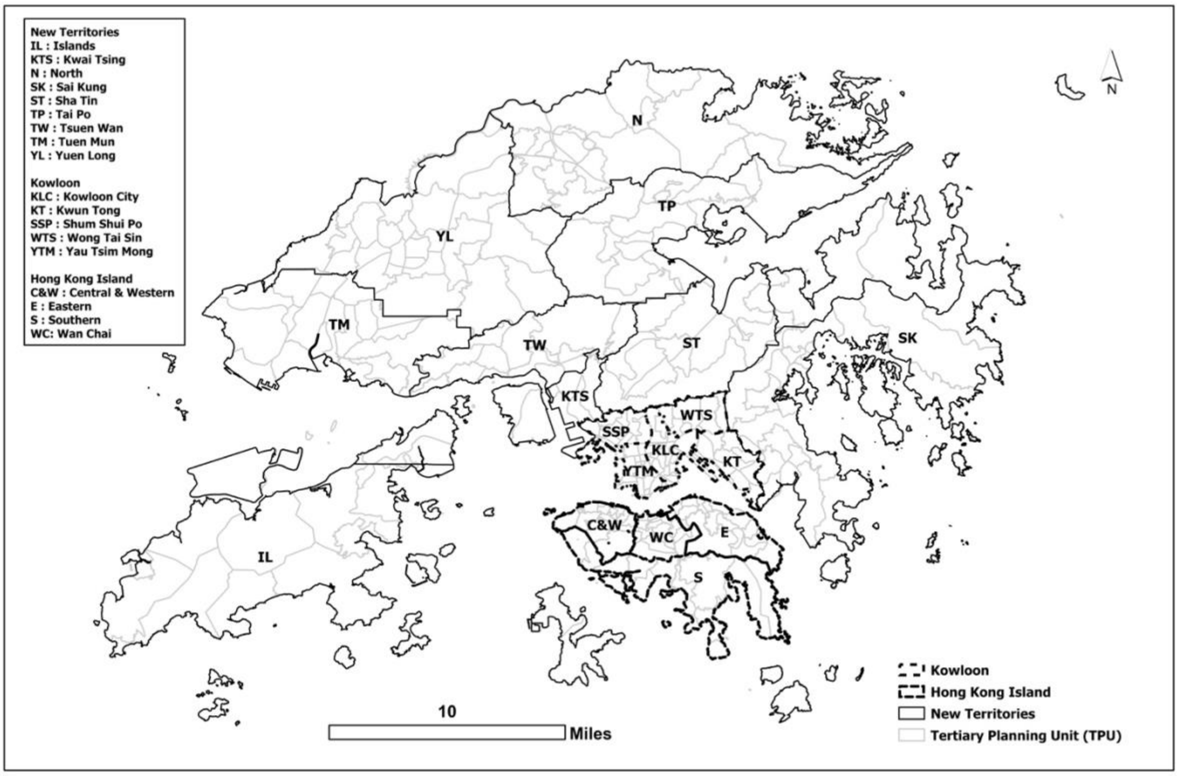

Figure 1. Study area.

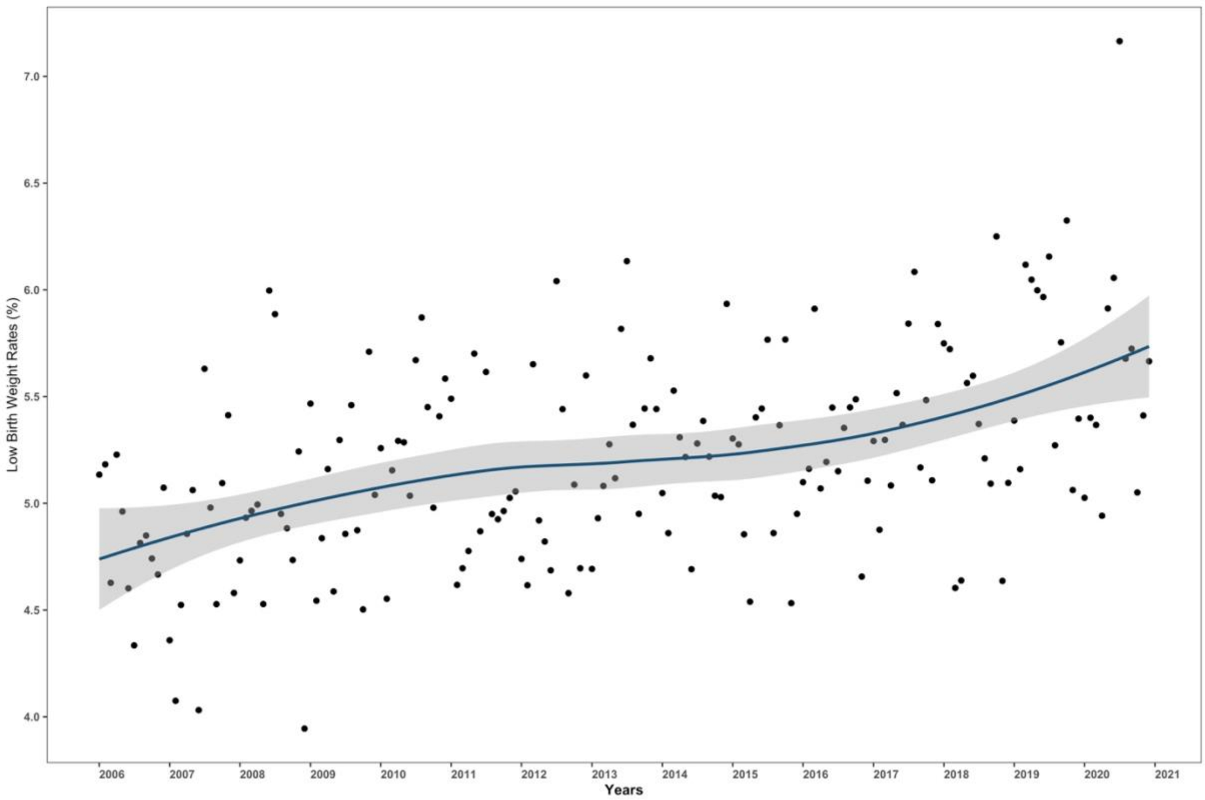

Figure 2. Trend of low birthweight rates in Hong Kong from 2006 to 2020.

Note. [1] Points represent monthly LBW rates in Hong Kong from 2006 to 2020. [2] The fitted line is the non-parametric locally weighted scatterplot smoother (commonly known as LOWESS) to monthly LBW rates data from 2006 to 2020 with 95% confidence interval.

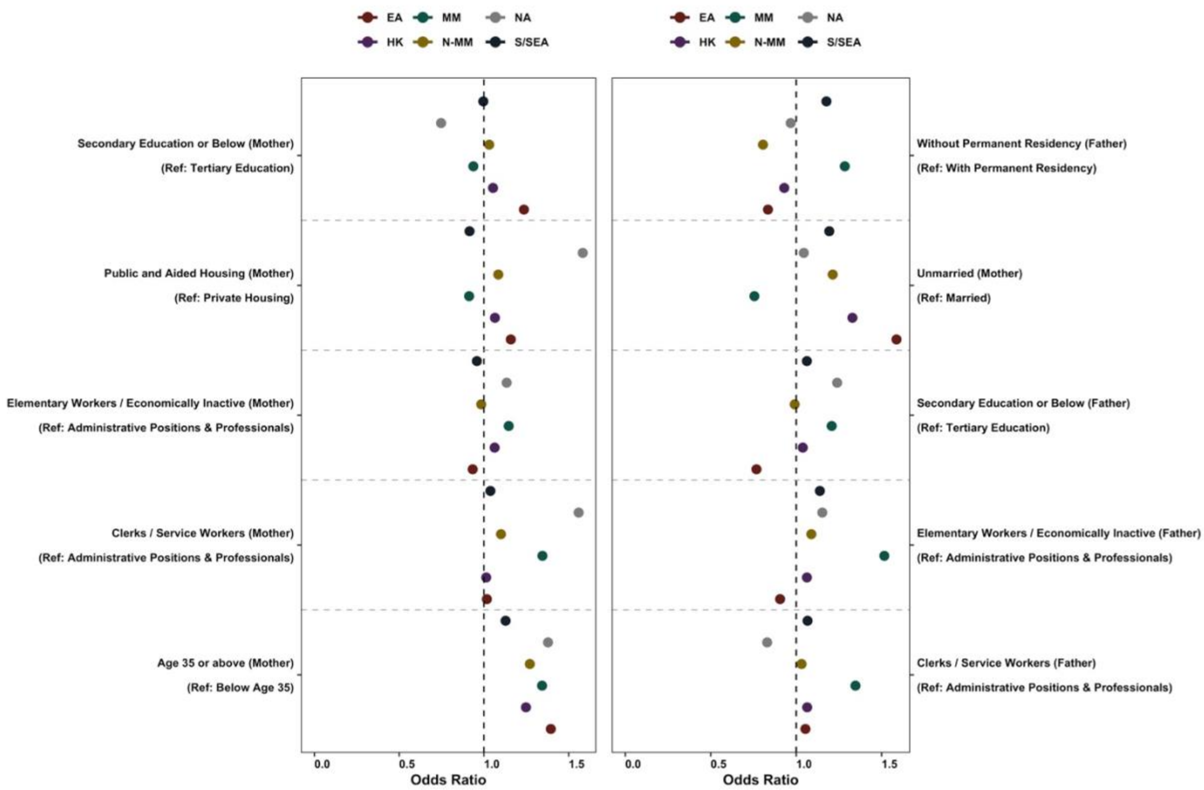

Figure 3. Coefficient plots of the associations between socioeconomic determinants and LBW of the study population by origin with adjusted estimates of odds ratios.

Note. [1] Adjusted odds ratio (adjusted for sex of newborn and year of birth). [2] Ref = reference group in the logistic regression. [3] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories

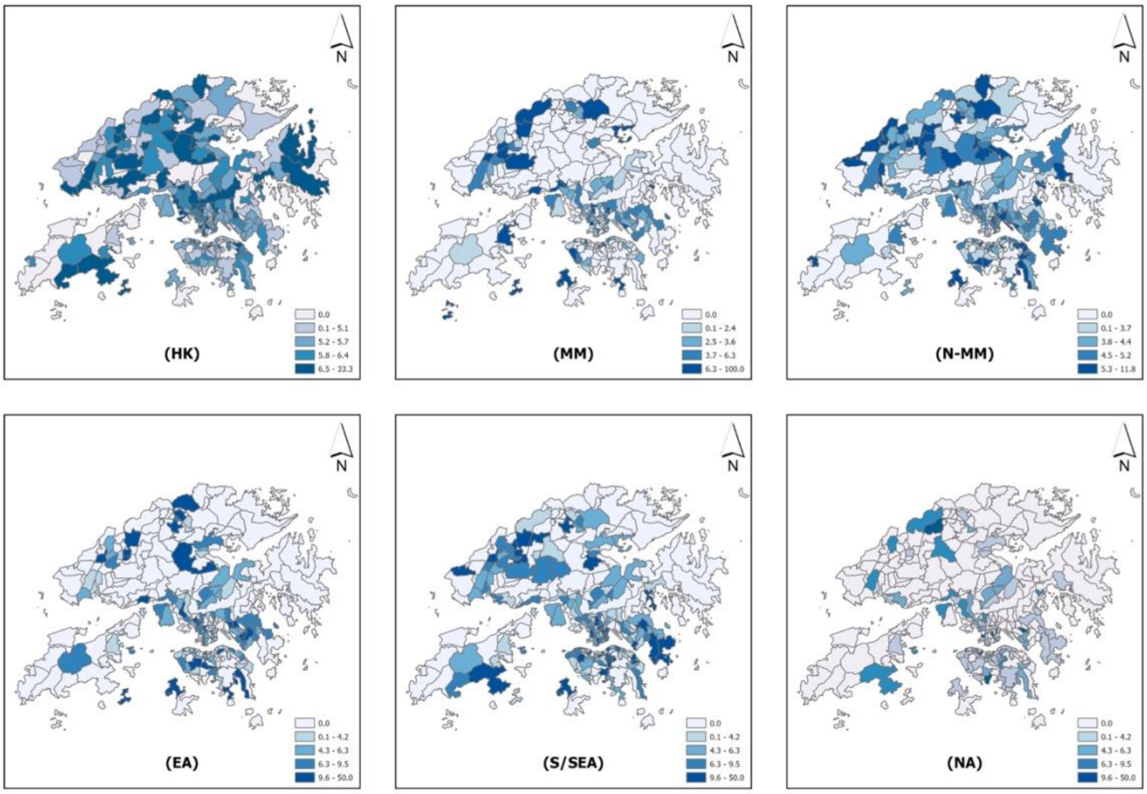

Figure 4. TPU-level spatial distribution of the average LBW rate of the study population by origin, 2006-2020.

Note. [1] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories

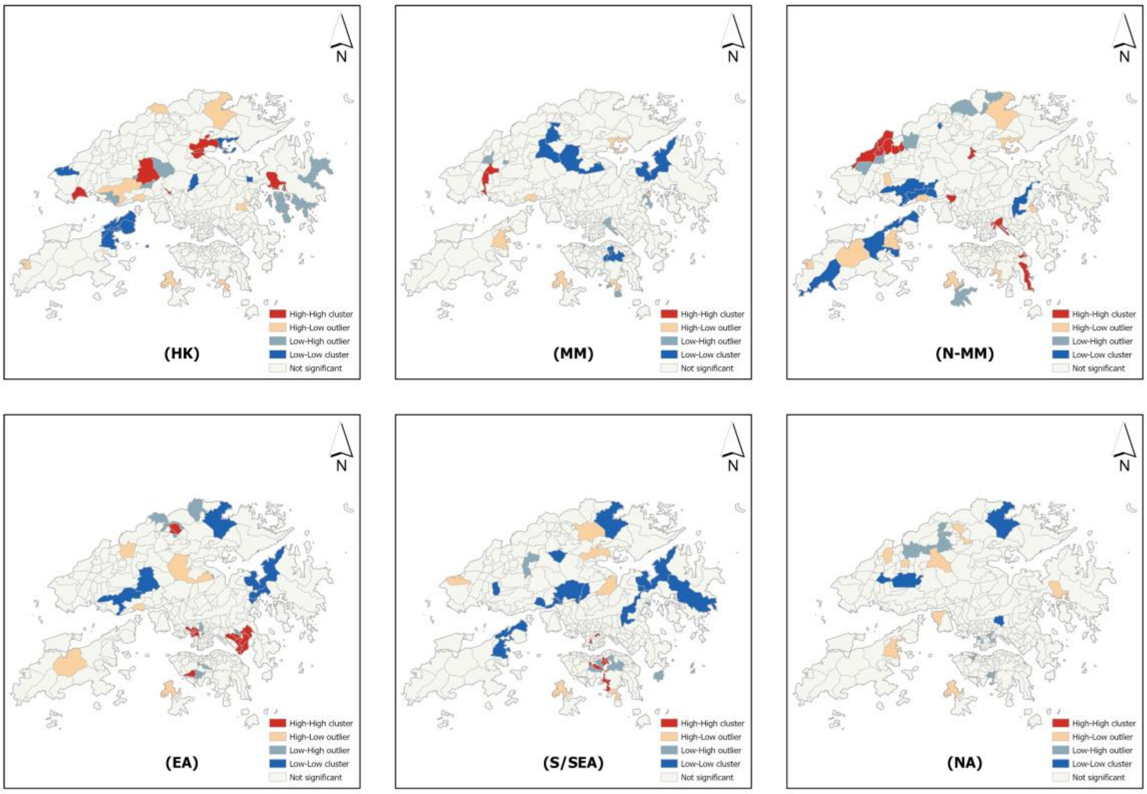

Figure 5. TPU-level LISA analysis for the average LBW rate of the study population by origin, 2006-2020.

Note. [1] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories

Table 1. Number of births and LBW births in each territory, 2006-2020.

Study Group / Territories	Number of births	Number of LBW births
"HK"	**322,971**	**18,596**
"MM"	**10,174**	**329**
"N-MM"	**180,608**	**7,725**
"EA"	**7,060**	**359**
Macau	3,072	144
Taiwan	1,520	93
Japan	1,728	97
Korea	740	25
"S/SEA"	**18,472**	**1,143**
Indonesia	2,675	130
Malaysia	1,215	70
Singapore	763	35
Philippines	3,405	237
Thailand	1,265	76
India, Pakistan, Bangladesh and Sri Lanka	7,475	542
Vietnam	1,595	50
Brunei, Laos and Cambodia	79	3
"NA"	**10,400**	**339**
Australia	2,063	61
New Zealand	355	16
United Kingdom	3,286	105
France	1,095	39
Germany	335	14
Canada	1,297	37
USA	1,969	67

Note. "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories.

Table 2. Descriptive statistics for LBW prevalence of the study population by origin, 2006-2020.

Origin	N	Percentage (%)	Mean (kg)	Median (kg)	SD (kg)	Range (kg)
HK	18,596	5.76	2.08	2.2	0.41	0.4-2.4
MM	329	3.23	2.05	2.2	0.43	0.6-2.4
N-MM	7,725	4.28	2.05	2.2	0.43	0.4-2.4
EA	359	5.08	2.06	2.2	0.45	0.5-2.4
S/SEA	1,143	6.19	2.03	2.2	0.43	0.5-2.4
NA	339	3.26	2.05	2.2	0.43	0.5-2.4
All	28,491	5.18	2.07	2.2	0.42	0.4-2.4

Note. [1] SD = standard deviation [2] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories.

Table 3. Descriptive statistics for socioeconomic characteristics of LBW of the study population by origin, 2006-2020.

	HK (N = 18,596)		MM (N = 329)		N-MM (N = 7,725)		S/SEA (N = 1,143)		EA (N = 359)		NA (N = 339)		All (N = 28,491)	
	N	Percentage	N	Percentage	N	Percentage	N	Percentage	N	Percentage	N	Percentage	N	Percentage
Maternal Age														
Below 35	12,769	68.67	255	77.51	5,476	70.89	837	73.23	217	60.45	182	53.69	19,736	69.27
35 or above	5,827	31.33	74	22.49	2,249	29.11	306	26.77	142	39.55	157	46.31	8,755	30.73
Occupation of mother														
Administrative positions & professionals	7,100	38.18	43	13.07	1,511	19.56	206	18.02	118	32.87	221	65.19	9,199	32.29
Clerks / service workers	7,189	38.66	49	14.89	2,437	31.55	188	16.45	93	25.91	25	7.37	9,981	35.03
Elementary workers / economically inactive	4,307	23.16	237	72.04	3,777	48.89	749	65.53	148	41.23	93	27.43	9,311	32.68
Educational attainment of mother														
Secondary or below	9,392	50.51	244	74.16	5,366	69.46	718	62.82	129	35.93	23	6.78	15,872	55.71
Tertiary	9,204	49.49	85	25.84	2,359	30.54	425	37.18	230	64.07	316	93.22	12,619	44.29
Occupation of father														
Administrative positions & professionals	9,509	51.13	89	27.05	2,684	34.74	458	40.07	232	64.62	307	90.56	13,279	46.61
Clerks / service workers	5,314	28.58	88	26.75	2,220	28.74	293	25.63	82	22.84	20	5.90	8,017	28.14
Elementary workers / economically inactive	3,773	20.29	152	46.20	2,821	36.52	392	34.30	45	12.53	12	3.54	7,195	25.25
Educational attainment of father														
Secondary or below	9,085	48.85	244	74.16	5,031	65.13	676	59.14	113	31.48	25	7.37	15,174	53.26
Tertiary	9,511	51.15	85	25.84	2,694	34.87	467	40.86	246	68.52	314	92.63	13,317	46.74
Type of housing of mother														
Public and aided housing	4,353	23.41	144	43.77	3,028	39.20	275	24.06	66	18.38	12	3.54	7,878	27.65
Private housing	14,243	76.59	185	56.23	4,697	60.80	868	75.94	293	81.62	327	96.46	20,613	72.35
Marital status of mother														
Married	17,245	92.73	318	96.66	7,064	91.44	1,026	89.76	343	95.54	321	94.69	26,317	92.37
Unmarried	1,351	7.27	11	3.34	661	8.56	117	10.24	16	4.46	18	5.31	2,174	7.63
Permanent residency of father														
Yes	15,997	86.02	117	35.56	3,965	51.33	349	30.53	209	58.22	85	25.07	20,722	72.73
No	2,599	13.98	212	64.44	3,760	48.67	794	69.47	150	41.78	254	74.93	7,769	27.27

Note. [1] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories.

Table 4. Associations between socioeconomic determinants and LBW of the study population by origin with unadjusted and adjusted estimates of odds ratios (ORs) with 95% confidence interval.

	HK (N = 322,971)			MM (N = 10,174)			N-MM (N = 180,608)			S/SEA (N = 18,472)			EA (N = 7,060)			NA (N = 10,400)			All (N = 549,685)		
	UOR	AOR	VIF	UOR	AOR	VIF	UOR	AOR	VIF	UOR	AOR	VIF	UOR	AOR	VIF	UOR	AOR	VIF	UOR	AOR	VIF
Maternal Age																					
Below 35 (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
35 or above	1.24*** (1.21-1.27)	1.25*** (1.22-1.28)	1.03	1.34** (1.07-1.61)	1.34** (1.08-1.61)	1.01	1.25*** (1.20-1.30)	1.27*** (1.22-1.32)	1.02	1.12 (0.98-1.26)	1.13* (0.99-1.27)	1.02	1.41*** (1.18-1.63)	1.40*** (1.17-1.62)	1.03	1.37*** (1.16-1.59)	1.38*** (1.16-1.60)	1.01	1.24*** (1.21-1.26)	1.25*** (1.22-1.27)	1.02
Occupation of Mother																					
Administrative positions & professionals (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clerks / service workers	1.02 (0.98-1.07)	1.01 (0.97-1.06)	2.04	1.35 (0.88-1.83)	1.35 (0.87-1.82)	2.37	1.11** (1.03-1.19)	1.10** (1.02-1.18)	2.62	1.02 (0.79-1.25)	1.04 (0.81-1.27)	2.04	1.02 (0.68-1.36)	1.02 (0.68-1.35)	1.90	1.55 (1.00-2.10)	1.56 (1.02-2.10)	1.70	1.06*** (1.02-1.09)	1.05*** (1.02-1.09)	2.16
Elementary workers / economically inactive	1.07*** (1.02-1.12)	1.06*** (1.02-1.11)	1.84	1.14 (0.72-1.57)	1.15 (0.72-1.57)	2.97	0.98 (0.90-1.06)	0.98 (0.90-1.06)	3.04	0.94 (0.75-1.14)	0.96 (0.76-1.15)	2.37	0.95 (0.68-1.22)	0.93 (0.66-1.20)	1.57	1.13 (0.87-1.39)	1.13 (0.87-1.39)	1.15	0.99 (0.95-1.02)	0.99 (0.95-1.02)	2.25
Educational Attainment of Mother																					
Secondary or below	1.03 (0.99-1.07)	1.05** (1.01-1.10)	2.30	0.92 (0.55-1.30)	0.94 (0.57-1.31)	2.15	1.01 (0.94-1.09)	1.03 (0.96-1.10)	2.15	0.99 (0.80-1.19)	1.00 (0.81-1.19)	2.39	1.24 (0.91-1.58)	1.24 (0.90-1.57)	2.25	0.75 (0.22-1.28)	0.75 (0.22-1.28)	1.49	1.01 (0.97-1.04)	1.02 (0.99-1.06)	2.34
Tertiary (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Occupation of Father																					
Administrative positions & professionals (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Clerks / service workers	1.08*** (1.03-1.12)	1.06*** (1.02-1.11)	1.77	1.34 (0.97-1.72)	1.35 (0.97-1.72)	2.30	1.04 (0.97-1.11)	1.03 (0.96-1.10)	1.92	1.07 (0.88-1.27)	1.07 (0.88-1.26)	1.93	1.04 (0.72-1.37)	1.05 (0.72-1.39)	1.70	0.83 (0.25-1.42)	0.83 (0.24-1.42)	1.65	1.06*** (1.02-1.10)	1.05*** (1.01-1.09)	1.82
Elementary workers / economically inactive	1.08** (1.03-1.12)	1.06** (1.02-1.11)	1.68	1.52** (1.16-1.89)	1.52** (1.15-1.88)	2.70	1.10*** (1.03-1.17)	1.09** (1.02-1.16)	2.17	1.15 (0.96-1.34)	1.14 (0.95-1.33)	2.23	0.89 (0.49-1.30)	0.91 (0.50-1.31)	1.57	1.15 (0.57-1.74)	1.15 (0.52-1.78)	1.15	1.07*** (1.03-1.11)	1.06*** (1.02-1.10)	1.89
Educational Attainment of Father																					
Secondary or below	1.03 (0.98-1.07)	1.04* (0.99-1.08)	2.29	1.20 (0.80-1.59)	1.21 (0.82-1.60)	2.41	0.98 (0.91-1.05)	0.99 (0.92-1.06)	2.21	1.04 (0.83-1.26)	1.06 (0.86-1.27)	2.76	0.78 (0.41-1.14)	0.77 (0.40-1.13)	2.54	1.24 (0.73-1.75)	1.24 (0.72-1.76)	1.57	1.01 (0.98-1.05)	1.03 (0.99-1.06)	2.38
Tertiary (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Type of Housing of Mother																					

Public and aided housing	1.07*** (1.03-1.11)	1.07*** (1.03-1.10)	1.13	0.91 (0.68-1.15)	0.91 (0.68-1.15)	1.10	1.09*** (1.04-1.13)	1.09*** (1.04-1.13)	1.12	0.92 (0.77-1.08)	0.92 (0.77-1.07)	1.15	1.15 (0.85-1.45)	1.16 (0.86-1.46)	1.22	1.58 (0.99-2.17)	1.58 (0.97-2.19)	1.06	1.04*** (1.01-1.07)	1.04** (1.01-1.07)	1.15
Private housing (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Marital status of mother																					
Married (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Unmarried	1.34*** (1.28-1.40)	1.33*** (1.27-1.39)	1.07	0.75 (0.14-1.36)	0.76 (0.14-1.37)	1.01	1.22*** (1.14-1.30)	1.21*** (1.13-1.30)	1.01	1.20* (1.00-1.40)	1.20* (0.99-1.40)	1.04	1.59* (1.06-2.11)	1.59* (1.06-2.12)	1.03	1.06 (0.57-1.54)	1.05 (0.56-1.53)	1.02	1.31*** (1.27-1.36)	1.31*** (1.26-1.35)	1.03
Permanent residency of father																					
Yes (ref)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
No	0.94*** (0.89-0.98)	0.93*** (0.89-0.97)	1.00	1.28** (1.05-1.52)	1.28** (1.05-1.52)	1.05	0.81*** (0.76-0.85)	0.81*** (0.76-0.85)	1.02	1.19*** (1.06-1.32)	1.18** (1.05-1.31)	1.02	0.84 (0.61-1.07)	0.84 (0.61-1.06)	1.10	0.97 (0.72-1.23)	0.97 (0.71-1.22)	1.05	0.80*** (0.77-0.83)	0.80*** (0.77-0.83)	1.04

Note. [1] UOR = Unadjusted Odds Ratio. [2] AOR = Adjusted Odds Ratio (adjusted for sex of newborn and year of birth). [3] VIF = variance inflation factor (based on the adjusted models) [4] ref = reference group in the logistic regression. [5] $^{*}p<0.1$; $^{**}p<0.05$; $^{***}p<0.01$ [6] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories.

Table 5. Spatial autocorrelation (Global Moran's I) analysis of LBW rates of the study population by origin, 2006-2020.

Study Groups	Moran's I	Z-Score	P-value
HK	0.0035	0.18	0.86
MM	-0.00046	0.10	0.92
N-MM	0.11	2.97	0.0030***
EA	0.068	1.86	0.063*
S/SEA	0.07	1.93	0.053*
NA	-0.0074	-0.10	0.92

Note. [1] *p<0.1; **p<0.05; ***p<0.01 [2] "HK" = Native Hong Kong, "MM" = Mainland China (Maternity Migration), "N-MM" = Mainland China (Non-Maternity Migration), "EA" = East Asian High-Income Territories, "S/SEA" = South/Southeast Asian territories, "NA" = Non-Asian High-Income Territories.