# Socioeconomic Risk Factors for Extreme Preterm Birth in Hawai'i

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## Abstract

*Socioeconomic status and race/ethnicity are widely understood to be determinants of adverse birth outcomes, but studies have been limited by lack of income data in health records and aggregation of racial groups in reporting. This study aims to evaluate the relationship of socioeconomic status to extreme preterm birth outcomes in the diverse ethnic population of Hawai'i. Statistical analyses were conducted on Hawai'i birth records 2004-2013 linked to American Community Survey data by maternal residence. Community-level income demographics were stratified into wealth quintiles and stratum specific odds ratios were calculated for extreme preterm birth with analysis focused on the highest and lowest income-quintiles. The overall rates of extreme preterm birth were similar in high vs low-income communities, yet the individual risk factors were significantly different. In low-income communities, increased risk of extreme preterm birth was identified for women less than 20 years old and Black women, while in high-income communities, Native Hawaiian and Black women were at increased risk. Previous preterm birth, birth of a first child and cumulative maternal medical conditions were significant risk factors at all income levels. For Native Hawaiian women, the significant overall increased risk of extreme preterm birth persists in high-income communities but not in low-income communities, suggesting that increased risks previously attributed to Native Hawaiian race/ethnicity may be partially explained by low socioeconomic status.*

## Abbreviations

ACS = American Community Survey
EPTB = Extreme Preterm Birth
GA = Gestational Age
PCSA = Primary Care Service Area

## Introduction

Racial disparities in infant mortality persist in the United States, with non-Hispanic Blacks having a 3-fold increase and Native Hawaiians/Pacific Islanders having a rate 2.6 times that of Asian Americans, the racial group with the lowest rate.[1] Preterm birth is the most significant cause of infant mortality, with 65% of infant deaths in the United States in 2022 occurring among babies born preterm.[2] Among Native Hawaiians in Hawai'i from 2002-2009, 43.9% of excess infant mortality was attributed to preterm related causes.[3]

Income inequality has been identified as a significant factor in preterm birth and infant mortality disparities in the United States and around the world.[4-9] Significant income inequality exists in Hawai'i and has been steadily increasing since the mid-1950s.[10] Of ethnic groups in Hawai'i, Native Hawaiian families have the lowest median income, the largest average family size and per capita income of 69.2% of the statewide level.[11] Income inequality and low socioeconomic status have been proposed as contributing to a wide range of health disparities for Native Hawaiian families.[12-15] A 2022 study by the National Bureau of Economic Research examined parental income and race/ethnicity for births in California and found significant disparities in an aggregated subgroup of "Asian or Pacific Islander", but did not disaggregate race/ethnicity for Native Hawaiian or Asian American populations.[16] The diverse racial population of Hawai'i provides an opportunity to extend the analysis to include Asian Americans, Native Hawaiians, and other Pacific Islander populations, which continue to be underrepresented in national health data with rare subgroup disaggregation.[3,17] This study aims to provide additional insight into the relationship of socioeconomic status to preterm birth for disaggregated racial groups in Hawai'i.

The extent of prematurity is a critical factor when studying preterm birth, as those born at the extreme of viability are at the highest risk of demise.[2] Babies born at less than 28 weeks of gestation are categorized as "extremely preterm". Native Hawaiian women are 2.2 times more likely than White women to have babies born extremely low birthweight (<1000 g) and extremely preterm.[3] In addition to its causal role in infant mortality, a focus on extreme preterm birth is important because of the health complications and long-term disabilities associated with surviving preterm babies and the high societal and economic costs of preterm birth.[18] The excess cost associated with prematurity for the 2016 US birth cohort was estimated to be $25.2 billion, with over one-third of this cost attributable to the 7% of births which occur before 28 weeks of gestation.[19]

Researchers have used a variety of approaches to evaluate the effects of socioeconomic factors on health disparities.[6,7,13,20] In Hawai'i, the birth file is based on Vital Statistics birth records and does not contain maternal income demographics. This is a widespread shortcoming of birth records which has made it difficult to perform analysis of the effects of socioeconomic status on birth outcomes.[16] In this study, an ecological approach was taken to evaluate socioeconomic status, wherein the per capita income level of the community in which the mother resided at the time of the infant's birth was assigned to each birth record as a proxy for maternal income.[21] The authors assess the re-

lationships between community-level income and extreme preterm birth in conjunction with other factors that may be associated with increased risk of extreme preterm birth.

## Methods

State of Hawai'i Birth Records from 2004-2013 (N = 188 076) were obtained from the Hawai'i Department of Health and used to identify extreme preterm births based on gestational age greater than 16 weeks and less than 28 weeks. This gestational age was chosen to maximize capture of adverse birth outcomes, which may have resulted in either a live birth or a fetal death, where a birth certificate was issued. Analysis was limited to mothers who identified as Hawai'i residents at the time of the baby's birth and had a recorded gestational age greater than 16 weeks (600 records excluded). Data suppression was applied for demographics with n<10 according to National Center for Health Statistics guidelines. Demographic variables included in all models: age, race/ethnicity, education, marital status, previous preterm birth or first-time birth and a count of preexisting maternal medical conditions. The maternal medical conditions included on the birth record as checkbox items include anemia, cardiac disease, lung disease, diabetes, genital herpes, oligohydramnios, hemoglobinopathy, chronic hypertension, pregnancy-associated hypertension, eclampsia, incompetent cervix, previous fetal macrosomia, previous preterm infant, renal disease, Rh sensitization, uterine bleeding, and other. The Hawai'i Department of Health, Office of Health Status and Monitoring assigns all people that report more than one race on the birth certificate to a single race for reporting purposes. If more than one race/ethnicity is reported, the following rules apply: If Hawaiian is one of the multiple ethnicities listed, Part Hawaiian is coded; If any non-White ethnicity is listed in combination with White, the first non-White ethnicity is coded; If more than one non-White ethnicity is listed, the first one is coded.[22]

Community-level average per capita income data was taken from the American Community Survey (ACS) from 2006-2010. This ACS period was chosen as it approximates a midsection of the birth records period. Communities were defined using Primary Care Service Areas (PCSA) created by stakeholders in Hawai'i through the Primary Care Access Plan in the mid-1990s with modifications by the Hawai'i Department of Health to provide more detail in the 3 largest identified areas.[23] PCSA's were chosen for this analysis as they standardize availability and utilization of health care resources at the community level.[24] Mothers were assigned to one of Hawai'i 35 PCSAs based on resident census tract at the time of the infant's birth. There were 344 birth records (0.2%) with Hawai'i addresses that were not able to be linked and were excluded from the community-level analysis. ACS per capita income data was stratified into the wealthiest 20% (high-income), middle 60% and the poorest 20% (low-income), utilizing methodology from the 20:20 ratio of income inequality.[25] Analysis focused on the differences between the highest-income and lowest-income communities.

The research protocol was submitted to and approved by the University of Hawai'i Office of Research Compliance Human Studies Program as an exempt study, protocol number CHS#23517.

All analysis was conducted in SAS version 9.2 (SAS Institute, Cary, North Carolina). The study population was summarized using descriptive statistics. Chi-square tests were used to calculate *P* values. Potential confounding variables were included in the models. Multiple logistic regression models were created to explore associations between community-level income and extreme preterm birth outcomes. Adjusted odds ratios (AOR) and 95% confidence intervals (CI) were obtained using these models. Statistical significance was set at $P < .05$.

## Results

Maternal demographics of all births and extreme preterm births are presented in **Table 1**. Variables found to be significant by *P*-value include maternal age, race/ethnicity, marital status, previous preterm birth, and cumulative maternal medical conditions. Demographics with increased distribution of extreme preterm birth compared to all birth included women less than 20 years old (+5.4%), greater than 35 years old (+1.5%), Native Hawaiians (+7.4%), Blacks (+5.9%), less than high school education (+2.0%), not married (+7.6%), previous preterm birth (+2.3%), first child (+7.7%), and those with one or more maternal medical condition. Native Hawaiians accounted for 27.4% of all births, had the highest distribution of extreme preterm birth at 34.8%, with an extreme preterm birth rate of 0.81 per 100 live births. Black women accounted for 2.6% of all births, had 8.5% of the extreme preterm births, with the highest extreme birth rate of all race/ethnicities at 2.06 per 100 live births.

Population, income, and birth demographics of the high and low-income communities are presented in **Table 2**. The total population of the high-income communities is 1.60 times that of the low-income communities, yet the total number of births is remarkably similar (37 945 vs 37 651 births) due to a higher crude birth rate in the low-income communities (17.8 vs 11.2 births per 1000 persons per year). The extreme preterm birth rate in the high-income area is 0.60 while the low-income area rate is similar at 0.67 per 100 live births. The income-inequality ratio of per capita income in the highest income community (Hawai'i Kai-Kaimuki, $46,800) to the lowest income community (Waianae, $17,300) is 2.70.

The maternal demographics of extreme preterm birth by community-level income stratification is presented in **Table 3**. In high-income communities, the distribution of extreme preterm birth increases in a stepwise fashion with increasing age with women 35 years or older accounting for 3.7 times more of the extreme preterm birth than women less than 20 years. In low-income communities, the distribution of extreme preterm birth is skewed towards younger women, with women less than 20 years accounting for 2.0 times more of the extreme preterm birth than women 35 years or older.

Table 1. Maternal Demographics of Births and Extreme Preterm Births in Hawai'i (2004-2013)

| | All Births | | EPTB | | | |
|---|---|---|---|---|---|---|
| **Characteristic (bivariate *P*-value)** | **No.** | **(%)** | **No.** | **(%)** | **EPTB Rate[a]** | **Variance EPTB vs Birth (%)** |
| Total Births Included in Analysis | 187476 | | 1195 | | 0.64 | |
| Age, years (*P*<.001) | | | | | | |
| <20 | 14019 | *(7.5)* | 154 | *(12.9)* | 1.10 | *5.4* |
| 20-24 | 44400 | *(23.7)* | 261 | *(21.8)* | 0.59 | *(1.9)* |
| 25-29 | 51198 | *(27.3)* | 293 | *(24.5)* | 0.57 | *(2.8)* |
| 30-34 | 44952 | *(24.0)* | 259 | *(21.7)* | 0.58 | *(2.3)* |
| >=35 | 32907 | *(17.6)* | 228 | *(19.1)* | 0.69 | *1.5* |
| Race/Ethnicity (*P*<.001) | | | | | | |
| Native Hawaiian | 51437 | *(27.4)* | 416 | *(34.8)* | 0.81 | *7.4* |
| White | 41382 | *(22.1)* | 162 | *(13.6)* | 0.39 | *(8.5)* |
| Filipino | 33643 | *(17.9)* | 211 | *(17.7)* | 0.63 | *(0.2)* |
| Japanese | 19095 | *(10.2)* | 96 | *(8.0)* | 0.50 | *(2.2)* |
| Other Pacific Islanders | 17205 | *(9.2)* | 89 | *(7.4)* | 0.52 | *(1.8)* |
| Other Asian | 13981 | *(7.5)* | 77 | *(6.4)* | 0.55 | *(1.1)* |
| All Others | 5645 | *(3.0)* | 27 | *(2.3)* | 0.48 | *(0.7)* |
| Blacks | 4897 | *(2.6)* | 101 | *(8.5)* | 2.06 | *5.9* |
| *Race Unknown* | 191 | *(0.1)* | 16 | *(1.3)* | 8.38 | *1.2* |
| Education (*P*=.149) | | | | | | |
| High School or Less | 86162 | *(46.0)* | 574 | *(48.0)* | 0.67 | *2.0* |
| Some College or More | 101314 | *(54.0)* | 621 | *(52.0)* | 0.61 | *(2.0)* |
| Marital Status (*P*<.001) | | | | | | |
| Married | 117995 | *(62.9)* | 661 | *(55.3)* | 0.56 | *(7.6)* |
| Not Married | 69481 | *(37.1)* | 534 | *(44.7)* | 0.77 | *7.6* |
| Previous Preterm Birth (*P*<.001) | | | | | | |
| Yes | 1048 | *(0.6)* | 35 | *(2.9)* | 3.34 | *2.3* |
| No | 110708 | *(59.1)* | 585 | *(49.0)* | 0.53 | *(10.1)* |
| First child | 75720 | *(40.4)* | 575 | *(48.1)* | 0.76 | *7.7* |
| Maternal Medical Conditions (*P*<.001) | | | | | | |
| 0 Medical conditions | 127252 | *(67.9)* | 565 | *(47.3)* | 0.44 | *(20.6)* |
| 1 Medical conditions | 46612 | *(24.9)* | 423 | *(35.4)* | 0.91 | *10.5* |
| 2 Medical conditions | 10853 | *(5.8)* | 151 | *(12.6)* | 1.39 | *6.8* |
| 3 Medical conditions | 2272 | *(1.2)* | 38 | *(3.2)* | 1.67 | *2.0* |
| 4+ Medical conditions | 487 | *(0.3)* | 18 | *(1.5)* | 3.70 | *1.2* |
| Primary Care Service Areas (*P*=.52) | | | | | | |
| Highest 20% income stratum | 37945 | *(20.2)* | 228 | *(19.1)* | 0.60 | *(1.1)* |
| Middle 60% income stratum | 111536 | *(59.5)* | 712 | *(59.6)* | 0.64 | *0.1* |
| Bottom 20% income stratum | 37651 | *(20.1)* | 251 | *(21.0)* | 0.67 | *0.9* |
| *Address Unknown or not linked* | 344 | *(0.2)* | *nr* | | | |

Abbreviations: EPTB=Extreme Preterm Birth (gestational age < 28 weeks)
[a]EPTB Rate=(No. EPTB / No. Total Births) * 100

The distribution of extreme preterm birth by race/ethnicity (**Table 3**) identifies that 44.6% of extreme preterm birth in low-income communities (112 cases) and 32.0% of extreme preterm birth in high-income communities (73 cases) during the period were to Native Hawaiian mothers. In low-income communities, the distribution of extreme preterm birth for Native Hawaiians is 3.0 times that of the next closest racial group (44.6% in Native Hawaiians versus 14.7% in Whites). In high-income communities, there are 2.3 times more cases of extreme preterm birth among Native Hawaiians than in the next closest racial group (32.0% in Native Hawaiians vs. 14.0% in Japanese). The extreme preterm birth rate for Native Hawaiians is similar in high-income (0.87) and low-income (0.84) communities.

Results of the multivariate regression analyses for all extreme preterm birth and high and low-income communities are presented in **Table 4**. In the unstratified model for all extreme preterm birth, significant risk factors include age

Table 2. Population, Income and Birth Demographics of Hawai'i Communities by Primary Care Service Areas

| **Primary Care Service Area** | Per capita Income | Total Population | No. of Births | Crude Annual Birth Rate[a] | No. of EPTB | EPTB Rate[b] |
|---|---|---|---|---|---|---|
| Hawai'i Kai-Kaimuki, O'ahu | $ 46,800 | 71026 | 5773 | 8.1 | 32 | 0.55 |
| South Kohala, Hawai'i | $ 36,400 | 17752 | 2533 | 14.3 | 20 | 0.79 |
| McCully-Makiki, O'ahu | $ 35,100 | 59080 | 5227 | 8.8 | 34 | 0.65 |
| Lāhainā, Maui | $ 34,100 | 20497 | 3014 | 14.7 | 12 | 0.40 |
| Makawao, Maui | $ 34,000 | 42416 | 4744 | 11.2 | 23 | 0.48 |
| 'Ewa-Kalaeloa, O'ahu | $ 33,400 | 56026 | 9175 | 16.4 | 70 | 0.76 |
| Ala Moana-Nu'uanu, O'ahu | $ 32,700 | 71114 | 7583 | 10.7 | 37 | 0.49 |
| *Highest: excluded due to missing data* | | | *-104* | | | |
| **Highest 20% Income Stratum** | **$ 36,071** | **337911** | **37945** | **11.2** | **228** | **0.60** |
| **Middle 60% Income Stratum** | **$ 26,995** | **811055** | **111536** | **13.8** | **712** | **0.64** |
| Hāna, Maui | $ 23,200 | 02351 | 309 | 13.1 | *nr* | |
| Ko'olauloa, O'ahu | $ 22,800 | 19634 | 3871 | 19.7 | 19 | 0.49 |
| Downtown-Kalihi, O'ahu | $ 22,500 | 66102 | 8945 | 13.5 | 54 | 0.60 |
| Lāna'i | $ 21,200 | 03335 | 405 | 12.1 | *nr* | |
| Wahiawā, O'ahu | $ 20,800 | 36724 | 9140 | 24.9 | 64 | 0.70 |
| Puna, Hawai'i | $ 19,300 | 36707 | 5690 | 15.5 | 26 | 0.46 |
| Wai'anae, O'ahu | $ 17,300 | 46482 | 9441 | 20.3 | 84 | 0.89 |
| *Lowest: excluded due to missing data* | | | *-150* | | | |
| **Lowest 20% Income Stratum** | **$ 21,014** | **211335** | **37651** | **17.8** | **251** | **0.67** |

Data from: American Community Survey 2006-2010 and State of Hawaii Birth Records 2004-2013
Communities ordered and stratified by per capita income level, from highest to lowest.
Abbreviations: EPTB=Extreme Preterm Birth (gestational age < 28 weeks)
Data suppression: Per National Center for Health Statistics guidelines, grouping with n<10 are suppressed (*nr*)
[a]Crude annual birth rate: Births per 1000 persons per year
[b]EPTB Rate=(No. EPTB / No. Total Births) * 100

less than 20, Native Hawaiian, Filipino, Black, not-married, previous preterm birth, birth of a first child and cumulative maternal medical conditions for which risk increases in a step-wise fashion with increasing number of conditions. When the model is stratified by income levels, the significance of many of these factors is reduced or eliminated. In low-income communities, women less than 20 years old (AOR 1.62, 95% CI 1.04-2.53) and Black women (AOR 2.39, 95% CI 1.30-4.38) have increased risk of extreme preterm birth. In high-income communities, Native Hawaiian (AOR 2.18, 95% CI 1.37-3.45) and Black women (AOR 4.36, 95% CI 2.09-9.07) are at increased risk of extreme preterm birth while no age groupings are at increased risk. Maternal medical conditions, previous preterm birth, and birth of a first child were significant risk factor at all income levels.

## Discussion

In this analysis, community-level income stratification of the Hawai'i birth records enables the identification of socioeconomic population trends associated with risk of extreme preterm birth and allows critical consideration of the role of socioeconomic status. When extreme preterm birth is stratified by community-level income, the demographic patterns and risks differ between high and low-income communities.

In low-income communities, the significance of race/ethnicity as a risk factor is eliminated (for Native Hawaiian and Filipinos) or reduced (for Blacks) in multivariate analysis, suggesting that risks associated with race/ethnicity are better explained by low socioeconomic status.[26] Socioeconomic disadvantage has been widely shown to be associated with adverse birth outcomes.[27] Factors such as access to safe food, housing, education and medical care and stressors related to housing insecurity, domestic violence, low-literacy and unemployment may contribute to adverse birth outcomes.[28] Issues with affordability, access to and utilization of health care may be barriers to low-income mothers seeking preventative and prenatal health care services.[29]

In low-income communities in Hawai'i, women less than 20 years old are at increased risk for extreme preterm birth, while this pattern is not observed in high-income communities. Adolescent pregnancy in low and middle-income countries has been previously found to be associated with increased risks of adverse birth outcomes.[30] Factors associated with poverty that are believed to contribute to adolescent pregnancy include low-quality education, a negative perception of the future, limited employment opportunities, and feelings of helplessness and alienation.[31]

Table 3. Maternal Demographics of Births and Extreme Preterm Birth in Hawai'i (2004-2013) in High and Low-Income Community Stratuma

| | High-Income Stratum No of births (%) | | | | | Low-Income Stratum No of births (%) | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Characteristic (bivariate *P*-value)** | All | | EPTB | | EPTB Rate[b] | All | | EPTB | | EPTB Rate[b] |
| **Age, years** | *P*=.026 | | | | | *P*<.001 | | | | |
| <20 | 2001 | *(5.3)* | 19 | *(8.3)* | 0.95 | 3852 | *(10.2)* | 49 | *(19.5)* | 1.27 |
| 20-24 | 6575 | *(17.3)* | 33 | *(14.5)* | 0.50 | 11406 | *(30.1)* | 66 | *(26.3)* | 0.58 |
| 25-29 | 9638 | *(25.4)* | 51 | *(22.4)* | 0.53 | 10686 | *(28.2)* | 68 | *(27.1)* | 0.64 |
| 30-34 | 10696 | *(28.2)* | 56 | *(24.6)* | 0.52 | 7223 | *(19.0)* | 43 | *(17.1)* | 0.60 |
| >=35 | 9035 | *(23.8)* | 69 | *(30.3)* | 0.76 | 4484 | *(11.8)* | 25 | *(10.0)* | 0.56 |
| **Race/Ethnicity** | *P*<.001 | | | | | *P*=.006 | | | | |
| Native Hawaiian | 8422 | *(22.2)* | 73 | *(32.0)* | 0.87 | 13278 | *(35.0)* | 112 | *(44.6)* | 0.84 |
| White | 8030 | *(21.2)* | 28 | *(12.3)* | 0.35 | 6971 | *(18.4)* | 37 | *(14.7)* | 0.53 |
| Filipino | 5843 | *(15.4)* | 31 | *(13.6)* | 0.53 | 6131 | *(16.2)* | 34 | *(13.5)* | 0.55 |
| Japanese | 5709 | *(15.0)* | 32 | *(14.0)* | 0.56 | 1523 | *(4.0)* | *nr* | | |
| Other Pacific Islanders | 3148 | *(8.3)* | 15 | *(6.6)* | 0.48 | 5202 | *(13.7)* | 26 | *(10.4)* | 0.50 |
| Other Asian | 4945 | *(13.0)* | 24 | *(10.5)* | 0.49 | 2171 | *(5.7)* | 12 | *(4.8)* | 0.55 |
| All Others | 1202 | *(3.2)* | *nr* | | | 1110 | *(2.9)* | *nr* | | |
| Blacks | 615 | *(1.6)* | 10 | *(4.4)* | 1.63 | 1215 | *(3.2)* | 15 | *(6.0)* | 1.23 |
| *Race Unknown* | *31* | *(0.1)* | *nr* | | | *50* | *(0.1)* | *nr* | | |
| **Education** | *P*=.161 | | | | | *P*=.771 | | | | |
| High School or Less | 14440 | *(38.1)* | 97 | *(42.5)* | 0.67 | 21409 | *(56.4)* | 145 | *(57.8)* | 0.68 |
| Some College or More | 23505 | *(61.9)* | 131 | *(57.5)* | 0.56 | 16242 | *(42.8)* | 106 | *(42.2)* | 0.65 |
| **Marital Status** | *P*=.111 | | | | | *P*=.101 | | | | |
| Married | 25505 | *(67.2)* | 142 | *(62.3)* | 0.56 | 20835 | *(54.9)* | 126 | *(50.2)* | 0.60 |
| Not Married | 12440 | *(32.8)* | 86 | *(37.7)* | 0.69 | 16816 | *(44.3)* | 125 | *(49.8)* | 0.74 |
| **Previous Preterm Birth** | *P*<.001 | | | | | *P*<.001 | | | | |
| Yes | 158 | *(0.4)* | *nr* | | | 269 | *(0.7)* | *nr* | | |
| No | 21086 | *(55.6)* | 111 | *(48.7)* | 0.53 | 23939 | *(63.1)* | 126 | *(50.2)* | 0.53 |
| First Child | 16701 | *(44.0)* | 109 | *(47.8)* | 0.65 | 13443 | *(35.4)* | 119 | *(47.4)* | 0.89 |
| **Maternal Medical** | *P*<.001 | | | | | *P*<.001 | | | | |
| 0 Medical conditions | 25987 | *(68.5)* | 91 | *(39.9)* | 0.35 | 24078 | *(63.5)* | 122 | *(48.6)* | 0.51 |
| 1 Medical conditions | 9332 | *(24.6)* | 95 | *(41.7)* | 1.02 | 10080 | *(26.6)* | 86 | *(34.3)* | 0.85 |
| 2 Medical conditions | 2120 | *(5.6)* | 29 | *(12.7)* | 1.37 | 2726 | *(7.2)* | 36 | *(14.3)* | 1.32 |
| 3 Medical conditions | 423 | *(1.1)* | *nr* | | | 610 | *(1.6)* | *nr* | | |
| 4+ Medical conditions | 83 | *(0.2)* | *nr* | | | 157 | *(0.4)* | *nr* | | |
| **Total** | **37945** | | **228** | | **0.60** | **37651** | | **244** | | **0.65** |

Abbreviations: EPTB=Extreme Preterm Birth (gestational age < 28 weeks)
Data suppression: Per National Center for Health Statistics guidelines, grouping with n<10 are suppressed (*nr*)
[a]High and Low-income stratum = Top and bottom quintile per capita income levels
[b]EPTB Rate=(# EPTB / # Total Births) * 100

Native Hawaiian mothers have a higher percent distribution of extreme preterm birth compared to all births across community-income stratifications. Native Hawaiians also have the lowest median and per capita income of ethnic groups in Hawai'i.[11] This relationship between extreme preterm birth and socioeconomic status is consistent with study findings that the highest rates of preterm birth in California in 2022 occurred in American Indian or Alaska Native, Black, or Native Hawaiian/Pacific Islander individuals with public health insurance.[32]

In community-level income stratification, this study finds that Native Hawaiians are at increased risk of preterm birth in high-income communities. While the specific factors that may increase and mitigate risk for Native Hawaiians in high-income communities are beyond the scope of this study, this finding merits further consideration in

Table 4. Risk factors for Extreme Preterm Birth in Hawai'i (2004-2013): Adjusted Odds Ratios for All, High-Income and Low-Income Community Stratum[a].

| | All EPTB | | High-Income Stratum | | Low-Income Stratum | |
|---|---|---|---|---|---|---|
| **Characteristic** | AOR | 95% CI | AOR | 95% CI | AOR | 95% CI |
| **Age, years** | | | | | | |
| <20 | **1.41** | **(1.13-1.77)** | 1.25 | (0.70-2.26) | **1.62** | **(1.04-2.53)** |
| 20-24 | 0.92 | (0.77-1.09) | 0.85 | (0.54-1.34) | 0.83 | (0.58-1.19) |
| 25-29 | ref | | ref | | ref | |
| 30-34 | 1.04 | (0.88-1.23) | 1.08 | (0.73-1.60) | 0.93 | (0.63-1.37) |
| >=35 | 1.17 | (0.98-1.41) | 1.33 | (0.90-1.98) | 0.86 | (0.54-1.38) |
| **Race/Ethnicity** | | | | | | |
| Native Hawaiian | **1.72** | **(1.41-2.09)** | **2.18** | **(1.37-3.45)** | 1.42 | (0.95-2.13) |
| White | ref | | ref | | ref | |
| Filipino | **1.39** | **(1.12-1.71)** | 1.38 | (0.82-2.32) | 0.95 | (0.59-1.54) |
| Japanese | 1.14 | (0.88-1.47) | 1.46 | (0.87-2.43) | 0.69 | (0.29-1.66) |
| Other Pacific Islanders | 1.18 | (0.90-1.54) | 1.26 | (0.66-2.40) | 0.91 | (0.54-1.52) |
| Other Asian | 1.28 | (0.97-1.68) | 1.28 | (0.74-2.22) | 0.98 | (0.51-1.89) |
| All Others | 1.13 | (0.75-1.71) | 1.99 | (0.93-4.26) | 1.29 | (0.60-2.80) |
| Blacks | **5.20** | **(4.04-6.70)** | **4.36** | **(2.09-9.07)** | **2.39** | **(1.30-4.38)** |
| **Education** | | | | | | |
| High School or Less | 0.97 | (0.85-1.11) | 1.19 | (0.87-1.63) | 0.88 | (0.66-1.17) |
| Some College or More | ref | | ref | | ref | |
| **Marital Status** | | | | | | |
| Married | ref | | ref | | ref | |
| Not Married | **1.16** | **(1.01-1.33)** | 1.05 | (0.76-1.46) | 0.93 | (0.69-1.25) |
| **Previous Preterm Birth** | | | | | | |
| Yes | **5.06** | **(3.56-7.21)** | **6.73** | **(3.12-14.48)** | **3.62** | **(1.56-8.39)** |
| No | ref | | ref | | ref | |
| First Child | **1.43** | **(1.26-1.63)** | **1.34** | **(1.00-1.79)** | **1.54** | **(1.15-2.06)** |
| **Maternal Medical** | | | | | | |
| 0 Medical conditions | ref | | ref | | ref | |
| 1 Medical conditions | **1.98** | **(1.74-2.26)** | **2.71** | **(2.01-3.64)** | **1.68** | **(1.27-2.22)** |
| 2 Medical conditions | **3.01** | **(2.50-3.63)** | **3.56** | **(2.32-5.47)** | **2.60** | **(1.77-3.80)** |
| 3 Medical conditions | **3.49** | **(2.49-4.89)** | **3.95** | **(1.79-8.70)** | 0.94 | (0.30-2.98) |
| 4+ Medical conditions | **7.00** | **(4.29-11.42)** | **16.42** | **(6.73-40.06)** | **4.85** | **(1.73-13.60)** |

Abbreviations: EPTB=Extreme Preterm Birth (gestational age < 28 weeks)
[a]High and Low-income stratum = Top and bottom quintile per capita income levels

future studies. The legacy of colonization in Hawai'i has created complex psychosocial impacts for Native Hawaiians, including historical trauma, which can affect individuals regardless of their socioeconomic status and contribute to health disparities.[33] Income inequality may also have a more significant effect on Native Hawaiians than on other race/ethnic groups in Hawai'i due to the cultural discordance between traditional practices and Western economic systems, as has been proposed in study of health disparities in other Indigenous peoples.[12,34,35]

Preexisting maternal medical conditions, previous preterm birth, and birth of a first child were risk factors at all income levels, which is consistent with previous studies.[5,36] A gradient response in risk was observed with increasing number of maternal medical conditions. Although the collinearity of maternal advance age (>35) and preexisting maternal medical conditions was not directly evaluated in this study, it is probable that older women have more preexisting medical conditions than younger women, which would increase their risk of extreme preterm birth. Additionally, older women with preexisting medical conditions may be more likely to undergo assistive reproductive therapy in order to conceive, which has been shown in previous studies to be associated with a 3-fold increase in preterm birth.[37] A collinearity between maternal young age and birth of a first child may contribute to the increased risk associated with birth of a first child.

Finally, although the Black population in Hawai'i is a small subset of the total population (2.6% of all births), the rates of extreme preterm birth among Black women are increased in all models and are the highest of any race/ethnic group. These findings are consistent with other studies for Black Americans which show persistent racial disparities regardless of income levels, with suggested mechanisms

including access to and utilization of high-quality health care, lasting effects of income inequality, policy-induced racial segregation, and cumulative stress due to racial discrimination.[16,32,38] These findings merit further study in the Hawai'i population.

## Limitations

Limitations to this analysis stem from the use of vital statistics which are based on hospital birth records but not actual clinical records and may be subject to various reporting discrepancies, biases and limitations.[39] Maternal medical conditions may be under reported.[40] Tobacco and alcohol use are not reliably reported on birth certificates.[41] Preliminary analysis of tobacco and alcohol reporting in the data set supported this assertion, so these variables could not be used in this analysis. An additional birth certificate limitation is that while the Hawai'i birth certificate allows for self-identification of multiple races, the recorded data on racial identification is limited to one racial group, as described in the methods section, thus limiting the ability to consider ethnic admixing which occurs widely in Hawai'i and has been observed to have a significant correlation with health-related factors.[13,42]

An additional limitation for this study is that the low-income and high-income stratification is based on community-level average per capita income. The actual income level of each individual is not known and may not be consistent with the overall area average income. Mixed economic communities occur frequently in Hawai'i where high-value land, such as ocean-front properties, in low-income communities are owned by wealthier individuals. The opposite scenario, with low-income families residing in high-income communities, also occurs due to homestead lands, generational transfers of property and multi-generational living arrangements. This variation between the average income and individual incomes is a differential bias that is likely to understate the significance of findings in the study. Future studies could consider alternative complex social determinant measures such as concentrated disadvantage to evaluate socioeconomic status and social determinants.[43]

An additional consideration is the study size and timeframe of the data. The data used for this study included birth records from 2004-2013. While the rate of preterm birth has remained stable over the period 2013-2023 (10.2% in 2013, 10.1% in 2023), the rate of extremely preterm birth is not available for comparison and may have changed in the interval period.[44] Changes in approaches to preterm birth prevention may also have occurred which would affect the generalizability of this study. In addition, although the study included 10 years of birth records which allowed for significance in the full database, it is possible that the disaggregation to community-level income in conjunction with the rare outcome of extreme preterm birth did not find significance in some variables due to small numbers.

While more recent data may be available through the State of Hawai'i Department of Health, there are protocols that are prohibitive due to time constraints and cost. The authors share what was discovered, in hopes that those with current access to the data could repeat the analysis and update the study.

## Conclusion

These findings support a multifaceted approach to address extreme preterm birth disparities which focuses on the diverse and specialized needs of each community. The significance of socioeconomic status as a risk factor for poor birth outcomes should provide an impetus for medical providers to address socioeconomic risk factors and economic needs of patients.

### *Conflict of Interest Statement*

None of the authors identify any conflicts of interest.


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## References


1. Jang CJ, Lee HC. A review of racial disparities in infant mortality in the US. *Children*. 2022;9(2):257. doi:10.3390/children9020257

2. Ely DM, Driscoll AK. Infant mortality in the United States, 2022: data from the period linked birth/infant death file. *Natl Vital Stat Rep*. 2024;(5). doi:10.15620/cdc/157006

3. Hirai AH, Hayes DK, Taualii MM, Singh GK, Fuddy LJ. Excess infant mortality among Native Hawaiians: identifying determinants for preventive action. *Am J Public Health*. 2013;103(11):e88-95. doi:10.2105/AJPH.2013.301294

4. Chen A, Oster E, Williams H. Why is infant mortality higher in the United States than in Europe? *Am Econ J Econ Policy*. 2016;8(2):89-124. doi:10.1257/pol.20140224

5. Institute of Medicine (US) Committee on Understanding Premature Birth and Assuring Healthy Outcomes. *Preterm Birth: Causes, Consequences, and Prevention*. (Behrman RE, Butler AS, eds.). National Academies Press (US); 2007. https://pubmed.ncbi.nlm.nih.gov/20669423/

6. Gold R, Kawachi I, Kennedy B, Lynch P, Connell J. Ecological analysis of teen birth rates: association with community income and income inequality. *Matern Child Health J*. 2001;5(3):161-167. doi:10.1023/A:1011343817153

7. Madkour A, Harville S, Xie E. Neighborhood disadvantage, racial concentration and the birthweight of infants born to adolescent mothers. *Matern Child Health J*. 2014;18(3):663-671. doi:10.1007/s10995-013-1291-0

8. Wilkinson RG. *Unhealthy Societies: The Afflictions of Inequality*. Routledge; 1996.

9. Marmot MG. *The Status Syndrome: How Social Standing Affects Our Health and Longevity*. Holt Paperbacks; 2004.

10. Page J, Halliday T. Income inequality in Hawai'i since statehood. UHERO. June 5, 2014. Accessed August 23, 2025. https://uhero.hawaii.edu/income-inequality-in-hawaii-since-statehood

11. Hostetter CJ. *Income Inequality and Native Hawaiian Communities in the Wake of the Great Recession: 2005-2013*. Office of Hawaiian Affairs, Research Division, Special Projects; 2014. https://www.nhoassociation.org/uploads/6/5/8/4/65847333

12. Blaisdell RK. Health status of the Kānaka Maoli (Indigenous Hawaiians). *Asian Am Pac Isl J Health*. 1993;1(2):116-160. https://pubmed.ncbi.nlm.nih.gov/11567247/

13. Brown DE, Hampson SE, Dubanoski JP, Murai AS, Hillier TA. Effects of ethnicity and socioeconomic status on body composition in an admixed, multiethnic population in Hawaii. *Am J Hum Biol*. 2009;21(3):383-388. doi:10.1002/ajhb.20889

14. Liu DM, Alameda CK. Social determinants of health for Native Hawaiian children and adolescents. *Hawaii Med J*. 2011;70(11 Suppl 2):9-14. https://pubmed.ncbi.nlm.nih.gov/22235151/. PMID:22235151

15. Kaholokula JK, Grandinetti A, Keller S, Nacapoy AH, Kingi TK, Mau MK. Association between perceived racism and physiological stress indices in Native Hawaiians. *J Behav Med*. 2012;35(1):27-37. doi:10.1007/s10865-011-9330-z

16. Kennedy-Moulton K, Miller S, Persson P, Rossin-Slater M, Wherry L, Aldana G. *Maternal and Infant Health Inequality: New Evidence from Linked Administrative Data*.; 2022. doi:10.3386/w30693

17. Wang Kong C, Green J, Hamity C, Jackson A. Health disparity measurement among Asian American, Native Hawaiian, and Pacific Islander populations across the United States. *Health Equity*. 2022;6(1):533-539. doi:10.1089/heq.2022.0051

18. Hayes DK, Calhoun CR, Byers TJ, et al. Insights in public health: saving babies: reducing infant mortality in Hawai'i. *Hawaii J Med Public Health*. 2013;72(7):246-251. https://pmc.ncbi.nlm.nih.gov/articles/PMC3727575/

19. Waitzman NJ, Jalali A, Grosse SD. Preterm birth lifetime costs in the United States in 2016: An update. *Semin Perinatol*. 2021;45(3):151390. doi:10.1016/j.semperi.2021.151390

20. Burris HH, Collins JW Jr, Wright RO. Racial/ethnic disparities in preterm birth: clues from environmental exposures. *Curr Opin Pediatr*. 2011;23(2):227-232. doi:10.1097/MOP.0b013e328344568f

21. Vo A, Tao Y, Li Y, Albarrak A. The association between social determinants of health and population health outcomes: ecological analysis. *JMIR Public Health Surveill*. 2023;9:e44070. doi:10.2196/44070

22. Hawai'i Health Data Warehouse. 2022 Race-Ethnicity Documentation. https://hhdw.org/wp-content/uploads/2022/04/Race-Ethnicity_4.2.22.pdf

23. *State of Hawai'i Primary Care Needs Assessment Data Book 2012*. Family Health Services Division, Hawai'i Dept of Health; 2012. Accessed August 10, 2025. https://health.hawaii.gov/fhsd/files/2015/04/pcna2012databook.pdf

24. Goodman DC, Mick SS, Bott D, et al. Primary care service areas: a new tool for the evaluation of primary care services. *Health Serv Res*. 2003;38(1 Pt 1):287-309. doi:10.1111/1475-6773.00116

25. United Nations Development Program. *Human Development Report 2003: Millenium Development Goals: A Compact among Nations to End Human Poverty*. Oxford University Press; 2003. https://hdr.undp.org/system/files/documents/human-development-report-2003

26. Jones CP. Invited commentary: "race," racism, and the practice of epidemiology. *Am J Epidemiol*. 2001;154(4):299-304. doi:10.1093/aje/154.4.299

27. Blumenshine P, Egerter S, Barclay CJ, Cubbin C, Braveman PA. Socioeconomic disparities in adverse birth outcomes: a systematic review. *Am J Prev Med*. 2010;39(3):263-272. doi:10.1016/j.amepre.2010.05.012

28. Girardi G, Longo M, Bremer AA. Social determinants of health in pregnant individuals from underrepresented, understudied, and underreported populations in the United States. *Int J Equity Health*. 2023;22(186). doi:10.1186/s12939-023-01963-x

29. Long M, Frederiksen B, Ranji U, Salganicoff A. Women's health care utilization and costs: findings from the 2020 KFF Women's Health Survey | KFF. Accessed August 23, 2025. https://www.kff.org/womens-health-policy

30. Ganchimeg T, Ota E, Morisaki N, et al. Pregnancy and childbirth outcomes among adolescent mothers: a World Health Organization multicountry study. *BJOG*. 2014;121(Suppl 1):40-48. doi:10.1111/1471-0528.12630

31. Wymelenberg S, Institute of Medicine (US). The Dilemma of Teenage Parenthood. In: *Science and Babies: Private Decisions, Public Dilemmas*. National Academies Press (US); 1990. https://www.ncbi.nlm.nih.gov/books/NBK235276

32. Jelliffe-Pawlowski LL, Baer RJ, Oltman S, et al. Risk and protective factors for preterm birth among racial, ethnic, and socioeconomic groups in California. *JAMA Netw Open*. 2024;7(9):e2435887. doi:10.1001/jamanetworkopen.2024.35887

33. Riley L. Addressing Native Hawaiian historical trauma: opportunities for increased economic, environmental, and social advancement. *Soc Impacts*. 2023;1(1-2):100020. doi:10.1016/j.socimp.2023.100020

34. Raglan GB, Lannon SM, Jones KM, Schulkin J. Racial and ethnic disparities in preterm birth among American Indian and Alaska Native women. *Matern Child Health J*. 2016;20(1):16-24. doi:10.1007/s10995-015-1803-1

35. Sehgal A, Henderson R, Murry A, Crowshoe LL, Barnabe C. Advancing health equity for Indigenous peoples in Canada: development of a patient complexity assessment framework. *BMC Prim Care*. 2024;25(1):144. doi:10.1186/s12875-024-02362-z

36. Ju AC, Heyman MB, Garber AK, Wojcicki JM. Maternal obesity and risk of preterm birth and low birthweight in Hawaii PRAMS, 2000-2011. *Matern Child Health J*. 2018;22(6):893-902. doi:10.1007/s10995-018-2464-7

37. Santi E, Nencini G, Cerni A, et al. The PLART study: incidence of preterm labor and adverse pregnancy outcomes after assisted reproductive techniques-a retrospective cohort study. *Arch Gynecol Obstet*. 2019;300:911-916. doi:10.1007/s00404-019-05261-2

38. Matoba N, Collins JW Jr. Racial disparity in infant mortality. *Semin Perinatol*. 2017;41(6):354-359. doi:10.1053/j.semperi.2017.07.003

39. Robledo CA, Yeung EH, Mendola P, et al. Examining the prevalence rates of preexisting maternal medical conditions and pregnancy complications by source: Evidence to inform maternal and child research. *Matern Child Health J*. 2017;(4):852-862. doi:10.1007/s10995-016-2177-8

40. Lydon-Rochelle MT, Holt VL, Cárdenas V, et al. The reporting of pre-existing maternal medical conditions and complications of pregnancy on birth certificates and in hospital discharge data. *Am J Obstet Gynecol*. 2005;193(1):125-134. doi:10.1016/j.ajog.2005.02.096

41. Northam S, Knapp T. The reliability and validity of birth certificates. *J Obstet Gynecol Neonatal Nurs*. 2006;35(1):3-12. doi:10.1111/j.1552-6909.2006.00016.x

42. Office of Hawaiian Affairs. Native Hawaiian Data Book 2023: Appendix: Racial Ethnic Identification. Accessed August 23, 2025. https://ohadatabook.com/go_appendix.23.html

43. Sampson RJ, Raudenbush SW, Earls F. Neighborhoods and violent crime: a multilevel study of collective efficacy. *Science*. 1997;277(5328):918-924. doi:10.1126/science.277.5328.918

44. March of Dimes. A profile of prematurity of Hawaii | PeriStats | March of Dimes. Accessed August 23, 2025. https://www.marchofdimes.org/peristats/reports/hawaii/prematurity-profile