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Revealing the variations in impact of economic segregation on preterm birth among disaggregated Asian ethnicities across MSAs in the United States: 2015–2017

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ABSTRACT

Background: Preterm birth (PTB) accounts for the majority of perinatal morbidity and mortality in developed nations, accounting for 9.9% of all births in the U.S. in 2016. Prior research has primarily focused on disparities between Black and white mothers' rates of PTB due to racial segregation. However, population health scholarship has been limited on the fastest growing population in the U.S., Asian and Pacific Islanders (API). Racial residential segregation has been well studied, but relatively little research examines the effects of economic segregation on perinatal health. This cross-sectional analysis examines how economic segregation modifies risk for PTB among various API ethnic groups.

Methods: U.S. natality data were used to identify 134 Metropolitan Statistical Areas (MSA) with >500 API births from 2015 to 2017 (n = 766,711). Economic segregation was calculated for each MSA using 2017 income data using the Rank-Order Information Theory Index (H Index). Generalized Estimating Equations estimated the log-odds of PTB, allowing for modification by ethnicity.

Results: There is heterogeneity in PTB prevalence by ethnicity and the association of economic segregation is non-linear. The risk for PTB is higher in MSAs with both high and low H Index for Chinese, Filipino, Japanese, Korean, Vietnamese, and Other Pacific Islander mothers. The risk for PTB follows highest in MSAs with mid-range values of standardized H Index for Indian, Hawaiian, Guamanian, and Samoan mothers. Filipino, Hawaiian, Guamanian, and Other Pacific Islander mothers had the highest predicted risk for PTB at mean levels of economic segregation while Chinese mothers had the lowest.

Conclusion: These findings are examined through the lens of immigration histories related to European colonialism, U.S. imperialism, and globalization. Importantly, the results suggest that current practices of aggregating API health data mask disparities in health and how socially stratifying processes like economic segregation may differ by ethnic group.

1. Introduction

Preterm birth (PTB) accounts for the majority of perinatal morbidity and mortality in developed nations (Goldenberg et al., 2008). PTB is defined as births delivered less than 37 completed weeks of gestation. In 2016, PTBs accounted for 9.9% of all births in the U.S. (Martin et al., 2018). PTB places infants at an increased risk of neurodevelopmental impairments as well as respiratory and gastrointestinal complications (Institute of Medicine, 2007).

Considering that nearly 1 in 10 births are preterm deliveries, representing about 400,000 PTBs in 2016, it is important to understand the potential causes and risk factors for PTB to prevent the mortality and morbidity outcomes that occur due to preterm deliveries (Martin et al., 2018). Risk factors identified include previous preterm delivery, cigarette smoking, gestational diabetes and preeclampsia, maternal age, and socioeconomic status (Cripe et al., 2012; Fuchs et al., 2018; Gibbs et al., 2012; Hedderson, 2003; Kyrklund-Blomberg & Cnattingius, 1998; Mercer et al., 1999; Smith et al., 2007; Thompson, 2002; Vang et al., 2015).

Risk for PTB also varies by race and ethnicity. These findings suggest that risk for PTB is affected by social influence and experience and is not biologically essential or fixed. We define race as an ideology and

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"classification system that emerged from, and in support of, European colonialism, oppression, and discrimination … [and] … does not have its roots in biological reality" (Ackermann et al., 2019). We define ethnicity as a shared cultural and social identity that can be constructed both by individuals in an ethnic group and by dominant groups. That being said, Light et al. note that "most immigrant minorities did not arrive in North America with an ethnic identity already coincident with their national origin" (Light et al., 1993). As such, an American framing of ethnicity as national origin is the general basis of what the U.S. Standard Certificate of Live Birth defines as ethnicity. Much research into disparities and PTB have focused on the large and persistent Black-white disparities, with small to non-existent Hispanic-non-Hispanic disparities. Surveillance data from NCHS have revealed that the rate of PTBs for non-Hispanic Black mothers is 1.5 times the rate of PTBs for non-Hispanic white mothers while the rate for Hispanic mothers is only 1.04 times the rate of PTBs for non-Hispanic white mothers in 2016 (Martin & Osterman, 2018).

Often 'Asians' are omitted altogether because they are not the focus, or because of small numbers; and when they are included (e.g. national NCHS surveillance summaries) they are typically reported as the aggregate racial category 'Asian and Pacific Islander' (API) (Holland & Palaniappan, 2012; Islam et al., 2011). In the aggregate this group is often reported to have similar or even better PTB outcomes compared to Non-Hispanic white (Martin et al., 2018). However, the API 'race' category masks substantial heterogeneity in culture, migration history, and socioeconomic experience. Asian ethnic groups showed variation in odds for PTB compared to non-Hispanic whites. Cambodian-, Laotian-, and Vietnamese-born women in Washington state all had higher odds for PTB compared to non-Hispanic white women and even higher odds compared to immigrant Japanese women (Cripe et al., 2012). These findings suggest that there is likely heterogeneity in PTB outcomes between Asian ethnic groups.

An important dimension of the health-relevant experiences of socially constructed race and ethnicity categories is nativity status. Foreign-born Cambodian and Laotian women have a higher risk for preterm deliveries compared to foreign-born Vietnamese or U.S.-born white women (Cripe et al., 2011). Additionally, the health of foreign-born racialized minorities may decrease as time living in the U.S. increases (Borrell et al., 2008; White & Borrell, 2011). Overall, these studies demonstrate the heterogeneity in health risk between API ethnic groups, though not enough research has examined plausible reasons why these disparities exist. Understanding APIs as a heterogeneous racial category is important to identify and explain disparities in adverse birth outcomes.

1.1. Structural racism and orientalism

Williams' model for studying racial differences in health, borrowing from Lieberson's idea of "basic causes", argues that "culture, biology, racism, economic structures, and political and legal factors are the fundamental causes of racial differences in health" (Lieberson, 1985; Williams, 1997). Using this approach, we can understand how differences in health outcomes vary by race and ethnicity through various, historically driven conditions. For example, immigration policy, a potential mechanism of structural racism, informs how immigrants are perceived by the dominant social group. Historical non-white exclusionary U.S. immigration policies and the rationales behind them served to justify segregation of Chinese people (Gee & Ford, 2011).

Immigration policy can also serve to elevate the status of minority groups. The growth in industries that required skilled labor in the U.S. beginning in the 1980s as well as the United States' position as a premier higher education system facilitated the migration and development of middle-to high-class skilled laborers primarily from Asia (Zhou, Ocampo, & Gatewood, 2016). At the same time, the elevation of APIs has been used at the expense of African-Americans while still maintaining a distinction of "otherness" from white people. The "model minority" stereotype of APIs served to delegitimize African-Americans' claims for equality of outcomes (Zhou, Ocampo, & Gatewood, 2016). While it is true that APIs as a whole have better socioeconomic and health outcomes compared to other minority groups in the U.S., this "model minority" myth erases the heterogeneity in these outcomes and immigration histories by conceptualizing APIs as a monolithic racial category (Zhou, Ocampo, & Gatewood, 2016). It is in these ways that structural racism, along with other basic causes, can produce health outcomes that further reinforce basic causes of variations in health.

If Williams' model provides a framework to understand the process by which structural forces influence health, Orientalism offers a perspective to understand how these forces came to be. Professor of literature, Edward Said, described Orientalism in his 1978 book *Orientalism* as "a set of constraints upon and limitations of thought" that relies on "the ineradicable distinction between Western superiority and Oriental inferiority" (Said, 1979, p. 42). Orientalism served to consolidate European "intellectual power" through claims of objective knowledge of the Other and used to justify colonialism (Said, 1979, p. 41). We argue that the processes and "basic causes" produced by Orientalism (racialization, colonialism, and later, imperialism) pattern the life chances women have and the geography of opportunity in which they live. Segregation is potentially an accelerator or amplifier of these processes.

1.2. Segregation

Researchers have become increasingly interested in mapping patterns of socio-spatial stratification and segregation onto population experiences of perinatal birth outcomes, hypothesizing that racialized residential segregation is a fundamental driver of the experienced geography of opportunity critical to women's health across the life course including pregnancy (Kramer & Hogue, 2009; Williams & Collins, 2001). Studies have generally found racial and ethnic segregation to be detrimental to perinatal birth outcomes for non-Hispanic Black people (Kramer et al., 2010; Mason et al., 2011; Mehra et al., 2019; Walton, 2009). Interestingly, parallel literature identifies ethnic density and resulting 'ethnic enclaves' to be protective against PTB in all racial groups studied except for non-Hispanic Black mothers (Mason et al., 2011). Another study also found variation in the association between low birth weight and racial residential segregation; racial residential segregation was protective for APIs, harmful for African-Americans, and had no effect for Latino-Americans (Walton, 2009). These two studies suggest that certain racial and ethnic minorities may prevent adverse health outcomes through this sorting by race and ethnicity to produce ethnic enclaves that enhance collective social capital and support.

Income inequality has grown throughout the twentieth century and into the twenty-first century in U.S. metropolitan areas and has contributed to a particular form of residential sorting – income segregation (Bischoff & Reardon, 2014, pp. 208–233; Jargowsky, 1996; Saez & Zucman, 2016). This term is used by Sean Reardon and Kendra Bischoff to describe the "uneven geographic distribution of income groups within a certain area" that may present itself either as the poorest households segregated from middle- and high-income households or as the most affluent households segregated from the middle- and low-income households (Reardon & Bischoff, 2011). This is distinct from income inequality, which is the uneven distribution of income among units (e.g., individuals, families, households). An important consequence of income segregation is that it may affect local political capital and resource distribution through processes of property taxation and political control. Indeed, income segregation can reduce educational attainment of low-income children while increasing the educational attainment of high-income children (Mayer, 2002). Income segregation is implicated in the inequality of other social outcomes as well as health outcomes and has disproportionately grown among African-American and Hispanic populations in the U.S. (Bischoff & Reardon, 2014, pp. 208–233; Cooper et al., 2001; Lobmayer, 2002; Waitzman & Smith, 1998).

This paper aims to address two gaps in the literature. First, we add to the nascent literature studying the impact of residential segregation by income, rather than by race and ethnicity. Many studies have focused on the effects of racial residential segregation alone (Kramer et al., 2010; Mason et al., 2011; Mehra et al., 2019; White & Borrell, 2011). Residential segregation has been characterized among other races and ethnicities in the U.S. but very few studies have examined the effects of economic residential segregation on birth outcomes (Maddali, 2016; Ncube et al., 2016). This presents a gap in the literature to be filled to understand economic segregation in America's largest cities.

Second, we disaggregate a rapidly growing but under-studied group, API, into categories representing heterogeneous experiences with respect to colonization, immigration, and racialization. Similar to studies on racial residential segregation, the effects of economic segregation on risk for PTB have primarily been documented between white and African-Americans. The authors were able to find only one study that evaluates the association between racial residential segregation and birth outcomes among APIs (Walton, 2009).

This present cross-sectional study reports risk of PTB among ten ethnic groups conventionally collapsed together as 'Asian & Pacific Islander' in public health reporting. Using 134 Metropolitan Statistical Areas (MSA) in the U.S. from 2015 to 2017, this analysis examines whether a plausible metric of structural racism and stratification, economic segregation, is related to PTB in each of these disaggregated groups. By disaggregating the API category and examining residential segregation by income, we seek to at least partially address these gaps in knowledge.

2. Material and methods

2.1. Population

Restricted-access data from all live births from 2015 to 2017 that include county identifiers were obtained from the Centers for Disease Control and Prevention's National Center for Health Statistics (NCHS). According to the CDC User Guide to the 2016 Natality Public Use File, natality data only include births occurring in the U.S., irrespective of U. S. residency (CDC, 2016). Births to U.S. citizens or residents occurring outside the U.S. are not counted. Coverage of the registry is more than 99 percent of all births in the U.S. Data were restricted to API mothers whose ethnic categories were defined by NCHS (Asian Indian, Chinese, Filipino, Japanese, Vietnamese, Other Asian, Hawaiian, Guamanian, Samoan, and Other Pacific Islander) and who resided in one of the 50 states. Gestational age is estimated by self-reported last menstrual period. PTB is defined in this analysis as infants born less than 37 weeks' gestation. The inclusion criterion for MSAs were those that had greater than 500 API births from 2015 to 2017, yielding 134 MSAs and a total of 766,711 births.

2.2. Measures

Category-based measures of economic segregation, such as the dissimilarity index and the Index of Concentration at the Extremes, are easy to interpret. However, thresholds used to categorize incomes for households considered poor or affluent may be different depending on the local context and standards of living (Reardon et al., 2006). Additionally, a low number of categories may remove information about the distribution of income in a given area or population. These disadvantages make category-based measures difficult to compare populations across time and place.

This analysis quantifies income segregation using Reardon's Rank-Order Information Theory Index or H Index (Reardon et al., 2006). An H Index of zero suggests complete spatial evenness of the income distribution and occurs when the income distribution for households in a local areal unit (e.g. Census tract) matches that of the entire region of interest (e.g. Metropolitan Statistical Area). Likewise, an H Index of one suggests complete residential economic segregation and occurs when each local area unit has complete homogeneity of income, but there is difference between local area units. The advantage of the H Index lies in the use of the rank-order distribution of counts of households across 16 ordinal income categories reported by the Census to calculate the measure. This allows one to compare H Indices across time and place, irrespective of monetary inflation or the actual incomes (Reardon et al., 2006; Reardon & Bischoff, 2011). The H10 and H90 indices are a variation on the overall H index. The H10 index measures segregation of poverty, or specifically the degree to which the lowest ten percent of incomes within an MSA are segregated from households in the rest of the income distribution (Reardon & Bischoff, 2011). Similarly, the H90 index measures segregation of affluence (Reardon & Bischoff, 2011). Tract-level income data were obtained from the 2017 American Community Survey using the R package *tidycensus* version 0.9.6 (Walker, 2020). These income data were only used to calculate the second-level measure (MSA-level H index). A Census reference delineation file for 2017 was used to define which counties, and therefore census tracts, were part of an MSA (United States Census Bureau, 2017). Tract-level household income data categorized into 16 groups were matched to MSAs and used to calculate summary MSA-level economic segregation indices using the R package *OasisR* version 3.0.1 (Tivadar, 2019).

Mother's county of residence, obtained from natality data, were used to link the segregation indices to individual-level measures for the analysis. based on county of residence and the corresponding MSA. Individual level covariates (previous preterm delivery, cigarette smoking, gestational diabetes and preeclampsia, maternal age, highest educational attainment, and nativity) were obtained from NCHS. The outcome, PTB, was coded as a dichotomous variable.

2.3. Analysis plan

All statistical analyses were conducted using R version 3.6.1 (R Core Team, 2019). Population average models were estimated using generalized estimating equations (GEE) using the R package *geepack* version 1.3.1 (Halekoh et al., 2006). GEE models were selected to account for dependence induced by the clustering of births within MSAs; an exchangeable correlation structure for the MSA was specified. Segregation indices were standardized to diminish multicollinearity and improve interpretability. Covariates were included to estimate the association of segregation with preterm birth net of between-MSA differences in the individual prevalence of strong predictors of PTB. Specifically previous preterm delivery, cigarette smoking, gestational diabetes and preeclampsia, maternal age, highest educational attainment, and nativity were included based on review of prior literature. *A priori* covariate sets were built as follows to determine the final model:

$$logit(\mu_{ij}) = \beta_1 + \beta_2 Segregation + \beta_3 Segregation^2 + \beta_4 Ethnicity + \beta_5 (SegregationxEthnicity) + \beta_6 (Segregation^2 xEthnicity)$$

$$logit(\mu_{ij}) = \beta_1 + \beta_2 Segregation + \beta_3 Segregation^2 + \beta_4 Ethnicity + \beta_5 (SegregationxEthnicity) + \beta_6 (Segregation^2 xEthnicity) + \beta_7 IndividualVars$$

$$logit(\mu_{ij}) = \beta_1 + \beta_2 Segregation + \beta_3 Segregation^2 + \beta_4 Ethnicity + \beta_5 (SegregationxEthnicity) + \beta_6 (Segregation^2 xEthnicity) + \beta_7 IndividualVars + \beta_8 SES_{Education}$$

We evaluated the shape of the relationship between economic segregation and PTB and determined that non-linear, specifically quadratic, patterns were most appropriate. Therefore, models were allowed to follow a quadratic relationship to incorporate this non-linearity. Since this analysis aims to evaluate effect modification by API ethnicity, these interaction terms were retained. Effect modification are visualized using the R package *effects* version 4.1.4 (Fox, 2003; Fox &

Weisberg, 2019). The project was reviewed and approved by the Emory University IRB.

3. Results

There were 766,711 births and 134 MSAs that met the study inclusion criteria. A list of 134 MSAs are found in Supplementary Table 1. MSAs ranged in the degree of spatial evenness of the income distribution (H Index) from 0.032 (Trenton, NJ) to 0.15 (Kahului-Wailuku-Lahaina, HI). The degree to which the lowest ten percent of incomes within an MSA are segregated from households in the rest of the income distribution (H10) ranged from 0.034 (Fayetteville, NC) to 0.23 (Champaign-Urbana, IL). The degree to which the highest ten percent of incomes within an MSA are segregated from households in the rest of the income distribution(H90) ranged from 0.041 (Kahului-Wailuku-Lahaina, HI) to 0.22 (Trenton, NJ). MSA characteristics by Census Region are found in Supplementary Table 2; H Index distributions across MSAs are found in Supplementary Figures 1-3.

3.1. Study population characteristics

Study population characteristic distributions are presented by quintiles of exposure (H, H10, H90) in Table 1, Supplementary Table 3, and Supplementary Table 4. The distribution of mothers living in MSAs with H quintile by education and ethnicity are displayed in Fig. 1, Supplementary Figure 4, and Supplementary Figure 5.

Asian Indian mothers predominantly reside in MSAs that are most segregated, regardless of education level. However this proportion does decrease as education level increases (Fig. 1). By comparison, a large proportion of Samoan mothers live in Q2 MSAs with this proportion decreasing as education level increases. Maternal education level varied substantially between ethnic groups. Asian Indian, Chinese, and Korean mothers were the most highly educated groups with 41.9%, 34.0%, and 31.7% of mothers having a graduate degree, respectively. The proportion of U.S.-born mothers also varied between ethnic groups. Hawaiian and Samoan mothers had the highest proportion of U.S.-born with 90.2% and 53.8%, respectively.

3.2. Modeling results

Adjusted odds ratios from the three final multivariable models are displayed by ethnicity in Table 2. To allow for non-linear relationships, odds ratios represent 1 standard deviation contrasts of economic segregation indices' Z-scores on PTB at different locations in the observed range of segregation: 1-unit increase among lower-than-average segregation MSAs ($Z = -1$ vs $Z = -2$), 1-unit increase among average segregation MSAs ($Z = 0$ vs $Z = -1$), and 1-unit increase higher-than-average levels ($Z = 1$ vs $Z = 0$). Three odds ratios for each ethnicity are calculated for each of the three models to demonstrate the non-linear effects of economic segregation.

There is a relatively linear positive association between economic segregation and PTB for Asian Indian and Other Asian mothers. For Chinese, Filipino, Vietnamese, Hawaiian, and Guamanian mothers, economic segregation exhibited stronger associations with PTB at lower- and higher-than-average levels, as compared to average levels of segregation. For example, the odds of PTB for Chinese mothers living in MSAs with low H (Z = −1) was 0.90 times that compared to those living in MSAs with extremely low H (Z = −2) (OR = 0.90, 95% CI: 0.80, 1.00). Similarly, the odds of PTB for Chinese mothers living in MSAs with high H (Z = 1) was 0.98 times that compared to those living in MSAs with average H (Z = 0) (OR = 1.08, 95% CI: 1.05, 1.11). By contrast, the odds of PTB for Chinese mothers living in MSAs with average H was 0.98 times that compared to those living in MSAs with low H (OR = 0.98, 95% CI: 0.93, 1.05). However, for Japanese, Korean, Samoan, and Other Pacific Islander mothers, economic segregation exhibited stronger effects at lower-than-average and average levels, compared to higher than

Table 1
Demographics & risk factors for asian mothers of live births in MSAs in the U.S., by ethnicity & economic segregation.

	Overall H Index				
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
Covariate by ethnicity	*Mean (SD) or n (%)*				
MSA (n = 134)					
Asian Indian					
Preterm	571 (10.2%)	2596 (8.8%)	2057 (9.4%)	3941 (9.1%)	12,261 (10.4%)
Maternal age, years	30.38 (4.50)	31.12 (4.10)	31.01 (4.34)	31.22 (4.26)	30.87 (4.52)
Mother's Nativity					
Born in the U. S.	610 (10.9%)	2394 (8.2%)	2127 (9.7%)	4712 (10.9%)	13,609 (11.6%)
Chinese					
Preterm	232 (7.9%)	1363 (6.9%)	1193 (7.7%)	4800 (6.4%)	5251 (8.1%)
Maternal age, years	32.11 (5.32)	32.59 (4.63)	32.29 (4.79)	32.53 (4.69)	31.65 (4.99)
Mother's Nativity					
Born in the U. S.	572 (19.4%)	2853 (14.5%)	2545 (16.5%)	9137 (12.2%)	9144 (14.2%)
Filipino					
Preterm	568 (13.2%)	2046 (12.3%)	1456 (11.6%)	3671 (12.1%)	3200 (13.1%)
Maternal age, years	30.63 (5.54)	31.20 (5.54)	31.54 (5.42)	32.17 (5.30)	32.32 (5.43)
Mother's Nativity					
Born in the U. S.	1165 (27.1%)	5177 (31.2%)	4219 (33.7%)	9660 (31.8%)	6322 (25.9%)
Japanese					
Preterm	72 (8.8%)	510 (10.3%)	184 (8.4%)	491 (8.2%)	523 (9.1%)
Maternal age, years	33.28 (5.12)	34.13 (4.77)	33.76 (5.09)	34.55 (4.82)	34.26 (4.88)
Mother's Nativity					
Born in the U. S.	314 (38.3%)	2117 (42.9%)	482 (21.9%)	1863 (31.0%)	886 (15.3%)
Korean					
Preterm	157 (11.0%)	404 (8.0%)	319 (8.4%)	1150 (7.6%)	1556 (8.5%)
Maternal age, years	32.45 (4.82)	33.21 (4.49)	32.90 (4.39)	33.53 (4.43)	33.34 (4.47)
Mother's Nativity					
Born in the U. S.	286 (20.5%)	1120 (22.3%)	767 (21.0%)	3711 (24.6%)	4289 (24.3%)
Vietnamese					
Preterm	292 (11.4%)	1041 (10.1%)	845 (10.7%)	1845 (9.4%)	2043 (11.1%)
Maternal age, years	31.14 (5.44)	31.86 (5.16)	31.52 (5.28)	32.11 (5.17)	31.59 (5.22)
Mother's Nativity					
Born in the U. S.	618 (24.1%/)	1860 (18.1%)	1863 (23.7%)	3974 (20.3%)	4042 (22.0%)
Other Asian					
Preterm	867 (11.0%)	1651 (11.2%)	2215 (11.2%)	4112 (11.0%)	5541 (11.0%)
Maternal age, years	28.94 (5.56)	30.26 (5.50)	29.55 (5.51)	30.13 (5.70)	29.95 (5.35)
Mother's Nativity					
Born in the U. S.	3095 (39.4%)	5325 (36.5%)	6958 (35.3%)	12,634 (33.9%)	9730 (19.4%)
Hawaiian					
Preterm	33 (10.7%)	101 (16.1%)	40 (13.7%)	98 (14.9%)	57 (10.6%)
Maternal age, years	27.84 (5.63)	28.84 (6.08)	27.94 (5.72)	28.37 (6.22)	28.39 (5.85)
Mother's Nativity					
Born in the U. S.	290 (94.8%)	551 (88.7%)	270 (93.4%)	589 (90.3%)	469 (87.3%)
Guamanian					
Preterm					

(*continued on next page*)

Table 1 (*continued*)

	Overall H Index				
	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile
	68 (14.4%)	89 (11.0%)	63 (13.9%)	109 (16.3%)	78 (11.5%)
Maternal age, years	27.05 (5.54)	27.78 (6.08)	28.59 (6.02)	27.93 (6.08)	27.86 (6.08)
Mother's Nativity					
Born in the U.S.	131 (28.5%)	213 (26.5%)	156 (34.7%)	228 (34.7%)	167 (25.1%)
Samoan					
Preterm	43 (11.9%)	387 (14.6%)	167 (14.1%)	189 (11.1%)	67 (14.8%)
Maternal age, years	27.06 (5.46)	27.26 (5.49)	27.74 (5.37)	28.16 (5.61)	28.33 (5.86)
Mother's Nativity					
Born in the U.S.	162 (46.8%)	1194 (45.3%)	702 (59.1%)	1103 (65.1%)	233 (52.5%)
Other Pacific Islander					
Preterm	334 (17.4%)	1137 (18.8%)	277 (13.0%)	551 (12.1%)	515 (13.1%)
Maternal age, years	27.63 (5.69)	27.55 (5.86)	28.66 (5.70)	29.66 (5.62)	29.20 (5.91)
Born in the U.S.	434 (22.8%)	1073 (17.9%)	636 (30.8%)	1621 (35.8%)	1075 (27.5%)

average levels.

Segregation of poverty (H10) is associated with stronger effects for Hawaiian mothers at lower- and higher-than-average levels, as compared to average levels. By contrast, segregation of poverty exhibited stronger effects at lower-than-average and average levels compared to higher-than-average levels for Asian Indian, Chinese, Japanese, Korean, Vietnamese, Other Asian, Guamanian, and Samoan mothers. However, for Filipino and Other Pacific Islander mothers, segregation of poverty is associated with stronger effects at higher-than-average and average levels, as compared to lower-than-average levels.

There is a relatively linear positive association between segregation of affluence (H90) and PTB for Other Asian mothers. For Filipino, Japanese, Korean, Vietnamese, Guamanian, and Other Pacific Islander mothers, segregation of affluence is associated with stronger effects at lower-than-average and average levels, as compared to higher-than-average levels. By contrast, for Chinese, Hawaiian, and Samoan mothers, segregation of affluence exhibited stronger effects at lower- and higher-than-average levels, as compared to average levels. Segregation of affluence was associated with stronger effects at average and higher-than-average levels, as compared to lower-than-average levels for Asian Indian mothers.

Model results are plotted to visualize predicted risk of PTB by standardized economic segregation indices and effect modification by ethnicity (Figs. 2–4). The risk for PTB follows a quadratic relationship as standardized H Index increases for Chinese, Filipino, Japanese, Korean, Vietnamese, and Other Pacific Islander mothers. The risk for PTB follows a negative quadratic relationship as standardized H Index increases for Indian, Hawaiian, Guamanian, and Samoan mothers. The relationship appears linear for Other Asian mothers. An important feature of the plots that ORs comparing within-group associations do not address (Table 2) is the disparities between ethnicities. The disparity in risk vary dramatically by ethnicity at the extremes of the standardized H Index while the disparity in risk vary by about 0.05 at the mean.

The risk for PTB follows a quadratic relationship as standardized H10 increases for Filipino and Guamanian mothers. The risk for PTB follows

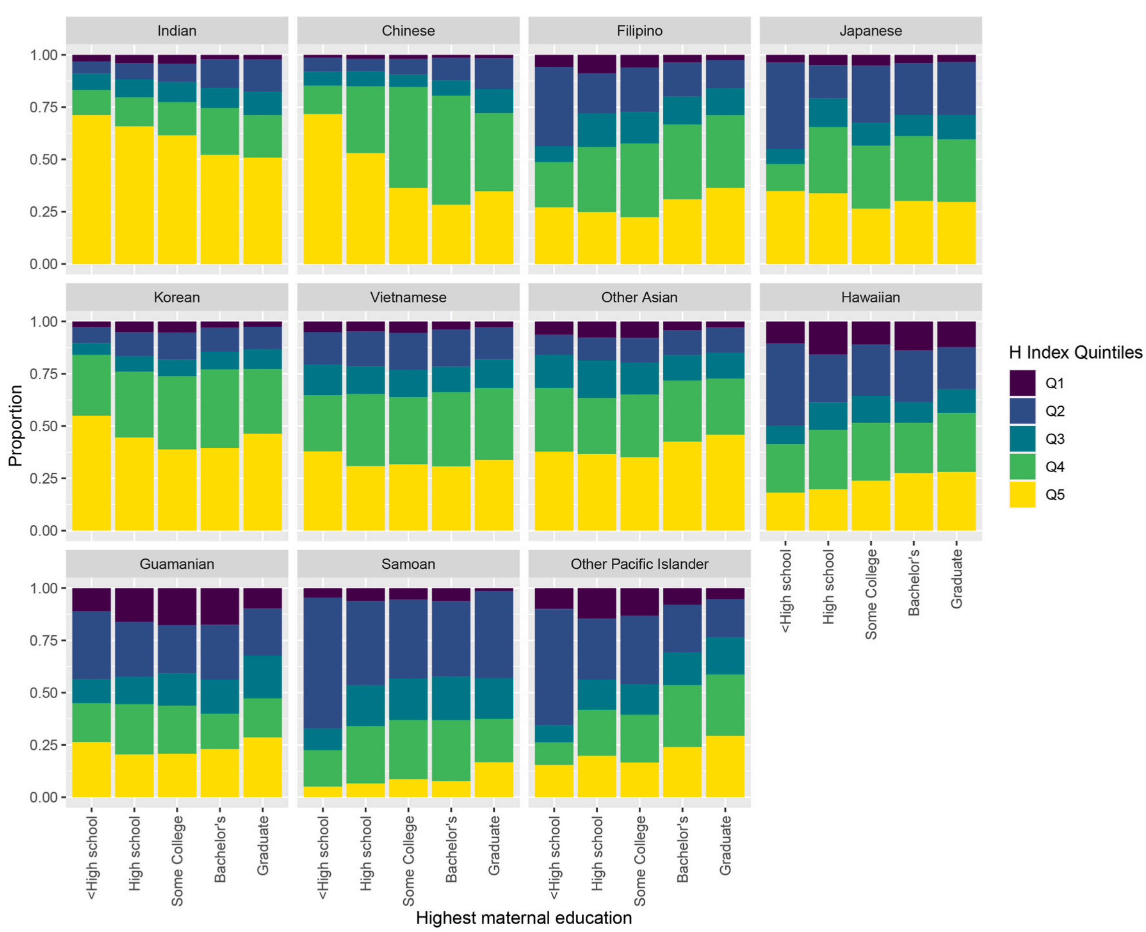

Fig. 1. Distribution of mothers living in MSAs with H quintile by education and ethnicity.

Table 2
Strengths of associations by ethnicity and standardized segregation index.

	$Z = -1$ vs. $Z = -2$	$Z = 0$ vs. $Z = -1$	$Z = 1$ vs. $Z = 0$	
	Odds Ratio (95% CI)			*H^2*Ethnicity p-value*
H Index				
Indian	1.08 (0.99-1.17)	1.06 (1.01-1.12)	1.05 (1.03-1.07)	*Reference*
Chinese	0.90 (0.80-1.00)	0.98 (0.93-1.05)	1.08 (1.05-1.11)	**0.001**
Filipino	0.92 (0.86-0.98)	0.98 (0.95-1.01)	1.04 (1.01-1.07)	**0.004**
Japanese	0.84 (0.72-0.99)	0.91 (0.84-1.00)	0.99 (0.92-1.06)	0.053
Korean	0.75 (0.65-0.87)	0.86 (0.79-0.94)	0.99 (0.95-1.04)	**<0.001**
Vietnamese	0.94 (0.83-1.06)	0.98 (0.92-1.05)	1.02 (0.99-1.06)	0.116
Other Asian	1.03 (0.96-1.09)	1.02 (0.99-1.06)	1.02 (1.00-1.05)	0.693
Hawaiian	1.26 (0.97-1.64)	1.02 (0.87-1.19)	0.82 (0.68-0.99)	**0.021**
Guamanian	1.08 (0.80-1.46)	1.02 (0.87-1.20)	0.96 (0.84-1.11)	0.622
Samoan	1.15 (0.84-1.59)	1.08 (0.92-1.27)	1.02 (0.86-1.21)	0.627
Other Pacific Islander	0.86 (0.79-0.94)	0.89 (0.85-0.94)	0.92 (0.86-0.98)	0.223
Segregation of **Poverty (H10)**				
Indian	1.09 (1.02-1.16)	1.06 (1.02-1.10)	1.03 (1.01-1.05)	*Reference*
Chinese	1.29 (1.19-1.41)	1.20 (1.14-1.26)	1.11 (1.08-1.15)	0.094
Filipino	1.00 (0.93-1.08)	1.04 (0.99-1.08)	1.07 (1.04-1.11)	**0.024**
Japanese	1.10 (0.88-1.38)	1.07 (0.95-1.20)	1.03 (0.95-1.12)	0.951
Korean	1.12 (0.99-1.27)	1.09 (1.01-1.17)	1.06 (1.01-1.11)	0.967
Vietnamese	1.17 (1.05-1.30)	1.12 (1.05-1.19)	1.07 (1.02-1.12)	0.602
Other Asian	1.08 (0.99-1.18)	1.05 (1.01-1.10)	1.02 (0.99-1.06)	0.994
Hawaiian	1.06 (0.61-1.84)	1.00 (0.80-1.25)	0.94 (0.67-1.33)	0.871
Guamanian	0.77 (0.56-1.05)	0.88 (0.73-1.04)	1.00 (0.82-1.20)	0.108
Samoan	1.31 (0.75-2.28)	1.27 (1.03-1.56)	1.23 (0.89-1.70)	0.988
Other Pacific Islander	1.06 (0.87-1.28)	0.93 (0.86-1.02)	0.82 (0.73-0.93)	0.17
Segregation of Affluence (H90)				
Indian	1.01 (0.92-1.11)	1.03 (0.98-1.09)	1.06 (1.04-1.08)	*Reference*
Chinese	0.87 (0.77-0.99)	0.95 (0.89-1.02)	1.04 (1.01-1.07)	0.082
Filipino	0.91 (0.85-0.97)	0.96 (0.93-0.99)	1.02 (0.99-1.05)	0.271
Japanese	0.75 (0.64-0.88)	0.85 (0.79-0.92)	0.96 (0.90-1.03)	0.058
Korean	0.74 (0.62-0.88)	0.84 (0.76-0.92)	0.95 (0.90-1.00)	**0.048**
Vietnamese	0.86 (0.75-0.99)	0.93 (0.86-1.00)	1.00 (0.97-1.04)	0.185
Other Asian	1.01 (0.94-1.08)	1.02 (0.98-1.05)	1.02 (1.00-1.05)	0.548
Hawaiian	1.32 (0.99-1.75)	1.05 (0.90-1.22)	0.83 (0.70-0.99)	**0.007**
Guamanian	1.12 (0.79-1.59)	1.06 (0.88-1.26)	1.00 (0.86-1.16)	0.444
Samoan	1.24 (0.89-1.73)	1.08 (0.93-1.26)	0.94 (0.81-1.09)	0.125
Other Pacific Islander	0.85 (0.77-0.94)	0.90 (0.86-0.95)	0.96 (0.90-1.02)	0.335

a negative quadratic relationship as standardized H10 increases for Indian, Chinese, Japanese, Korean, Vietnamese, Other Asian, Hawaiian, Samoan, and Other Pacific Islander mothers. The majority of ethnic groups have a predicted risk of around 0.10 at the mean. However, Chinese mothers notably have a predicted risk of approximately 0.075 and Other Pacific Islander mothers have a predicted risk of approximately 0.125 at the mean. Like in Fig. 2, the disparity in risk vary dramatically by ethnicity at the extremes of the standardized H10.

The risk for PTB follows a quadratic relationship as standardized H90 increases for Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, and Other Pacific Islander mothers. The risk for PTB follows a negative quadratic relationship for Hawaiian, Guamanian, and Samoan mothers. Other Asian mothers appear to have a positive linear relationship with the standardized H90. Indian, Filipino, Vietnamese, Other Asian, and Samoan mothers have a predicted risk of PTB of about 0.10 at the mean while Chinese, Japanese, and Korean mothers have a predicted risk of PTB approximately 0.075 at the mean. By contrast, Hawaiian, Guamanian, and Other Pacific Islander mothers have a predicted risk of approximately 0.125 at the mean. Like in Figs. 2 and 3, the disparity in risk vary dramatically by ethnicity at the extremes of the standardized H90.

4. Discussion

This analysis demonstrated that considerable heterogeneity in risk for PTB exists among ethnic subgroups conventionally aggregated as API in public health reporting. In addition, the relationship between a hypothesized structural determinant of population health (economic segregation) and the risk of PTB in these API ethnic subgroups is also heterogeneous, suggesting the risk or resilience related to spatial and social stratification may vary as a function of group-specific experiences and histories.

Table 2 and Figs. 2–4 clearly show that aggregation of Asian health data, as is the norm, could obfuscate differences in the risk profiles for PTB as economic segregation increases (Chin, 2017; Holland & Palaniappan, 2012; Islam et al., 2011; Paulose-Ram et al., 2017). Additionally, these data presented in Figs. 2–4 suggest that aggregation of Asian health data mask disparities by ethnicity. The issue of API health data aggregation was recently explored and suggests that aggregated data hides ethnic disparities and could lead to inaccurate interventions (Adia et al., 2020). Describing people from geographies as vast as Asia and imagining them as monolithic is not new. Said asserts that non-white persons are "*contained* and *represented* by dominating frameworks" through Orientalism (Said, 1979, p. 40). In other words, non-white individuals, populations, and cultures only exist through European epistemologies. The consequence of this is that Orientalism can essentialize the Other (i.e. Non-whites) as "almost everywhere nearly the same" (Said, 1979, p. 38). Race is socially constructed and often created by those in power. Thus, the present-day norm of aggregating Asian health data is grounded in colonial histories tied to racializing people as non-white. However, it should be noted that there are other mechanisms of racialization, such as the racialization of Muslims. Such a form of racialization may not necessarily distinguish between ethnic groups and races (Garner & Selod, 2015).

Asian Indian, Chinese, Japanese, Korean, Vietnamese mothers' risk for PTB were patterned together for all three indices of segregation (Figs. 2–4). Women who lived in places with average amounts of economic segregation or average amounts of segregation of affluence had the lowest risk of PTB, but that risk increased both for lower and for higher levels of segregation. Similarly, women who lived in places with average amounts of segregation of poverty had the highest risk for PTB, but that risk increased both for lower and for higher levels of segregation of poverty. These suggest that these ethnic groups may experience similar opportunity structures that define their risk profiles. This grouped patterning of risk profiles may be explained by globalization of the U.S. economy as well as international and domestic pressure for the

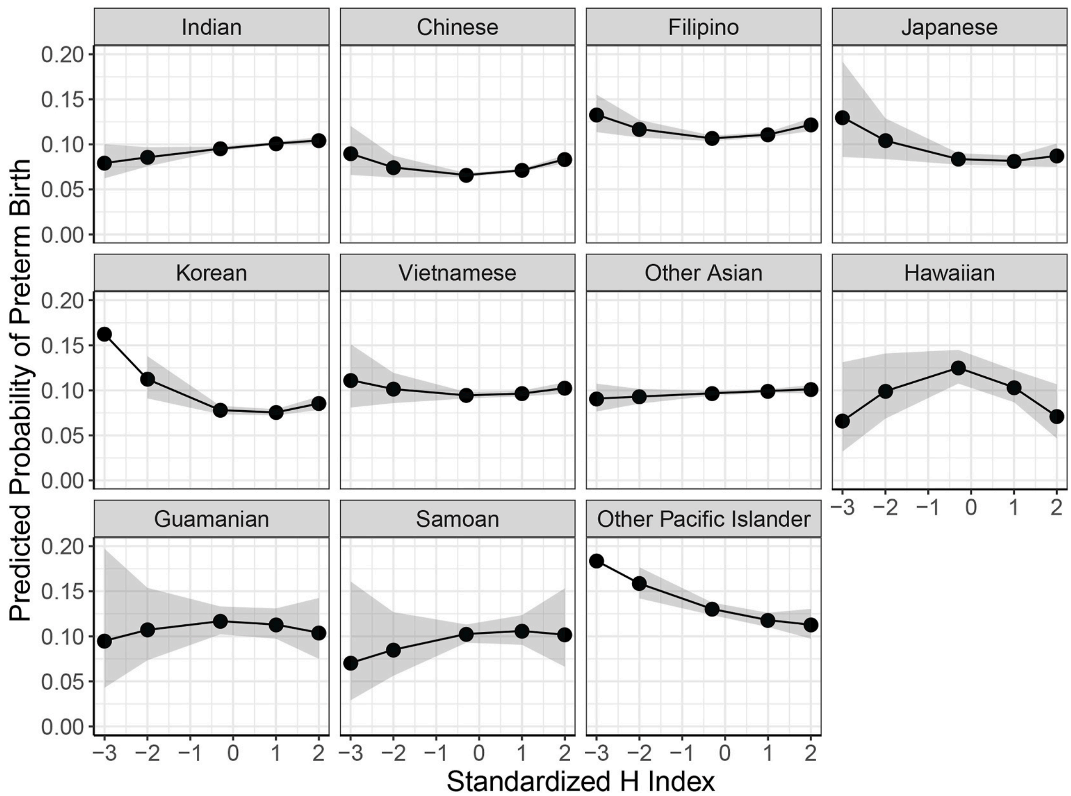

Fig. 2. Model-predicted association between standardized economic segregation and probability of preterm birth by Asian from 2015 to 2017 in 134 MSAs.

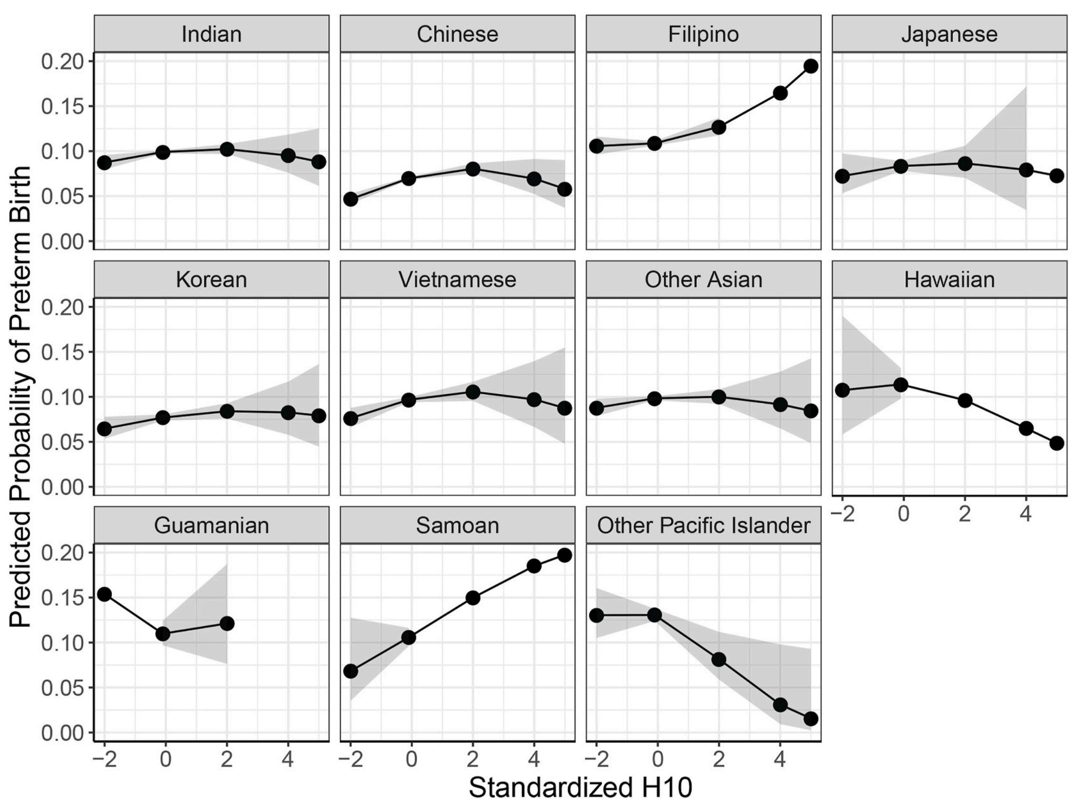

Fig. 3. Model-predicted association between standardized segregation of poverty and probability of preterm birth by Asian ethnicity from 2015 to 2017 in 134 MSAs.

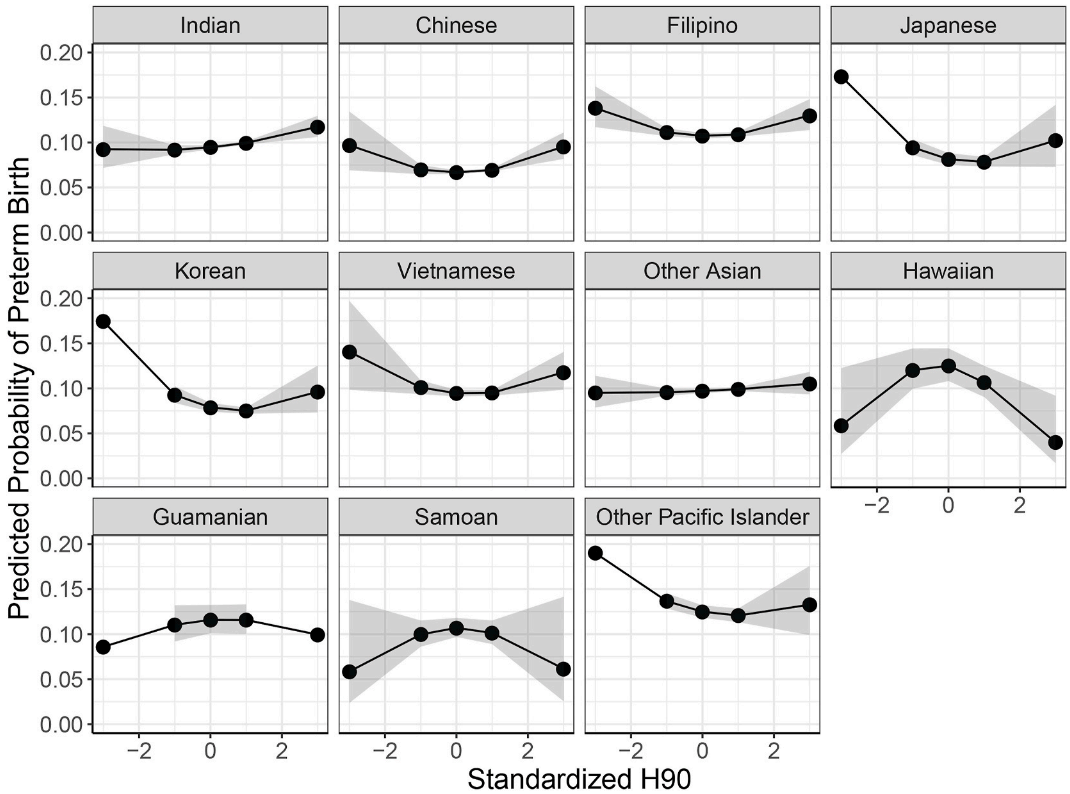

Fig. 4. Model-predicted association between standardized segregation of affluence and probability of preterm birth by Asian ethnicity from 2015 to 2017 in 134 MSAs.

U.S. Congress to abolish discriminatory immigration laws. The migration flows from various Asian countries observed in the 1970s to the 1980s have not solely been due to poverty or U.S. military intervention; the immigration patterns observed are also a result of U.S. foreign investment in export production and labor demand in the U.S. (Sassen, 1989). The Hart-Cellar Act of 1965 eliminated national origins quotas in order to reunite refugee families due to failed U.S. interventions in Southeast Asia and to meet labor market demands for skilled labor (Zhou, Ocampo, & Gatewood, 2016).

Skilled labor immigration is also due to the interaction between the opportunity structure in this group of immigrant's homelands and the globalization of higher education (Zhou, Ocampo, & Gatewood, 2016). This is evidenced by both the proportion of U.S.-born mothers and the distribution of educational attainment within this large group of mothers. Among Asian Indian mothers in the study population, 41.9% of them have a graduate degree and 10.8% were born in the U.S. Among Chinese mothers in the study population, 34.0% of them have a graduate degree and 13.7% were born in the U.S. Among Japanese mothers in the study population, 21.4% of them have a graduate degree and 28.7% were born in the U.S. Among Korean mothers in the study population, 31.7% of them have a graduate degree and 23.7% were born in the U.S. These statistics provide evidence to support the argument that Asian Indian, Chinese, Japanese, and Korean mothers immigrated to the U.S. due to globalization and U.S. demand for skilled labor. Among Vietnamese mothers in the study population, 14.3% of them have a graduate degree and 21.1% were born in the U.S. Vietnamese mothers stand out from the other ethnic groups analyzed because of their relatively lower educational attainment. This may be explained by the family-sponsored immigration that the Hart-Cellar Act of 1965 allowed. Overall, these forces might explain the similar patterning of these mothers' risk profiles. These forces may also explain why these ethnic groups do not have more than a 10% risk for PTB at an average level of economic segregation. Ethnic groups that are highly educated may be protected from the harmful effects of economic segregation.

Filipino mothers deviate from the other ethnic groups discussed in that they have a quadratic risk profile for all three indices. Only 10.4% of them have a graduate degree but they are still highly educated (42.6% hold a Bachelor's degree as their highest education); 30.1% of them were born in the U.S. This is consistent with the observation that "many Filipino immigrants to the United States are college graduates with transferable job skills" (Zhou, Ocampo, & Gatewood, 2016). Why Filipino mothers' risk profile is different from other ethnic groups that immigrated due to skilled labor demand in the U.S. is unclear.

The Hawaiian, Guamanian, Samoan mothers' risk for PTB had more complex patterns across the three indices. These ethnic groups are marked by histories of colonization and U.S. imperialism. These histories of colonization and continued U.S. imperialism may explain why these Pacific Islander groups have a higher risk for PTB at an average level of economic segregation than Asian ethnic groups. Among Hawaiian mothers in the study population, 4.8% of them have a graduate degree and 90.2% were born in the U.S. Among Guamanian mothers in the study population, 3.7% of them have a graduate degree and 29.5% were born in the U.S. Among Samoan mothers in the study population, 1.2% of them have a graduate degree and 53.8% were born in the U.S. Low educational attainment may explain why Guamanian and Samoan mothers are more affected by segregation of poverty than segregation of affluence.

The dynamics of colonialism and subsequent migration can produce varying patterns in women's experience and subsequent health outcomes. While the exact patterns may not be evident in other nation-state contexts, the nature of differences may be. This points to the importance of understanding historical patterns and drivers of migration and also the relevance of pregnancy outcomes as a 'model' for observing social determinants of health and health status in populations.

5. Conclusions

Socially stratifying processes like economic segregation affect population health in complex ways. The results demonstrate how this process may differ by API ethnic group. Recognizing the heterogeneity of the API population in the U.S., these findings were examined through the lens of immigration histories related to European colonialism, U.S. imperialism, and globalization to offer possible explanations for these differences. Importantly, the results suggest that current practices of aggregating API health data mask disparities in health, providing further evidence and support for efforts to disaggregate U.S. API data.

Limitations

This analysis did not have information on length of exposure to economic segregation; mothers with longer exposure to MSAs of high economic segregation may have a different risk for PTB compared to women who have been exposed for a shorter duration. Additionally, this analysis was not able to take into account individual-level income data. This data, in combination with educational attainment data, would provide more information on how populations are exposed to economic segregation. For example, relatively higher income populations living in an MSA with high segregation of affluence may have a different risk for PTB than another population with lower income. Individual-level income data could explain this difference more accurately than educational attainment data. Finally, the ethnic composition of Other Asian and Other Pacific Islander categories is unknown. As argued earlier, different ethnicities have histories that may shape their risk for PTB when exposed to economic segregation. Aggregating ethnic groups into Other Asian and Other Pacific Islander categories makes it difficult to understand why their risk for PTB are patterned as observed.

Ethical statement

I testify on behalf of all co-authors that our article submitted to SSM – Population Health has not been published in whole or in part elsewhere; the manuscript is not currently being considered for publication in another journal; all authors have been personally and actively involved in substantive work leading to the manuscript, and will hold themselves jointly and individually responsible for its content; all authors have no financial support or conflicts of interest to declare.

CRediT authorship contribution statement

Nathan S.N. Quan: Conceptualization, Methodology, Software, Validation, Formal analysis, Data curation, Writing – original draft, Writing – review & editing, Visualization. **Michael R. Kramer:** Supervision, Methodology, Software, Validation, Writing – review & editing, Resources.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ssmph.2021.100813.

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