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MATERNAL AND INFANT HEALTH INEQUALITY: NEW EVIDENCE FROM LINKED ADMINISTRATIVE DATA

Kate Kennedy-Moulton
Sarah Miller
Petra Persson
Maya Rossin-Slater
Laura Wherry
Gloria Aldana

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ABSTRACT

We use linked administrative data on the universe of California births to provide novel evidence on economic inequality in infant and maternal health. Infants and mothers at the top of the income distribution have worse birth and morbidity outcomes than their lowest-income counterparts, but are nevertheless the least likely to die in the year following birth. Racial disparities swamp these income disparities, with no racial convergence in health outcomes as income rises. A comparison with Sweden shows that infant and maternal health is worse in California at virtually all income levels.

Kate Kennedy-Moulton
Columbia University
kam2373@columbia.edu

Sarah Miller
University of Michigan
Ross School of Business
and NBER
mille@umich.edu

Petra Persson
Stanford University
Department of Economics
and NBER
perssonp@stanford.edu

Maya Rossin-Slater
Stanford University
Stanford University School of Medicine
Department of Economics
and NBER
mrossin@stanford.edu

Laura Wherry
New York University
and NBER
laura.wherry@nyu.edu

Gloria Aldana
U.S. Census Bureau
gloria.g.aldana@irs.gov

1 Introduction

Infant and maternal health in the United States is worse than in other wealthy nations. The US infant mortality rate ranks 33rd out of the 35 countries in the Organization for Economic Cooperation and Development (Bronstein et al., 2018) and the maternal mortality rate is more than double the rates of other OECD countries (Tikkanen et al., 2020). The US disadvantage in infant health reflects, in part, greater health inequality: Infants of college-educated non-Hispanic white mothers have similar mortality rates as their European and Canadian counterparts, while children of less educated and racial minority mothers in the US fare worse (Chen et al., 2016), and similar disparities drive the US disadvantage in maternal health. Yet, while racial and educational infant and maternal health disparities are well-documented (Lu and Halfon, 2003; Dominguez, 2008; Currie, 2009, 2011; MacDorman, 2011; MacDorman and Mathews, 2011; Aizer and Currie, 2014; Green and Hamilton, 2019; Petersen et al., 2019), little is known about the relationship between parental *income* and infant or maternal health, nor about how income and race interact. For example, we do not know whether racial infant and maternal health disparities become narrower as income increases.

Such research has been hampered by the fact that income is *not* reported in standard birth or death records. Thus, prior research on US health disparities relies on aggregate geographic measures, such as county-level poverty rates (David et al., 2010; Currie and Schwandt, 2016; Baker et al., 2019; Vilda et al., 2020; Schwandt et al., 2021, 2022), which may mask within-area heterogeneity. Other studies analyze surveys with small sample sizes to characterize the association between family income and infant health (Nepomnyaschy, 2009; Martinson and Reichman, 2016), often with limited health measures and insufficient statistical power to examine differences by race.

This paper brings a new data resource to fill this knowledge gap: the universe of California birth records over 2007–2016, linked to data from infant and maternal hospitalization and infant death certificate records from the California Department of Health Care Access and Information, and parental income data from Internal Revenue Service tax records. This population-level linked dataset allows us to comprehensively analyze the association between parental income and several key measures of infant and maternal health in the most populous US state, which accounts for 11 percent of all US births and represents the fifth largest economy in the world (Osterman et al., 2023; Forbes, 2019). Moreover, we study these gradients separately by race and ethnicity, allowing us to examine interactions between racial and economic inequality in infant and maternal health.

Additionally, we benchmark these income gradients in California to those in Sweden, a country known for its low infant and maternal mortality rates (Wallace et al., 1982, 1985; MacDorman et al., 2014; Tikkanen et al., 2020). Sweden's universal healthcare system and broad social safety net are often contrasted with the US policy environment (Frank, 2013; Finney, 2021; Chen et al., 2022), with Sweden considered to be better-equipped to foster good infant and maternal health outcomes for low-income families. It is less clear, however, how outcomes might compare across countries for families with the highest incomes.[1]

Our analysis delivers several findings. First, our three main birth outcomes—birth weight, an indicator for low birth weight (less than 2,500 grams, or LBW), and an indicator for preterm birth (less than 37 weeks gestation)—exhibit a strong *non-monotonic* relationship with parental income. These outcomes improve as income increases from the bottom to the middle of the income distribution, but worsen substantially at the top of the income distribution. In fact, children of parents in the top ventile of the income distribution have *lower* average birth weight and *higher* LBW and preterm birth rates than those in the bottom ventile.

[1]Our comparison builds on several recent studies that have compared health inequality in the US to those in other high-income countries (Chen et al., 2016; Baker et al., 2019; Currie et al., 2020a; Emanuel et al., 2021; Schwandt et al., 2021).

These patterns differ from those documented for other outcomes in the US. For instance, life expectancy at age 40 increases monotonically throughout the income distribution (Chetty et al., 2016). Furthermore, the conditional expectation of child income given their parents' income is linear in percentile ranks (Chetty et al., 2014). Yet, we show that children born into the top of the income distribution—who are likely to earn the top incomes in America in adulthood—have *worse* birth outcomes than those born at the bottom of the income distribution. Notably, we demonstrate that the non-monotonicity in LBW and preterm birth rates is more muted in gradients that use county-level median income, underscoring the value of using individual-level parental income data.

Second, we show that adjusting for two key factors—maternal age and an indicator for a non-singleton birth—changes this non-monotonic pattern, such that the relationship between parental income and favorable birth outcomes becomes increasing and concave. That is, the disproportionately adverse birth outcomes at the top of the income distribution are explained by higher average parental age and a greater share of non-singleton births among those families. This is consistent with advanced maternal age being a well-known pregnancy risk factor (Geiger et al., 2021) and non-singleton births having lower birth weights and shorter gestation lengths than singleton births. Non-singleton births are substantially more likely to occur in pregnancies conceived with assisted reproductive technologies (ART), which we show are disproportionately likely to be used by the highest-income parents.

Our third finding is that, unlike the birth outcomes, infant mortality varies monotonically with income, with substantially higher infant death rates at the bottom than at the top of the income distribution. The infant mortality rates among children of parents in the bottom and top ventiles of the income distribution are 7.0 and 3.5 deaths per 1,000 births, respectively, reflecting a two-fold difference ($p < 0.001$). Thus, despite having the riskiest pregnancies and the worst birth outcomes, women in the top ventile of the income distribution give birth to babies who are the *least* likely to die. This finding suggests that pregnancies carried by the highest-income women are not only the riskiest, but also the most protected.[2] This pattern remains after accounting for hospital fixed effects, suggesting that the relationship between infant mortality and income cannot be explained by differences in hospital quality alone.

Fourth, we find similar patterns of non-linearity in morbidity and a monotonic relationship in mortality when we examine maternal health. We find a U-shaped pattern when analyzing severe complications related to pregnancy and childbirth—women both at the bottom and the top of the income distribution have the highest rates of these complications. However, despite having similar morbidity rates as their lowest-income counterparts, women with incomes at the top of the income distribution are *2.7 times* less likely to die.[3]

Fifth, racial health disparities are significantly wider than those by income, with essentially no convergence in outcomes across racial groups as income increases. These differences are especially large when it comes to the Black-white gap. Across all income levels, Black infants and mothers have worse health than their non-Hispanic white counterparts, and LBW and preterm rates for infants of Black parents in the *top* of the income distribution are one and a half to two times higher than those for infants of white parents in the *bottom* of the income distribution. Infant mortality for Black infants in the top decile

[2]Non-singleton births experience higher infant mortality rates than singleton births conditional on gestation length (Almond et al., 2005), which implies that infants born in the highest income families, which are disproportionately non-singleton, should be at a particularly high risk of death *a priori*. At the same time, pregnancies among higher-income women—especially those conceived with ART—tend to be highly monitored (Velez et al., 2019), and recent work shows that additional prenatal care in high-risk pregnancies reduces perinatal mortality (Geiger et al., 2021).

[3]We have also examined whether the health-income associations have changed over time during the ten years covered by our data. While there have been some level shifts in outcomes over time, the relationships between income and maternal and infant health have remained quite stable.

of the income distribution is 7.6 deaths per 1,000 births—more than 30 percent higher than the rate of 5.8 deaths per 1,000 births among white infants in the bottom decile of the income distribution, although we do not have enough precision to reject that these two rates are equal. The maternal mortality rate for Black mothers in the top quintile of the income distribution is 7.0 deaths per 10,000, more than twice as high as the rate among white mothers in the bottom quintile, which is 2.5 deaths per 10,000 ($p = 0.035$). Notably, while Black mothers and infants have substantially higher rates of *all* adverse outcomes throughout the income distribution compared to the other groups, families belonging to the "Non-Hispanic Other" category—including American Indian/Alaska Native, multiracial individuals, and those with missing race information—have similarly high infant mortality rates as Black families at most income levels. Together, this evidence implies that policies seeking to achieve racial health equity cannot succeed if they only target economic disadvantage.[4]

Finally, comparing the health gradients in California with those in Sweden, we find that *all* measures of infant health are worse in California than in Sweden at *all* income levels. In particular, the lowest-income infants in Sweden have higher average birth weight, lower rates of preterm birth and LBW, and lower rates of infant mortality than Californian infants at any point in the income distribution. For maternal mortality, rates are lower in Sweden than in California at the bottom of the income distribution, but more similar toward the middle and the top.

Our paper contributes to the literature on early-life health. The research linking early-life health to later outcomes (see: Currie and Almond, 2011; Aizer and Currie, 2014; Nusslock and Miller, 2016; Almond et al., 2018), combined with studies showing a positive impact of parental economic resources on early-life health (Lindo, 2011; Hoynes et al., 2015; Amarante et al., 2016; Wehby et al., 2020), suggest that early-life health is an important

[4]Note that racial differences across the income distribution do not appear to have changed significantly over time.

driver of the observed intergenerational persistence of economic status. Our findings of a non-linear relationship between parental income and birth outcomes, and a strong linear income gradient in infant mortality, shed more light on the nature of this mechanism. Birth outcomes such as birth weight and gestation length may not serve as a central channel by which income persists across generations, as these outcomes are actually worse for children of parents at the very top of the income distribution who are then likely to go on to have the highest incomes themselves. However, health—and potentially healthcare and other resources—during the first year of life may be an important mechanism, as indicated by the lowest infant mortality rate for children of parents at the top of the income distribution.

Our paper also adds to the literature on maternal health inequality, which to date has been more limited compared to the literature on child health and overall mortality. While existing research links maternal education and marriage status with maternal pregnancy behaviors and conditions (e.g., Aizer and Currie, 2014), our study is, to our knowledge, the first to offer direct evidence on the association between individual-level income and maternal health in the US. Moreover, our novel linkage between birth records and maternal death records allows us to identify virtually all deaths of women in the first postpartum year without relying on the pregnancy status checkbox used in prior studies (Catalano et al., 2020; Hoyert et al., 2020).

Our evidence is descriptive and does not reflect the causal effects of income and race on infant and maternal health. However, we view it as an important launchpad for generating hypotheses regarding possible causal relationships. For instance, our research underscores the importance of understanding interactions between race and income, especially when it comes to maternal health. The fact that Black mothers at the top of the income distribution have statistically similar (and, based on the point estimates, higher) mortality rates as white mothers at the bottom of the income distribution suggests that the widely cited racial disparity in maternal mortality is unlikely to be exclusively caused by differences in average income levels across the two racial groups.

2 Data

Our analysis links California birth records from 2007 through 2016 to several administrative data sources containing parent information, income, and morbidity and mortality outcomes. Each birth record has personally identifying information for children and parents and information on birth weight, gestation length, parity, and plurality. They also contain maternal age, race, and ethnicity. We restrict the sample to births to first-time mothers who are state residents, accounting for 39.2 percent of all births during our analysis period.[5] Our resulting sample consists of approximately 2.04 million births.

We provided the birth records to the Census Bureau, who then used their Person Identification Validation System to assign anonymized individual identifiers (called Protected Identification Keys, or PIKs) to each infant and parent, allowing for linkages to other Census-held data without the use of personally identifying information (Mulrow et al., 2011). Most birth records contain parent identifiers, but occasionally these fields are missing. In these cases, we use additional administrative records to identify parents when possible (see Appendix A). Ultimately, we identify the mother (father) for 95.1 percent (86.7 percent) of the births in our sample.

Parental income data. Using parental PIKs, we link the birth records to parental income data from the IRS covering years 2005–2016. These data contain income information reported on the 1040 and W-2 forms, including earnings regardless of tax filing status, ad-

[5]We focus on births to first-time mothers to avoid confounding the relationships between race, maternal age, and parity. Since the average number of births per mother differs by race, and since mothers are mechanically older at higher-parity births, including all births would over-represent older women in racial groups with a higher average parity. Given our focus on understanding the relationships between race, family income, and infant and maternal health, we opted to study first births only.

justed gross income (AGI), and taxable Social Security benefits. We construct a measure of family "AGI-like" income during the two years prior to the birth (more details in Appendix A). Following Chetty et al. (2016), we do not include in our main analysis families who are unmatched to any measure of income, for whom $0 is reported on the tax return, or for whom the family "AGI-like income" is negative in either year. Average outcomes for these families are reported in Appendix Table B1.

We create percentile bins using the family income distribution in each birth year. In most analyses, we present estimates in ventiles, or five percent shares of each year's total number of births. When analyzing rarer outcomes in subgroups, such as infant and maternal mortality by race/ethnicity, we present estimates in deciles or quintiles to avoid averaging outcomes across a small number of observations.

To compare our individual family income measures with the more aggregate geographic measures used in prior work, we merge in data on county-level median income by maternal county of residence at birth from the Census Bureau's 2010 Small Area Income and Poverty Estimates (SAIPE) Program. We combine the 58 California counties into 14 bins, which represent groupings of approximately 5 percent of births, with the exception of very large counties that constitute their own bins (e.g., Los Angeles county, which accounts for 26 percent of California births).

Morbidity and mortality data. Some of our analyses use data that were already linked to the birth records by the California Department of Health Care Access and Information (HCAI). To measure maternal morbidity, we use HCAI data on maternal inpatient visits from nine months before through one year following childbirth available for years 2007–2012 (Healthcare Information Resource Center, 2006). We measure severe maternal morbidity (SMM) in this window using Internal Classification of Diseases ICD-9-CM diagnoses codes and ICD-9-PCS procedure codes and the CDC definition.[6] These events capture severe negative health consequences of labor and delivery, such as eclampsia or sepsis. Our SMM analysis sample includes about 1.26 million observations.

To calculate maternal and infant mortality—which we define as a maternal and infant death occurring within one year of childbirth, respectively—we use information on exact date of death for deaths occurring in 2017 and earlier from the 2019 Census Numident. The Census Numident contains administrative mortality data for the US population collected by the Social Security Administration for individuals with a Social Security Number (SSN) or Individual Tax Identification Number (ITIN) (Mulry and Keller, 2017). Mortality records in the Numident closely track adult mortality statistics as reported by the CDC (Finlay and Genadek, 2021; Miller et al., 2021). Additionally, measuring maternal mortality using the Numident allows us to circumvent known data issues associated with the pregnancy status checkbox in US death certificates (Catalano et al., 2020; Hoyert et al., 2020).

The Numident undercounts infant deaths since many infant deaths occur before the infant has obtained an SSN. Therefore, to measure infant mortality, we supplement the Numident mortality records with HCAI infant death records, available for birth years 2007 to 2011, and restrict our analysis of infant deaths to only those birth cohorts. Our infant mortality analysis sample consists of 1.06 million observations. The rates of infant deaths match closely to publicly-available statistics reported by the California Department of Public Health (see Appendix A and Appendix Table B2). We measure overall infant mortality rates, as well as neonatal (death within first 28 days of life) and post-neonatal (death between 28 days and 1 year) rates separately.

[6]See: https://www.cdc.gov/reproductivehealth/maternalinfanthealth/severematernalmorbidity.html for the exact codes.

Swedish data. To study infant and maternal health gradients in Sweden, we link comparable population-wide administrative datasets. Information on these data and the linkage process is in Appendix A. As in California, we restrict the Swedish sample to live births of first-time mothers. We cannot measure SMM in the Swedish data. Our final analysis sample for Swedish birth outcomes includes 482,401 observations, while the analysis sample for infant mortality, which is restricted to birth cohorts 2007–2011 as in the California data, includes 239,816 observations.

3 Results

3.1 Income Inequality in Infant and Maternal Health

Figure 1 plots average birth outcomes by family income ventile using the California data. Panels (a) through (c) show a non-monotonic relationship between parental income and infant health as captured on the birth record. Birth outcomes improve from the lowest ventiles until the middle of the income distribution. Average birth weight is 3,220 grams for infants born to families in the lowest income ventile and peaks at 3,264 grams, 1.4 percent higher, for infants born to families in the 12th ventile. Similarly, the preterm and LBW rates are 7.7 and 9.7 percent lower, respectively, for infants at the 12th ventile compared to the poorest families in the first ventile. These differences are statistically significant ($p < 0.001$).

Above the median, however, this relationship reverses, with birth outcomes worsening as parental income increases, such that the worst birth outcomes are observed among infants born to the highest income families. Preterm birth and LBW rates are higher by 14 and 24 percent, respectively, when comparing infants born to families at the top versus bottom of the income distribution. This "J-shaped" (or "inverted J-shaped," for average birth weight) pattern contrasts with income gradients in adult health measures, which vary monotonically with income (e.g., Chetty et al., 2016). Additionally, panels (b) and (c) of Appendix Figure C1 show that the "J-shaped" patterns in preterm birth and LBW rates, respectively, are considerably muted when we instead use a county-level measures of economic resources, median income. These comparisons highlight the insights about health inequality that can be discovered with individual-level administrative income data.

We find a different pattern when examining the most extreme measure of infant health—infant mortality—in panel (d) of Figure 1: The association between parental income and infant mortality is monotonic, with infants in the highest income families experiencing the lowest likelihood of death. Infants born to families in the top income ventile experience mortality rates that are half of those experienced by infants at the bottom ventile (3.5 deaths per 1,000 births versus 7.0 deaths per 1,000 births, $p < 0.001$). Thus, despite faring the worst in terms of birth outcomes, babies born into the highest income families are the most likely to survive to age one. We emphasize this point by predicting infant mortality based on birth weight, an indicator for LBW, gestational age in weeks, and an indicator for preterm birth using a linear probability regression. In the highest income households, *predicted* infant mortality based on birth outcomes is highest, while *true* infant mortality is lowest (Appendix Figure C2).

Appendix Figure C1(d) shows that similar patterns in infant mortality emerge when we use county-level median incomes instead of individual family incomes on the $x-$axes. This analysis provides support for the validity of findings in prior work that has relied on aggregate economic measures to study mortality inequality (Currie and Schwandt, 2016; Baker et al., 2019; Schwandt et al., 2021, 2022).

The last two panels of Figure 1 show measures of maternal health. We see a U-shaped pattern for SMM (panel (e)), with the highest rates for both the lowest and highest income mothers. However, as with infant mortality, maternal mortality is monotonic in income, with the highest income mothers experiencing the lowest mortality rates, despite their high rates of morbidity. Death rates are more than 2.5 times higher for mothers in the bottom income ventile as compared to the top ventile (3.8 maternal deaths per 10,000 births versus 1.4 maternal deaths per 10,000 births; $p = 0.001$).[7]

In Figure 2, we investigate how much of these patterns can be explained by two key characteristics: maternal age and an indicator for non-singleton birth. Specifically, we calculate residuals from a regression of each outcome on fixed effects for maternal age group bins (less than 20, 20-24, 25-34, 35+) and an indicator for a non-singleton birth. We then plot the average residuals in each income bin. In contrast to the results reported in Figure 1 using raw outcome means, we find that once these characteristics are accounted for, the patterns for LBW, preterm birth, and SMM become largely monotonic in income, with the best outcomes associated with the highest family incomes. We continue to observe some reduction in average birth weight for infants born to the highest income families, but the decline from the 15th ventile to the 20th ventile is far less severe than in the raw data. Thus, it appears that the "J-shaped" pattern in adverse birth outcomes and the "U-shaped" pattern in SMM are largely explained by the fact that mothers in the highest income families tend to be older and more likely to have non-singleton births. Moreover, as we show in Appendix Figure C3, high-income mothers are substantially more likely to use assisted reproductive technologies (ART) to conceive than their lower-income counterparts (6.6 percent of births to mothers in the highest-income bin are conceived with ART, as compared to 0.2 percent of births in the lowest-income bin), and ART-conceived pregnancies are much more likely to result in non-singleton deliveries than those conceived without ART.

At the same time, the patterns for infant and maternal mortality remain monotonic after controlling for maternal age and non-singleton birth status, with similar relative differences in the death rates across the top and bottom income ventiles, as described above.[8] Appendix Figure C4 also considers neonatal and post-neonatal mortality separately in panels (b) and (c) with the income gradient for overall infant mortality replicated

[7]The county-level maternal health gradients in Appendix Figures C1(e) and (f) show similar patterns, although with less precision.

[8]Further, patterns of inequality in infant and maternal mortality are unchanged when the sample is

in panel (a). The downward-sloping relationship with income holds for both measures. Since hospital characteristics play an important role in influencing neonatal mortality in particular, one explanation is that mothers with different incomes sort into giving birth at different types of hospitals. However, when we adjust for hospital fixed effects (in addition to maternal age and a non-singleton birth indicator as in the other adjusted models) in Appendix Figure C5, the qualitative relationship between income and infant mortality is largely unchanged. Thus, it is unlikely that differential sorting into higher versus lower-quality hospitals is the primary explanation for the inequality in infant mortality that we document.

3.2 The Intersection Between Race and Income Inequality in Infant and Maternal Health

Figure 3 explores the intersection between race and income inequality by plotting infant and maternal health outcomes by income separately for non-Hispanic white, non-Hispanic Black, non-Hispanic Asian, Hispanic, and non-Hispanic mothers of another race (including American Indian/Alaskan Native, those belonging to multiple racial groups, and those with missing race information). These figures reveal that disparities across racial and ethnic groups are far larger than disparities across the income distribution. Panel (a) of Figure 3 shows that, on average, infants of non-Hispanic white mothers have the highest birth weights at all points in the income distribution. Indeed, at no point in the income distribution does average birth weight for any other racial or ethnic group exceed that of infants of the lowest income (first ventile) non-Hispanic white mothers. Infants born to non-Hispanic mothers of other races and Hispanic mothers have the next highest birth weights on average, and non-Hispanic Black and non-Hispanic Asian mothers have infants with the lowest average birth weights.

Panels (b) and (c) show similarly large disparities in rates of preterm and LBW births.

restricted to singleton births (see Appendix Figure C10).

By these measures, infants born to non-Hispanic Black mothers have by far the worst outcomes at all points in the income distribution. Rates of preterm birth range from 11.7 percent to 14.9 percent and rates of LBW range from 11.2 percent to 14.3 percent for this group. In contrast, rates of preterm birth range from 8.2 percent to 11.4 percent and LBW rates range from 6.3 percent to 8.8 percent for infants born to non-Hispanic white mothers. Further, the gap between non-Hispanic Black and non-Hispanic white mothers does *not* close as we move higher in the income distribution; instead, it remains roughly constant. We see similar patterns for SMM and maternal mortality (panels (e) and (f)), with rates elevated for non-Hispanic Black mothers at all points in the distribution. For infant mortality (panel (d)), infants of non-Hispanic Black mothers and infants of mothers belonging to the non-Hispanic other group have the highest mortality rates throughout the income distribution. In particular, for infants of Black mothers, the mortality rate ranges from 6.0 to 12.9 per 1,000 births, while for infants in the other group, it ranges from 5.6 to 11.2 per 1,000 births. Given the rare nature of these mortality events, these subgroup-specific means tend to be noisy and do not always exhibit a clear pattern in relation to family income; there does, however, still appear to be some monotonic relationship with income.

We explore the role of maternal characteristics in these cross-race/ethnicity differences by residualizing our outcomes based on maternal age and non-singleton birth status—the two key factors driving the non-linear patterns between health outcomes and income in the overall population. Appendix Figure C6 plots the residual means by income bin and racial/ethnic group.[9] Residualizing does not appear to meaningfully close the gaps between racial and ethnic groups, although it does sometimes reduce the rate of adverse health outcomes at the top of the income distribution within these groups. Even after accounting for these characteristics, we observe that non-Hispanic Black mothers and in-

[9] We calculate residuals using the same coefficient estimates from the regressions of each outcome on fixed effects for maternal age group and an indicator for non-singleton births used in Figure 2.

fants in the *highest* income families fare worse than the *poorest* non-Hispanic white mothers and infants.

3.3 Income Inequality in Infant and Maternal Health Over Time

Our analysis period covers several substantial changes to the healthcare system, including the introduction of the Affordable Care Act (ACA), which may have affected the relationships between maternal and infant health outcomes and income. We therefore investigate how the patterns described above evolve over time. Appendix Figure C7 plots our key outcomes using data from three sets of birth cohorts: 2007–2009, 2010–2013, and 2014–2016.[10] Overall, while there have been some level shifts in outcomes over time, the relationships between income and these outcomes have remained remarkably stable. That is, our key conclusions about (a) the non-monotonic ("J-shaped" or "U-shaped") relationships between infant and maternal morbidity and income, and (b) the monotonic and decreasing relationships between mortality and income, are the same no matter which time period we consider.

In Appendix Figure C8, we plot the ratio in outcomes between Black and white mothers across income bins, separately over the three time periods. For most outcomes, the Black-white disparity and its interaction with income have been largely unchanged over time. For some outcomes, such as SMM, the Black-white gap has gotten somewhat larger, especially at higher income levels.

The patterns in Appendix Figures C7 and C8 suggest that the reforms in the healthcare system due to the ACA did not appear to meaningfully alter the relationship between maternal and infant health and income. One reason may be that the ACA did not change Medicaid eligibility for pregnant women. While more insurance coverage in the pre-

[10]Since our infant mortality data are only available for birth cohorts 2007–2011, this graph uses data for birth years 2010–2011 in the middle period, with no infant mortality graph for the latest time period. Similarly, we do not have an SMM graph for the latest time period given data availability.

conception period—which was affected by the ACA's Medicaid expansions for childless adults—could lead to better health outcomes, it is possible that these benefits take longer to emerge than we can observe in our data. Finally, other time trends unrelated to the ACA may have altered these patterns, making it difficult to detect an ACA-specific effect.

3.4 Comparing California to Sweden

To contextualize these patterns, we compare the health gradients in California to those observed in Sweden. Figure 4 plots average outcomes by parental income ventile for Sweden (in grey) and California (in black). Infant health outcomes are dramatically better in Sweden, where we observe higher average birth weight and lower rates of preterm birth, LBW, and infant mortality (panels (a)–(d)). Appendix Figure C9 shows the raw gradients in California and Sweden separately for neonatal and post-neonatal mortality rates, in panels (a) and (b), respectively. For both measures, Sweden has substantially lower rates than California at all points in the income distribution. In sum, for all measures of infant health, even the lowest income Swedish mothers have much better outcomes than the wealthiest Californians ($p < 0.001$ for LBW and preterm birth; $p = 0.07$ for infant mortality).

We examine how maternal mortality rates compare in panel (e) of Figure 4. Since this is a rare outcome, the patterns are somewhat noisy. That said, it appears that maternal mortality rates are lower in Sweden than in California, at least in the bottom half of the income distribution (although the differences are not statistically significant). Infant health comparisons across countries can be complicated by differences in what is recorded as a live birth versus a stillbirth or miscarriage. In particular, some cases that are classified as (early) infant deaths in California may be classified as stillbirths in Sweden and, thus, omitted from our analysis sample that only captures live births. To account for this reporting difference, we apply the sample restrictions proposed in Chen et al. (2016) to create a sample of births that are unlikely to be categorized as stillbirths in either country: singleton births with at least 22 weeks gestation and a birth weight of at least 500 grams. Gradients based on these restricted samples are shown in Appendix Figure C10. Our main conclusions—that infant health is better in Sweden than in California at every point in the income distribution, and that maternal mortality is lower in Sweden than in California at many points in the income distribution—are virtually unchanged in this restricted sample.

We also compare outcomes in Sweden to those in the two racial groups in California with the worst and best infant and maternal health outcomes, respectively: non-Hispanic Blacks and non-Hispanic whites. Appendix Figure C11 shows that, at any income ventile, infants born in Sweden have better outcomes than infants in both of these groups. Further, for all birth outcomes, even the lowest income Swedish infants do better than Californian infants at any point in the income distribution in either racial group. In terms of infant mortality, only higher income non-Hispanic white families achieve rates as low as the lowest income Swedish families. When it comes to maternal health, we observe that non-Hispanic white mothers experience mortality rates similar to those of Swedish mothers.[11]

4 Conclusion

America is considered a world leader in healthcare innovation (The Foundation for Research on Equal Opportunity, 2020), and the rapid pace of innovation in the last few decades is often credited as a key driver of improvements in population health in the US, including in infant and maternal health (Newhouse, 1992; Cutler, 2004; Chandra and Skinner, 2012).

[11]We use country-specific income distributions in the above analysis. Appendix Figure C12 plots the histograms of the income distributions of our two samples in California and Sweden, respectively; while overlapping, they are not identical. Notably, the US has a lower median and more mass in the far right tail of the income distribution. Appendix Figures C13 and C14 show that our findings are similar if we use the California income distribution to assign family income percentiles in Sweden.

Our findings show that infants and mothers in the highest-income households appear to be the biggest beneficiaries of these technological advances—they are the most likely to survive despite having the riskiest pregnancies and worst birth outcomes. At the same time, our results underscore that these benefits do not "trickle down" to all Californians. Infants in lower income families experience higher mortality rates in the first year of life despite being observably healthier in terms of birth weight and gestation length than their highest income counterparts. Similarly, rates of maternal mortality are greatest among the lowest income mothers.

Additionally, we find that mothers and infants in California fare worse than their counterparts in Sweden on almost all measures of health. Remarkably, this is true even for the infants and mothers at the very top of the income distribution, who are likely to have access to the best healthcare technologies available. This finding underscores that aspects of the social and economic environment beyond healthcare innovation are likely important determinants of the observed cross-country differences in infant and maternal health.

Further, the income differences in California are amplified by a deep racial divide. Infant and maternal health gaps between non-Hispanic white and non-Hispanic Black families—the groups that fare the best and worst, respectively—are larger than the income differences within race. These inequities are striking given that California has one of the most generous social safety net systems in the US, and is well-known for its efforts to improve maternal and infant health outcomes and address racial disparities.[12]

While the causal drivers of the racial inequities that we document are beyond the scope of this paper, we speculate that a variety of potential mechanisms may be relevant. Recent evidence suggests that differences in access to and utilization of high-quality healthcare across the income distribution may be amplified by a racial gradient. Black in-

[12] Examples include the Black Infant Health Program and the California Maternal Quality Care Collaborative.

fants and mothers may face disproportionate supply-side barriers within the healthcare system (e.g., due to financial incentives within the Medicaid managed care reimbursement system, as in Kuziemko et al., 2018), as well as demand-side barriers rooted in a long history of racism (Alsan and Wanamaker, 2018; Sacks, 2018; Green and Darity Jr, 2010; Green et al., 2021). In addition, a large and persistent racial wealth gap in the US (Derenoncourt et al., 2022), policy-induced racial segregation (Collins et al., 1998; Aaronson et al., 2020, 2021), racial disparities in pollution exposure (Currie et al., 2020b), and cumulative stress due to racial discrimination (Geronimus et al., 2006; Collins et al., 2009; Love et al., 2010) are likely other important causes of poor health outcomes among Black Americans.

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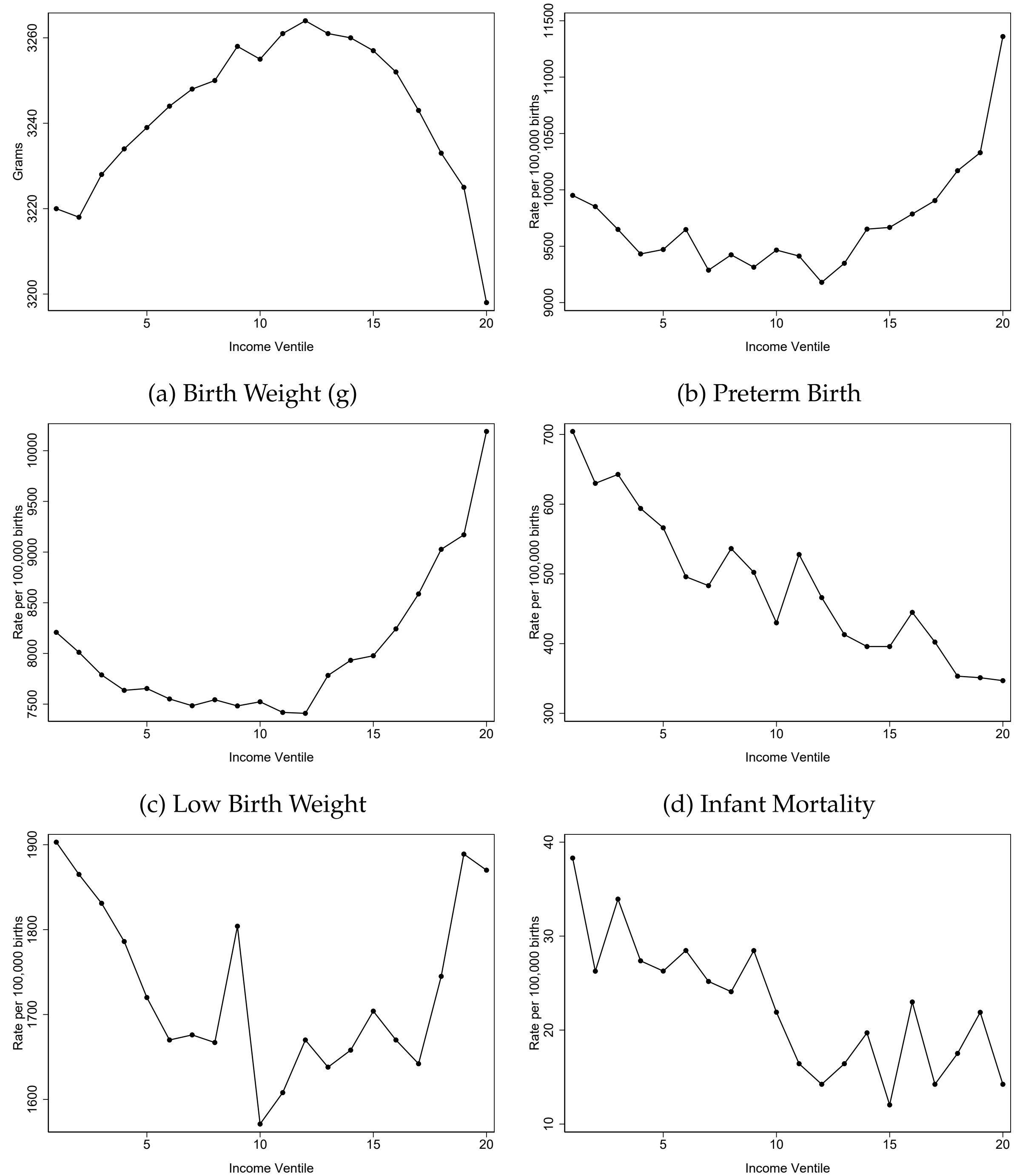
5 Figures

Figure 1: California Infant and Maternal Health Income Gradients



(a) Birth Weight (g)

(b) Preterm Birth

(c) Low Birth Weight

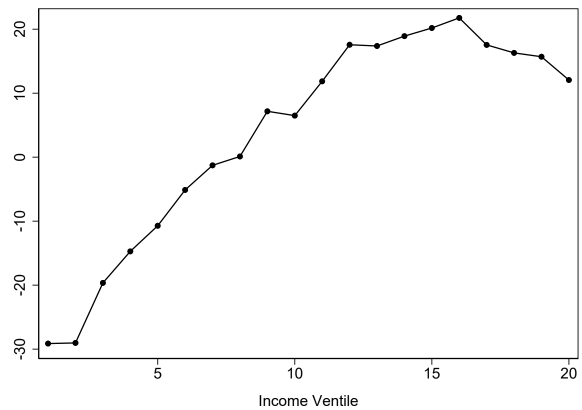
(d) Infant Mortality

(e) Severe Maternal Morbidity

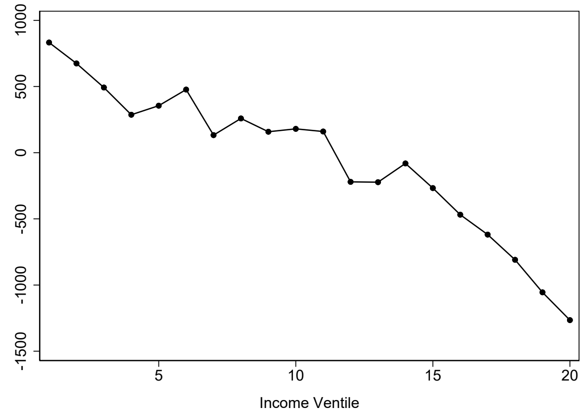
(f) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes for births to first-time mothers in California between 2007-2016 averaged within income bins corresponding to ventiles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

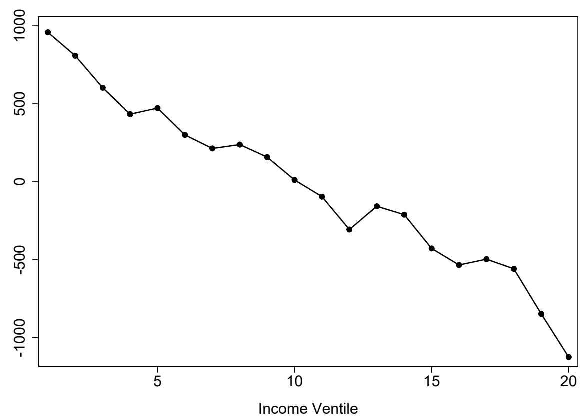
Figure 2: California Residualized Infant and Maternal Health Income Gradients



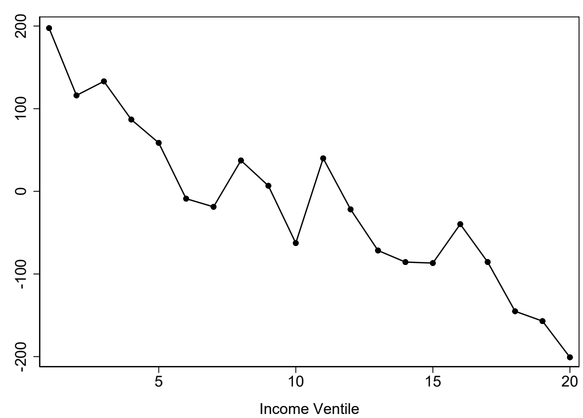
(a) Birth Weight



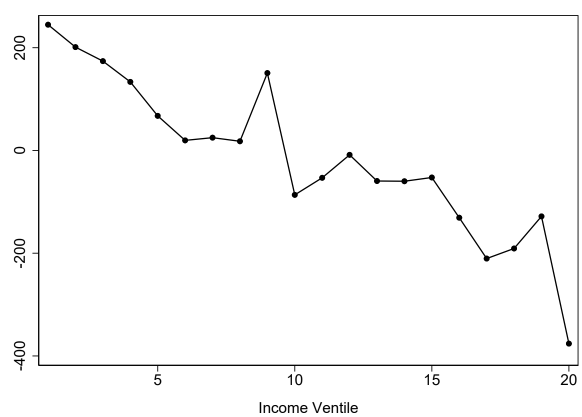
(b) Preterm Birth



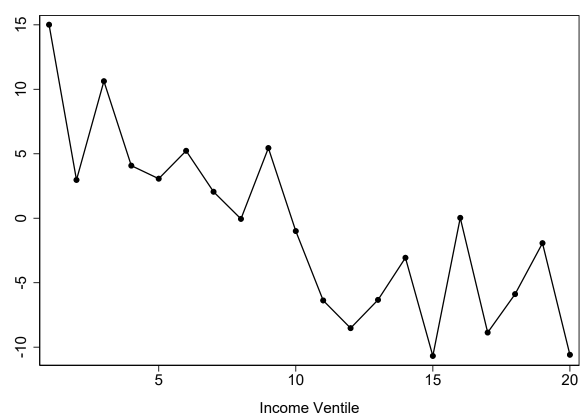
(c) Low Birth Weight



(d) Infant Mortality



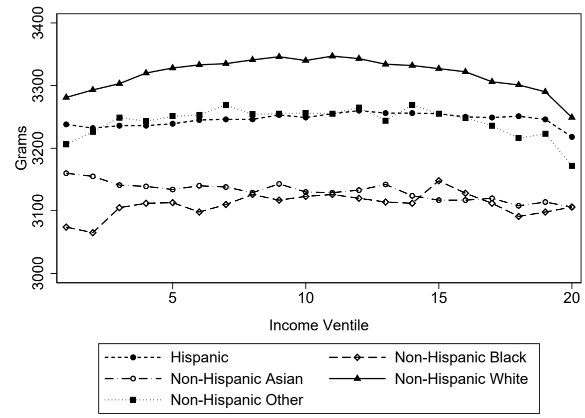
(e) Severe Maternal Morbidity



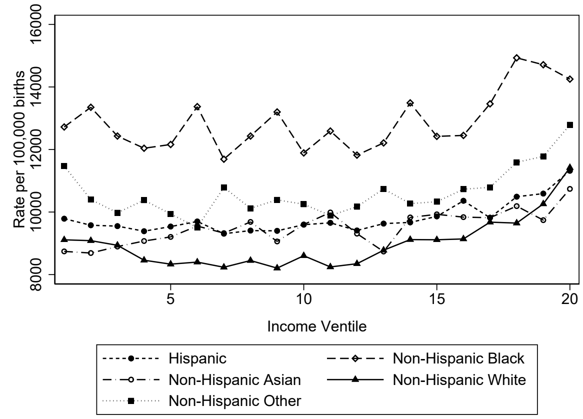
(f) Maternal Mortality

Notes: Figure plots average of residuals from a regression of measures of infant and maternal health on maternal age and non-singleton birth. The analysis used data for births to first-time mothers in California between 2007-2016. Binned residuals are plotted against income bins corresponding to ventiles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

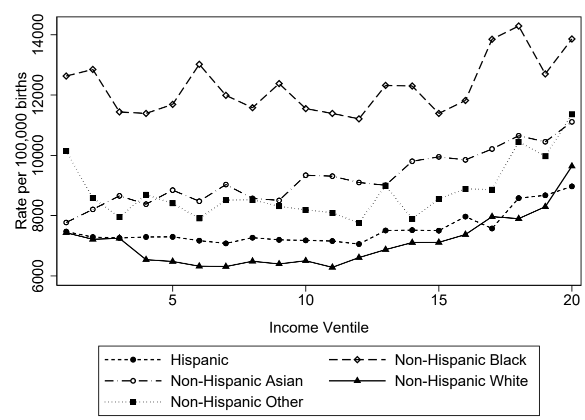
Figure 3: California Infant and Maternal Health Income Gradients by Racial and Ethnic Groups



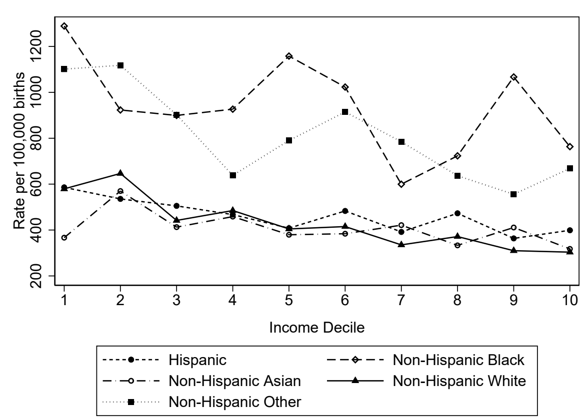
(a) Birth Weight (g)



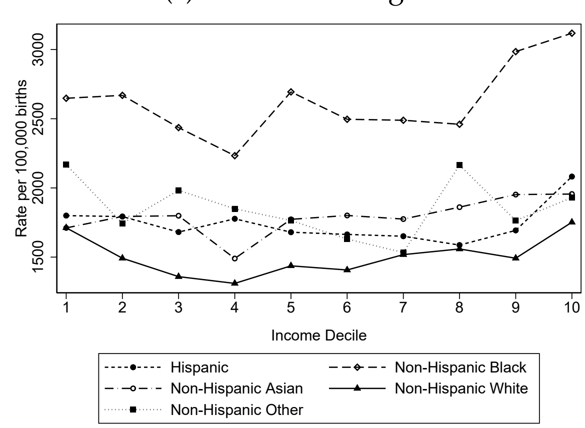
(b) Preterm Birth



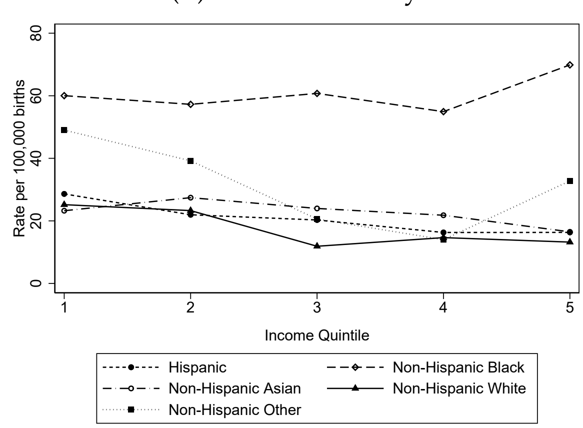
(c) Low Birth Weight



(d) Infant Mortality



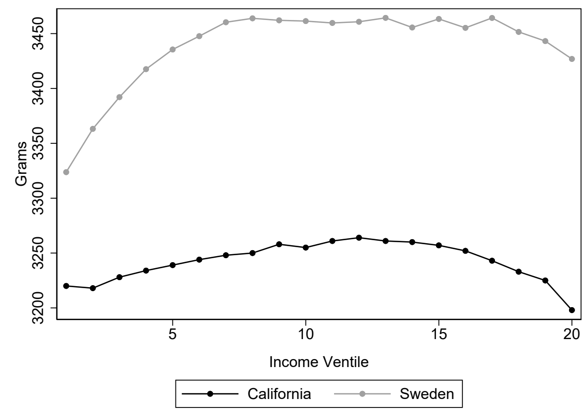
(e) Severe Maternal Morbidity



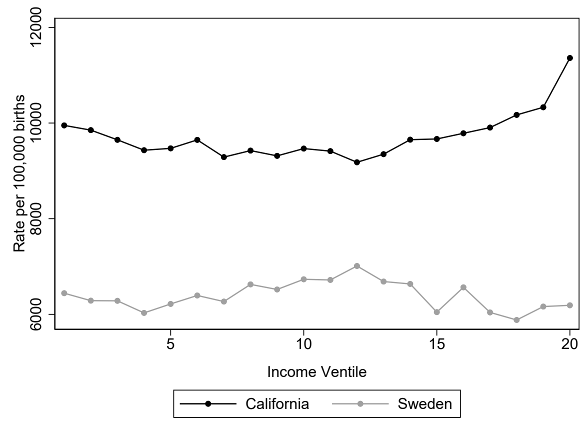
(f) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes for births to first-time mothers in California between 2007-2016 averaged within income bins corresponding to ventiles, deciles, or quintiles of the family income distribution in each birth year. Averages are separated into subgroups based on maternal race and ethnicity. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

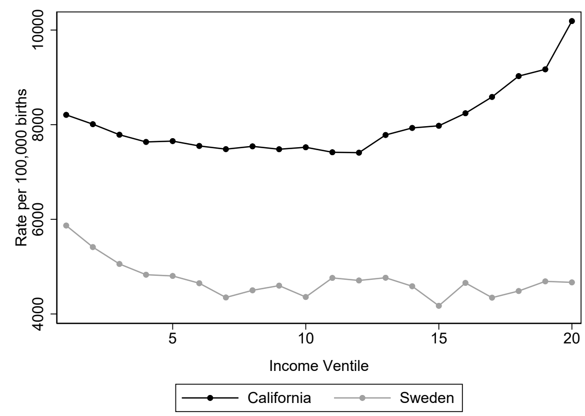
Figure 4: Infant and Maternal Health Income Gradients, California vs. Sweden



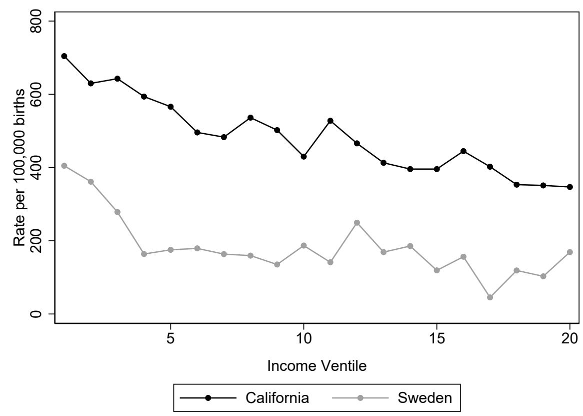
(a) Birth Weight (g)



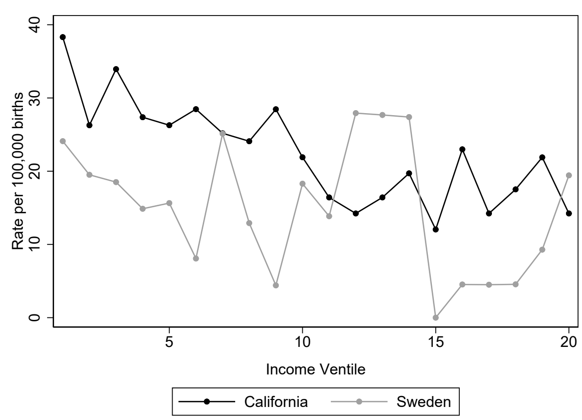
(b) Preterm Birth



(c) Low Birth Weight



(d) Infant Mortality



(e) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes for births to first-time mothers in California and Sweden between 2007-2016 averaged within income bins corresponding to ventiles of the family income distribution in each birth year. See text for more details. All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

ONLINE APPENDIX

Manuscript Title: Maternal and Infant Health Inequality: New Evidence from Linked Administrative Data

Author Names: Kate Kennedy-Moulton, Sarah Miller, Petra Persson, Maya Rossin-Slater, Laura R. Wherry, and Gloria Aldana

A Additional Details About Data, Sample, and Analyses

Identifying Parents in California Tax Records: For infants for whom we cannot find information on parents on the birth record, we do the following: First, we observe parent information on a composite administrative dataset called the Census Household Composition Key (CHCK) available for years 2016 to 2022. This dataset uses information from a variety of federal sources, including Social Security Number applications, the IRS Form 1040, and the Decennial Census, to identify the parents of each child (U.S. Census Bureau, 2020; Genadek et al., 2021). Second, for some children with missing parent information on the birth certificate or in the CHCK, we observe parents living with their children if they appear in the 2010 Decennial Census or the 2007 to 2021 waves of American Community Survey (ACS).[13]

Finally, we fill in as parents any individuals observed filing taxes with the infant listed as their dependent for the tax year corresponding to the year of birth. Specifically, if we are missing information on both parents, but we observe the infant is listed on a tax filing in the year of birth that contains information on one or two filers, then we assume the filer(s) are the missing parent(s). If infants are missing information on only one parent, we look for infants listed on tax filings where the identified parent is listed as a filer and assume the second filer is the other missing parent. In cases where the gender of the par-

[13] See Miller and Wherry (2022) for additional information on how parents are identified using family relationship variables in the Census surveys.

ent is unknown, we exclude these observations from our analysis of maternal outcomes. Using all these sources, we are able to identify the mother (father) for 94.0 percent (86.3 percent) of all the births in our sample.

Income in the California Data: To construct "AGI-like" income, we use information on AGI and taxable Social Security benefits from the US tax records, and wages from W2 forms. We also observe quarterly data from the state unemployment insurance (UI) system through the Longitudinal Employer-Household Dynamics (LEHD) file for 12 states: Arizona, California, DC, Delaware, Kansas, Maine, Maryland, Nevada, North Dakota, Oklahoma, Tennessee, and Wisconsin. These data are available from 2005 to 2014. We use earnings information from the LEHD for only a very small number of cases—about 0.1 percent of our sample—in which earnings are missing in the W-2 filings but non-missing in the LEHD records.

Specifically, for each parent, we use:

- If parent filed: AGI-like income = AGI−taxable Social Security benefits
- If parent did not file: AGI-like income = wage earnings

After calculating the AGI-like income for each parent that we can observe in the data, we determine the family AGI to be:

- If the mother filed jointly: Family AGI-like income = joint parent income
  - For the few cases in which the mother's AGI does not match the father's AGI (for example, sometimes one of the parent's AGI is recorded as 0 while the other is not), we use the parent with the higher AGI
- If the mother did not file jointly, we construct the family AGI as the sum of each parent's separate AGI-like income, where:
  - If we have both parents' incomes: Family AGI-like income = mother's AGI-like income + father's AGI-like income

– If we only have one parent's income: Family AGI-like income = that parent's AGI-like income

For parents who are dependents themselves, we consider the dependent's AGI and Social Security benefits to be the one reported in the federal tax records; this is likely their household income.

We are unable to observe a parent's income for two reasons: (i) we cannot identify the parent for a given child, or (ii) we have the parent's identifier but their income is missing. When either case occurs, we use only the observable parent's income as the family AGI-like income.

Family income ranking at birth is assigned based on the average of family AGI-like income in the two years before the child was born relative to other families with first-born children in the same birth cohort. For a child born in year t, the average family income is defined as:

$$AvgFamilyIncome_t = \frac{FamilyAGI_{t-1} + FamilyAGI_{t-2}}{2}$$

If the family AGI-like income is available for only one of the two years prior to the birth, we use that year's income as the $AvgFamilyIncome_t$ instead of calculating the average between years. Additionally, if family AGI is negative in either year, missing, or reported to be 0, the child is dropped from the main analysis sample and considered separately. Those with missing, negative, or zero income are likely comprised of a combination of families for whom we are unable to identify the parents, or those who have no earnings and rely exclusively on transfer payments, have only income from investments, primarily have income abroad that is not reported in the US tax data, are not successfully linked to their W2 (due to, e.g., an incorrect entry of their SSN), or have another source of support (such as living with parents or other family) that we are unable to identify. Since this is a heterogeneous group, and we are unable to identify the reason that income is missing, negative, or zero, we report outcome averages for this group separately.

Average outcomes for these families are reported in Appendix Table B1.

Infant Mortality in the California Data: Our measure of infant mortality in California is primarily based on infant death information from the California Department of Health Care Access and Information (HCAI) Linked Birth Files, which have mortality information from the California Department of Public Health (CDPH) Birth Cohort Files. These annual files are issued by the CDPH approximately 12 months after the end of the calendar year. Our research team has linked these records to confidential versions of the 2007-2011 Birth Statistical Master Files (BSMF) received directly from CDPH, and which contain the identifying information for the child and parents used in our analyses. The BSMF files are generated at an earlier time point than the Birth Cohort File, at approximately ten months after the end of the calendar year, and do not include any additional records, amendments, or updates made following file generation. For this reason, there are slight differences in the infant mortality rates estimated for births in our data source (BSMF linked to the Birth Cohort File) and those published by CDPH using the Birth Cohort File alone.[14]

Appendix Table B2 reports the infant mortality rates for California residents by year calculated from the data used in our analyses, as described above.

Swedish Data Sources: We obtained Medical Birth Records (MBR) from 2007 through 2016, as well as death records from 2007 through 2017, from the National Board of Health and Welfare (Socialstyrelsen, 2019). The MBR contains information on all pregnancies carried to at least 22 weeks of gestation.[15] It records the pregnancy outcome (live birth or stillbirth), birth weight, gestation length, and singleton versus multiple birth indicators.

The death records contain exact date of death, allowing us to construct infant and

[14] Additional documentation on each of these data sources and their differences may be found in the Birth Data Sources Comparison Chart on the CDPH website.

[15] Prior to July 1, 2008, the MBR contained all pregnancies carried 28 weeks or longer.

maternal mortality. Similar to California, infant deaths that occur very early are undercounted in the administrative deaths data, as an infant may not have been issued a *Personnummer* (the Swedish equivalent of a Social Security Number) before dying. To get better coverage of the early infant deaths, we therefore also use a variable from the MBR that indicates death within one month of birth. As a result, we are able to closely match publicly available statistics on Swedish infant and neonatal mortality rates—i.e., we are sure that we are not undercounting the overall Swedish infant death rate in our analysis sample.

We note that we are unable to construct an SMM indicator in the Swedish data because the hospitalizations data only contain 3-digit ICD codes, which are not specific enough to capture this outcome accurately (the CDC definition relies on 5-digit codes). Thus, we omit this outcome from the Swedish comparison.

To link children to their biological parents, we use family linkage data from Statistics Sweden. We are able to identify all (100 percent of) mothers and 97.7 percent of fathers. We also observe birth order in the family linkage data, which we use to identify firstborn children.[16] We merge these data to Statistics Sweden's longitudinal database of individuals (LISA) from 2005 through 2016, which contains information drawn from various administrative records (Statistics Sweden, n.d.). These data allow us to observe parent demographics, as well as various third-party reported individual income measures.

Income in the Swedish Data: Using administrative data from Statistics Sweden, we construct an individual-level "AGI-like" income measure for each parent. Specifically, we take the sum of income from employment and work-related benefits, positive income from active self-employment, income from passive self-employment, capital income, unemployment benefits, educational transfers, income during studies from different education support programs, income from military service, parental leave benefit income,

[16] When birth order is missing, we impute birth order using birth history.

income from benefits for taking care of a child who is sick or disabled, and income from benefits for taking care of a young child at home.

After calculating the AGI-like income for each individual, we determine the family AGI to be:

- If we have both parents' incomes: Family AGI-like income = mother's AGI-like income + father's AGI-like income
- If we only have one parent's income: Family AGI-like income = that parent's AGI-like income

As in California, we average the sum of the family AGI-like income across the 2 years prior to birth. We similarly exclude from our main analysis sample births that have no observed measures of income, those for whom income is reported as exactly $0, and those for whom family income is negative in either year prior to birth. Average outcomes for these families are reported in Appendix Table B1.

Family income ranking at birth is defined the same as in the California data.

Analysis samples and outcomes: Our primary analysis sample includes all California births to first-time mothers. We construct the analogous sample in the Swedish data.

- **Main birth outcomes and maternal mortality (2007–2016):** We observe birth weight, gestation length, and maternal mortality for all years 2007–2016, so we use this sample for analyzing these outcomes in both California and Sweden.
- **Severe maternal morbidity (2007–2012):** For severe maternal morbidity, we rely on the HCAI data which covers birth cohorts 2007–2012. Thus, in the California data, we restrict the analysis sample to births within 2007–2012 which link to the HCAI data. As noted, we do not analyze this outcome in the Swedish data.
- **Infant mortality (2007–2011):** The infant mortality indicators which we use to supplement the Numident file are only available in the HCAI data for births from 2007

to 2011. Therefore, we restrict the analysis sample for infant mortality to the subset of 2007–2011 births which link to the HCAI data. In the Swedish analysis, we restrict to the 2007–2011 birth cohorts.

B Appendix Tables

Table B1: Average of Infant and Maternal Health Outcomes for Missing, Negative, or Zero Family Income Births

	California		Sweden	
	Mean	N	Mean	N
Birth Weight	3213	214000	3318	18849
Low Birth Weight	0.07837	214000	0.05735	18849
Preterm	0.09902	214000	0.06180	18884
Infant Death	0.006217	120000	0.002396	9600
Maternal Morbidity	0.01816	138000	-	-
Maternal Death	0.0002942	214000	0.000264	18907

Notes: Table presents average outcomes associated with births to mothers where family income is missing, negative, or zero for the two years prior to the birth year. All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

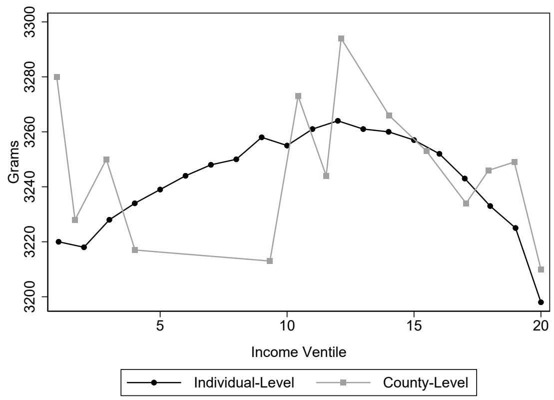
Table B2: Infant Mortality Rates for California Residents by Year

Year	Total deaths	Total births	IMR per 1,000 births
2007	2,912	566,125	5.14
2008	2,804	551,557	5.08
2009	2,541	526,770	4.82
2010	2,420	509,968	4.75
2011	2,345	502,019	4.67

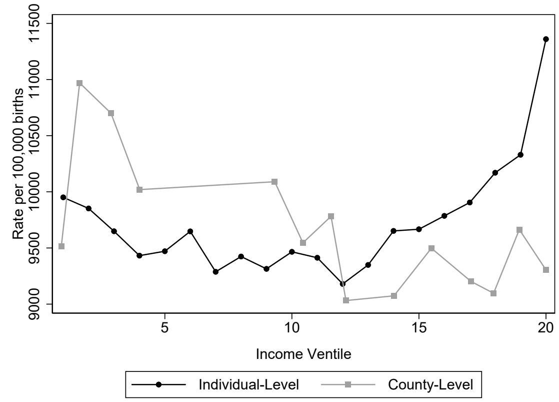
Notes: Table presents total infant deaths and total infant births calculated from the 2007-2011 HCAI Linked Birth Files merged to the 2007-2011 CDPH Static Birth Statistical Master Files used in our analyses. Following the methodology used for official CDPH infant mortality statistics, these numbers exclude non-California residents.

C Appendix Figures

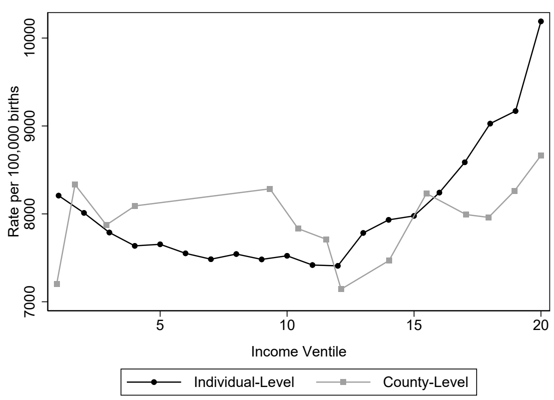
Figure C1: California Infant and Maternal Health Income Gradients, Individual Family Income vs. County-Level Median Income



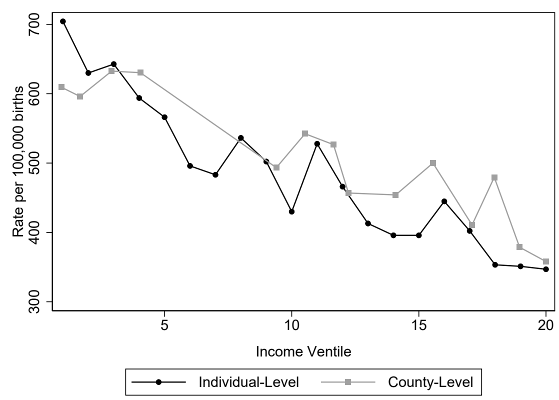
(a) Birth Weight (g)



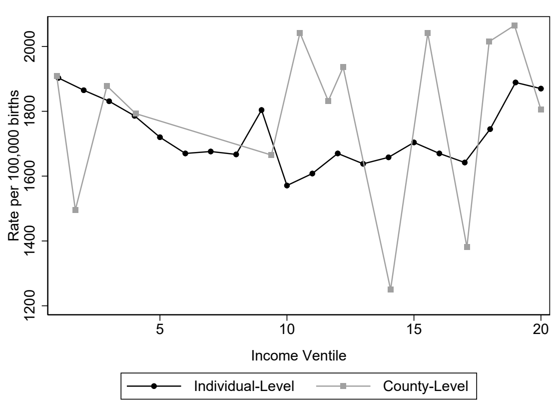
(b) Preterm Birth



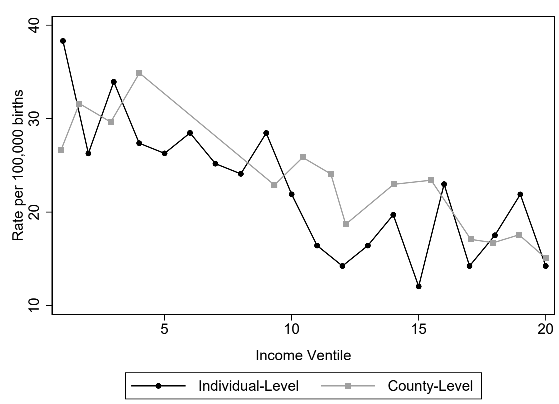
(c) Low Birth Weight



(d) Infant Mortality



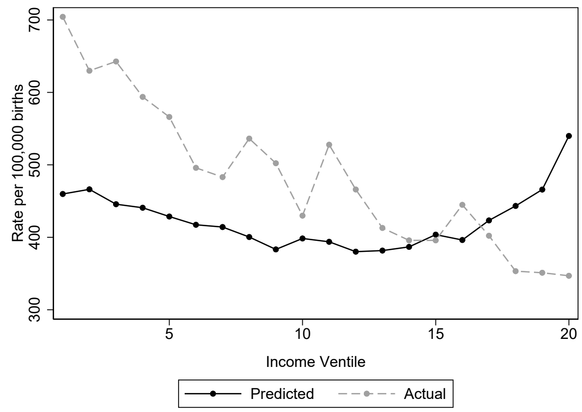
(e) Severe Maternal Morbidity



(f) Maternal Mortality

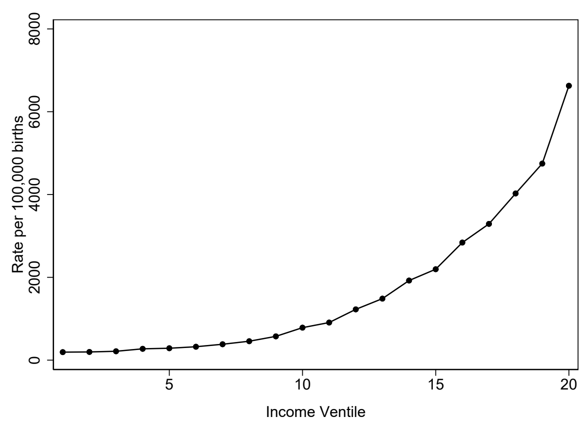
Notes: Figure plots infant and maternal health outcomes based on births to first-time mothers in California between 2007-2016 averaged within income bins of the family income distribution, calculated either using individual family incomes (in the darker series with circles) or based on county-level median income (in the lighter series with squares). See text for more details about the family income calculation. The county groupings are formed by ranking counties by median household income measured in the 2010 Small Area Income and Poverty Estimates (SAIPE) Program of the US Census Bureau, and then combining counties into 5 percent groups as closely as possible. Larger counties (e.g., Los Angeles county, which accounts for 26 percent of births in California) are in their own bin. There are 14 county-level bins and 20 individual-level bins in total. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY23-0405 and CBDRB-FY25-0462.

Figure C2: Predicted versus Actual Infant Mortality Income Gradients



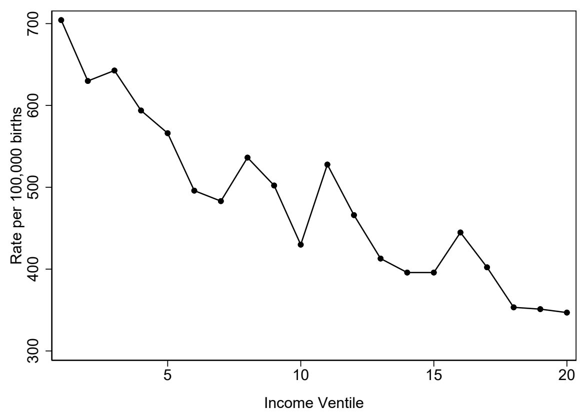
Notes: Figure plots predicted infant mortality (in black solid line) and actual infant mortality (in dashed grey line) based on births to first-time mothers in California between 2007 and 2011, averaged within income bins corresponding to ventiles of the family income distribution in each birth year. Predicted infant mortality is generated from a regression of infant mortality on birth weight, a low-birthweight indicator, gestation length, and a preterm birth indicator. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY23-0405.

Figure C3: California Assisted Reproductive Technology (ART) Use Income Gradient

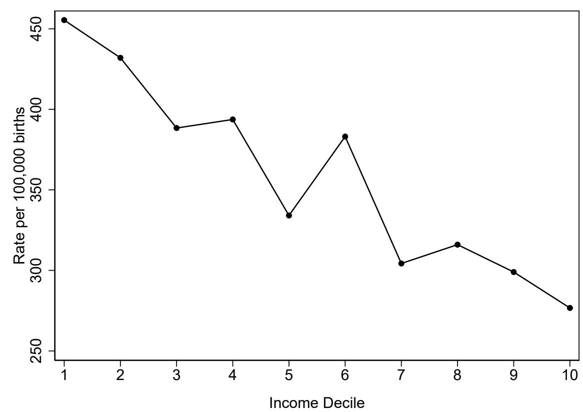


Notes: Figure plots assisted reproductive technology (ART) use rates based on births to first-time mothers in California between 2007 and 2016, averaged within income bins corresponding to ventiles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY23-0405.

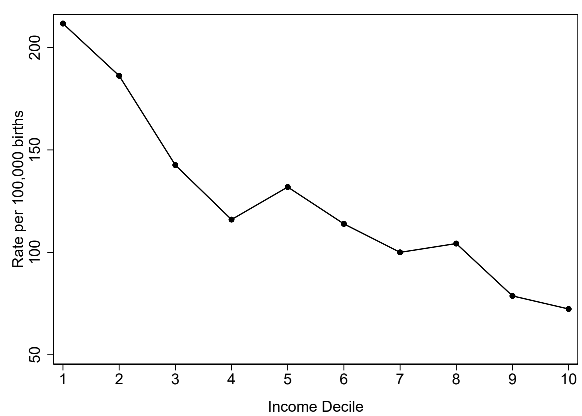
Figure C4: California Infant Mortality Income Gradients: Neonatal vs. Post-Neonatal Mortality



(a) Infant Mortality



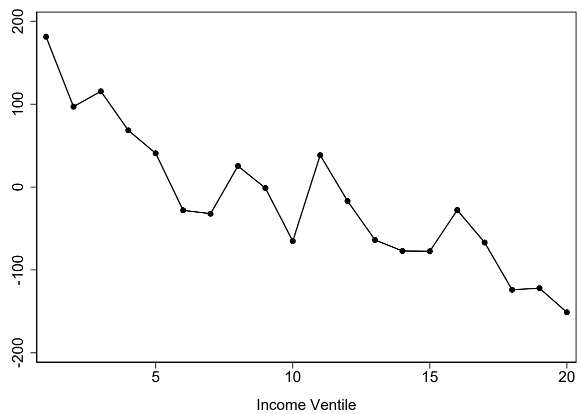
(b) Neonatal Mortality



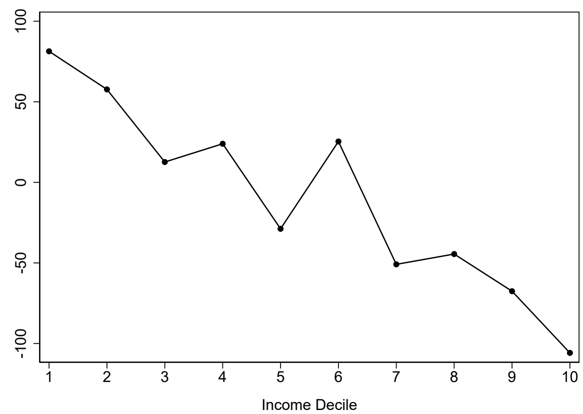
(c) Post-Neonatal Mortality

Notes: Figure plots infant mortality outcomes based on births to first-time mothers in California between 2007-2011 averaged within income bins corresponding to ventiles or deciles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

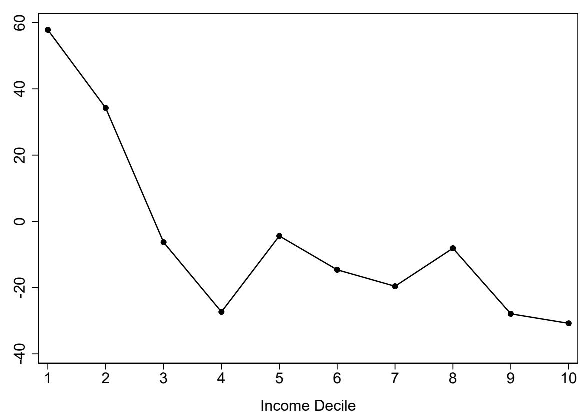
Figure C5: California Residualized Infant Mortality Income Gradients: Including Hospital Fixed Effects



(a) Infant Mortality



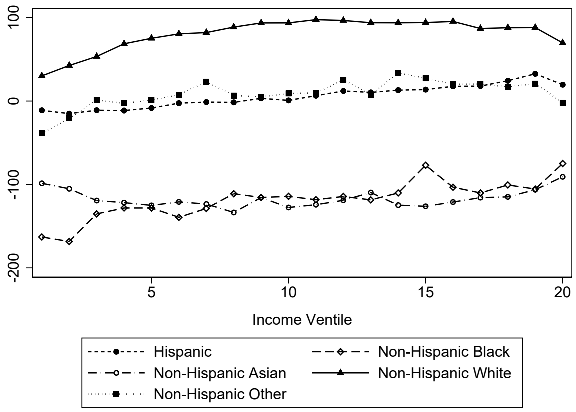
(b) Neonatal Mortality



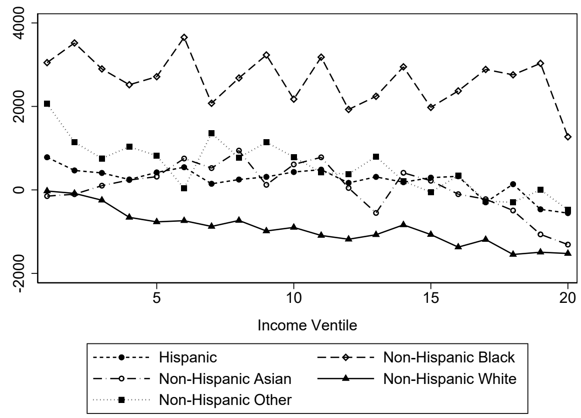
(c) Post-Neonatal Mortality

Notes: Figure plots average of residuals from a regression of measures of infant mortality outcomes on maternal age, non-singleton birth, and childbirth hospital fixed effects. The analysis used data on births to first-time mothers in California between 2007-2011. Binned residuals are plotted against income bins corresponding to ventiles or deciles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

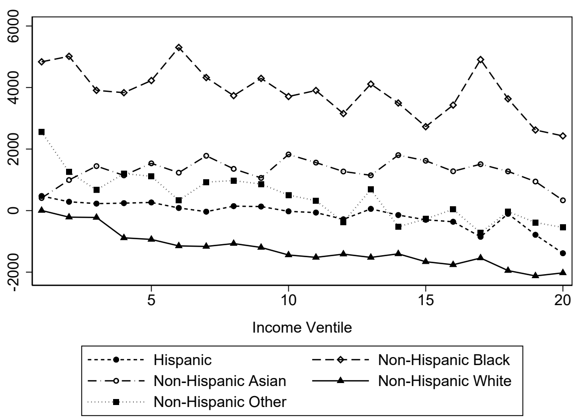
Figure C6: California Residualized Infant and Maternal Health Income Gradients by Racial and Ethnic Groups



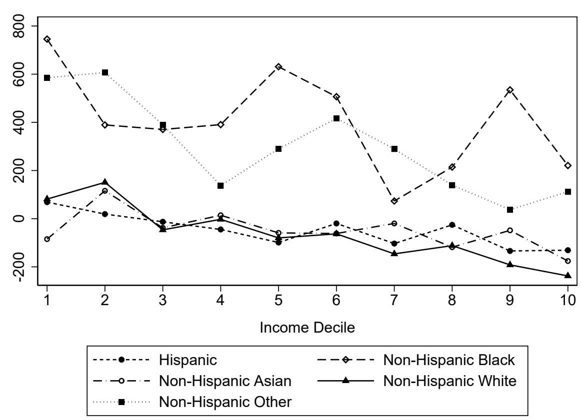
(a) Birth Weight (g)



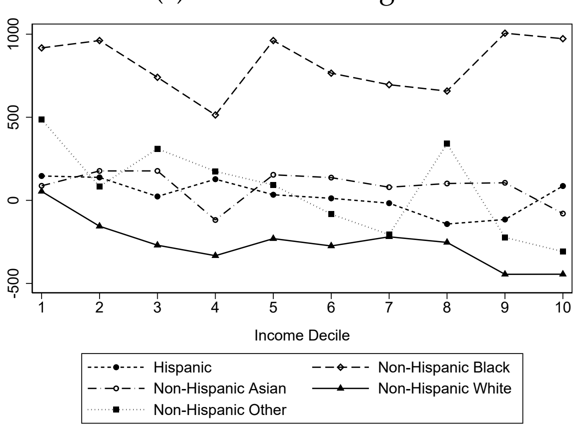
(b) Preterm Birth



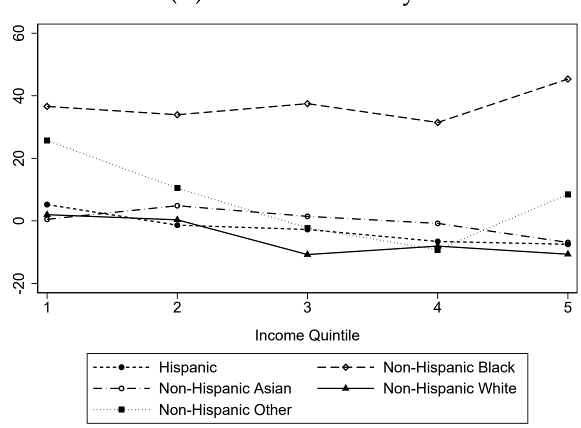
(c) Low Birth Weight



(d) Infant Mortality



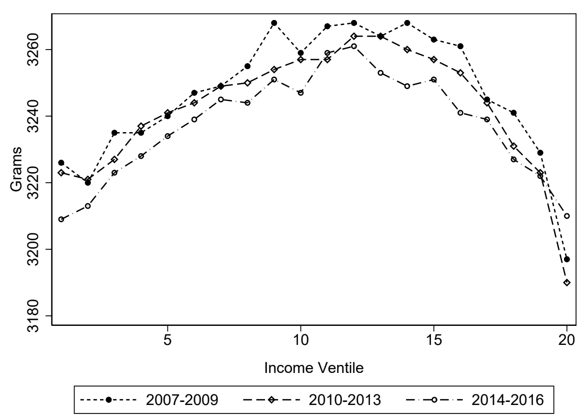
(e) Severe Maternal Morbidity



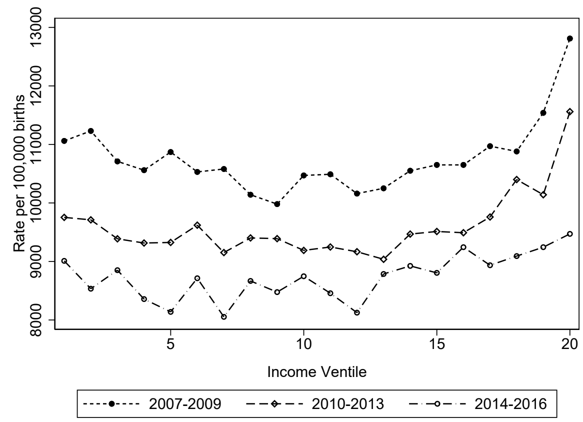
(f) Maternal Mortality

Notes: Figure plots average of residuals from a regression of measures of infant and maternal health on maternal age and non-singleton birth. The analysis used data on births to first-time mothers in California between 2007-2016. Binned residuals are plotted against income bins corresponding to ventiles, deciles, or quintiles of the family income distribution in each birth year, separated into subgroups based on maternal race and ethnicity. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

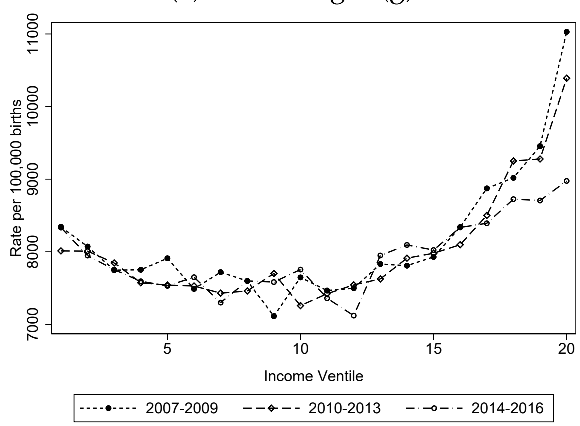
Figure C7: California Infant and Maternal Health Income Gradients, By Time Period



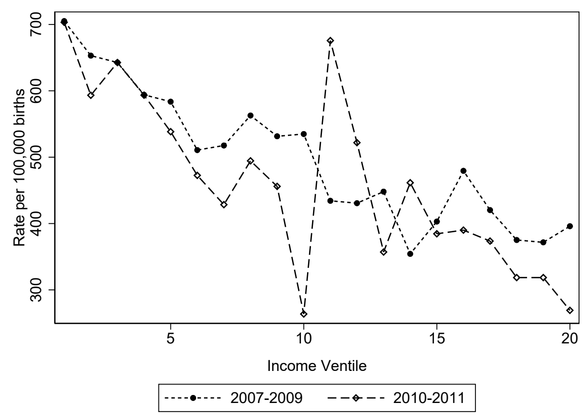
(a) Birth Weight (g)



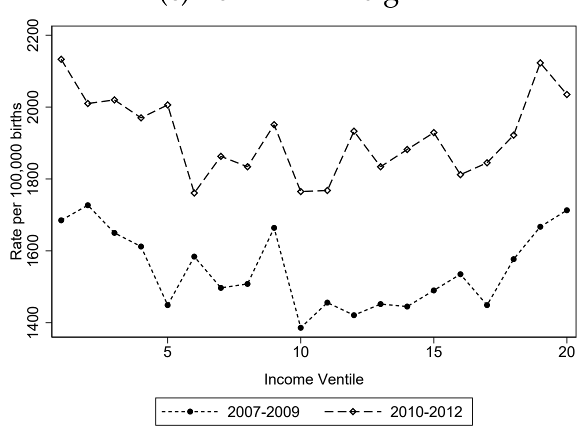
(b) Preterm Birth



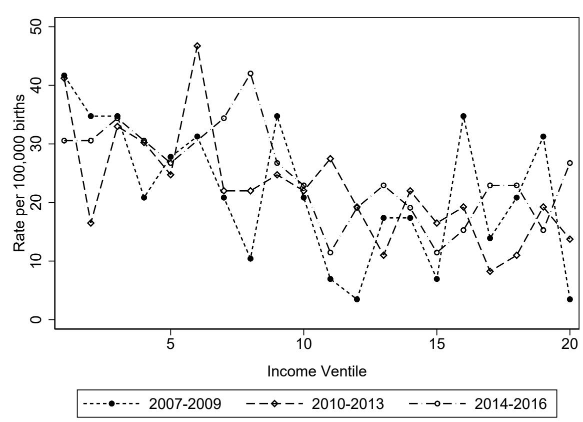
(c) Low Birth Weight



(d) Infant Mortality



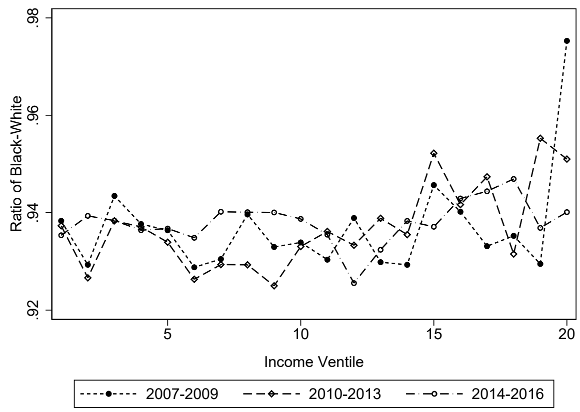
(e) Severe Maternal Morbidity



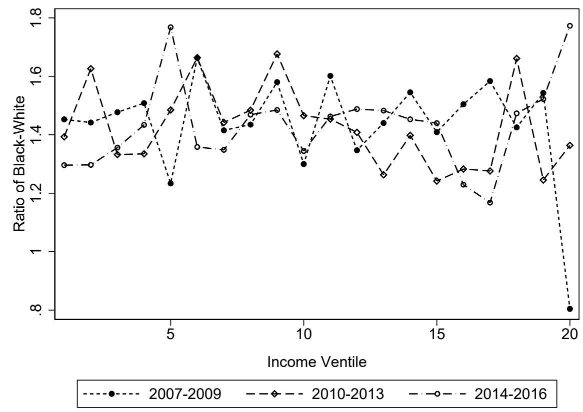
(f) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes for births to first-time mothers in California over three time periods (2007-2009, 2010-2013, and 2014-2016) within income bins corresponding to ventiles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

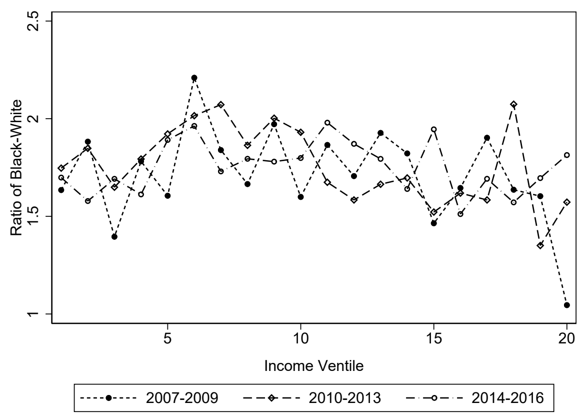
Figure C8: California Infant and Maternal Health Income Gradients in Black/White Differences, By Time Period



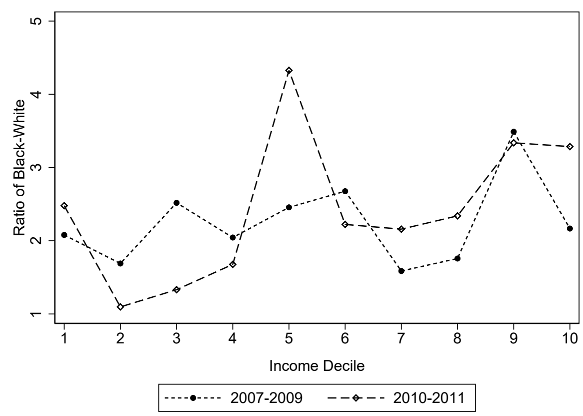
(a) Birth Weight (g)



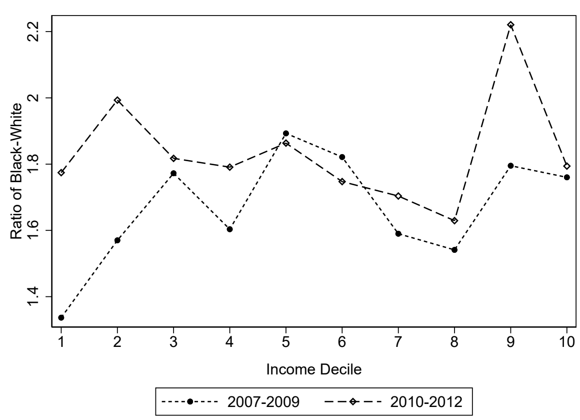
(b) Preterm Birth



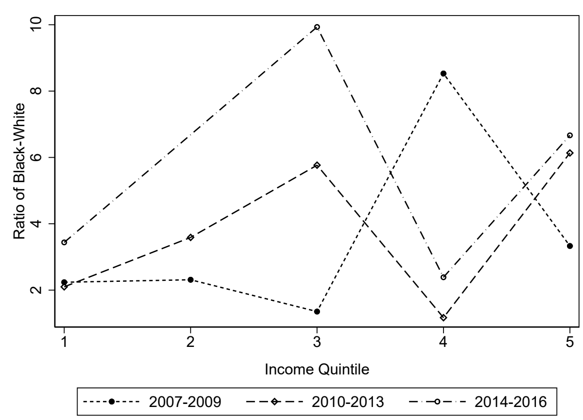
(c) Low Birth Weight



(d) Infant Mortality



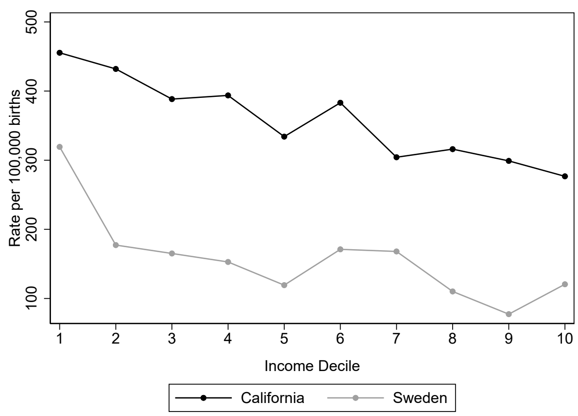
(e) Severe Maternal Morbidity



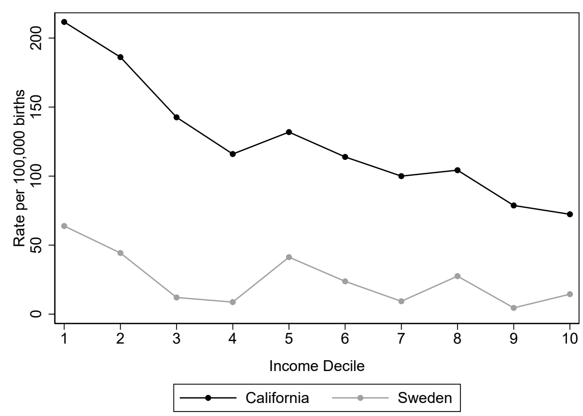
(f) Maternal Mortality

Notes: Figure plots the ratios of mean infant and maternal health outcomes for Black vs. white mothers, among first-time mothers in California over three time periods (2007-2009, 2010-2013, and 2014-2016) within income bins corresponding to ventiles of the family income distribution in each birth year. See text for more details. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

Figure C9: Infant Mortality Income Gradients: Neonatal vs. Post-Neonatal Mortality, California vs. Sweden



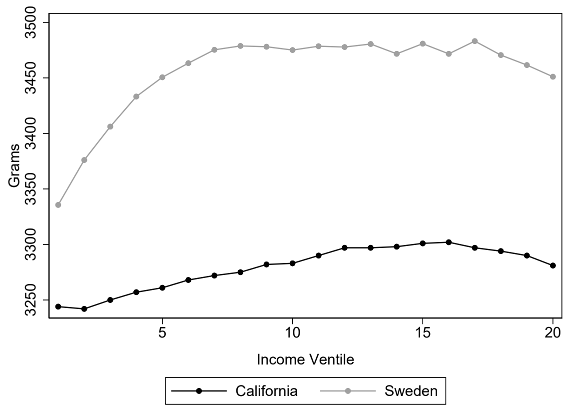
(a) Neonatal Mortality



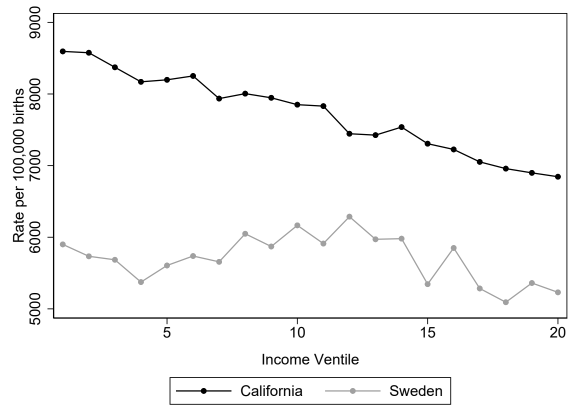
(b) Post-Neonatal Mortality

Notes: Figure plots infant mortality outcomes based on births to first-time mothers in California and Sweden between 2007-2011 averaged within income bins corresponding to deciles of the family income distribution in each birth year. See text for more details. All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

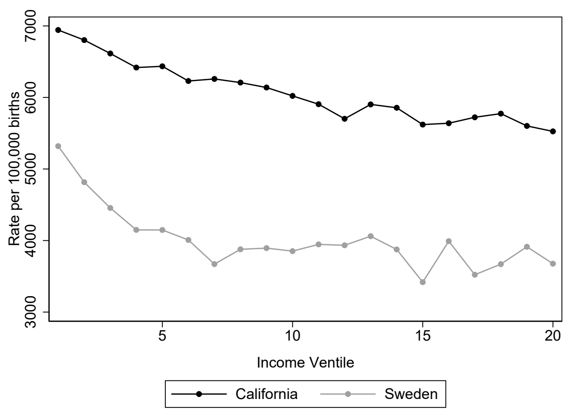
Figure C10: Infant and Maternal Health Income Gradients, California vs. Sweden using Chen, Oster & Williams (2016) Sample Restriction



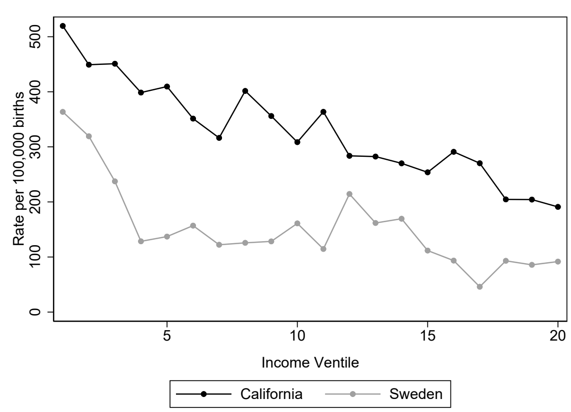
(a) Birth Weight (g)



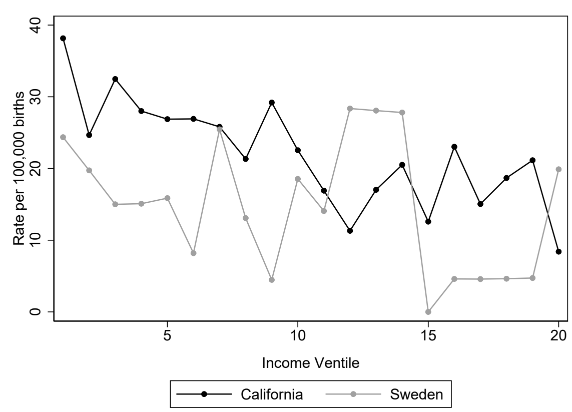
(b) Preterm Birth



(c) Low Birth Weight



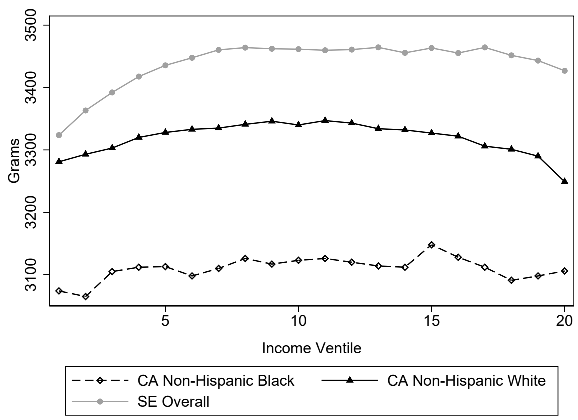
(d) Infant Mortality



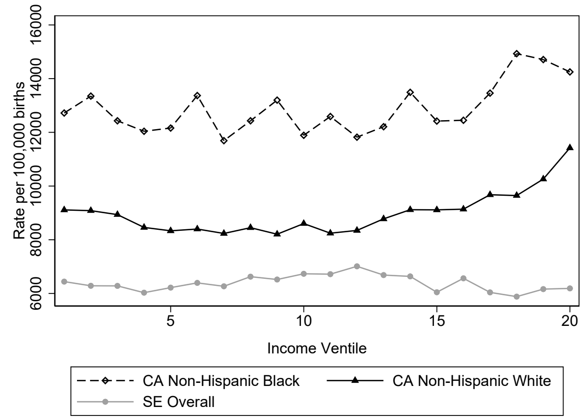
(e) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes based on births to first-time mothers in California and Sweden between 2007-2016 averaged within income bins corresponding to ventiles of the family income distribution in each birth year. The sample here is limited to singleton births with gestation length of at least 22 weeks and birth weight of at least 500 grams, following Chen et al. (2016). All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

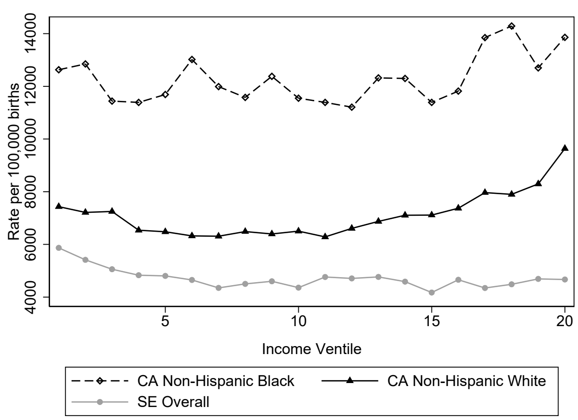
Figure C11: Infant and Maternal Health Income Gradients by Racial and Ethnic Groups, California vs. Sweden



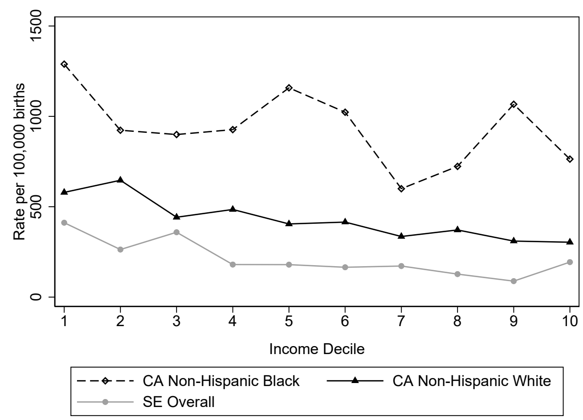
(a) Birth Weight (g)



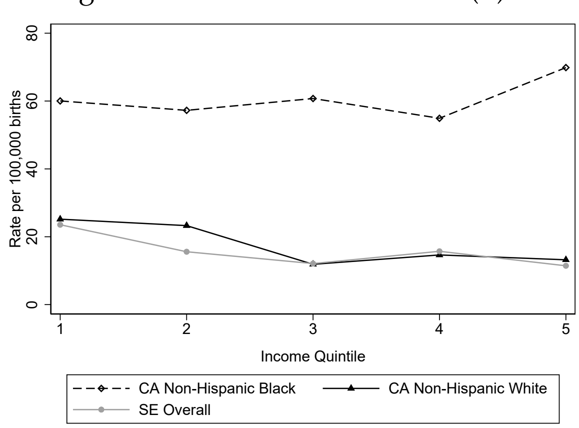
(b) Preterm Birth



(c) Low Birth Weight



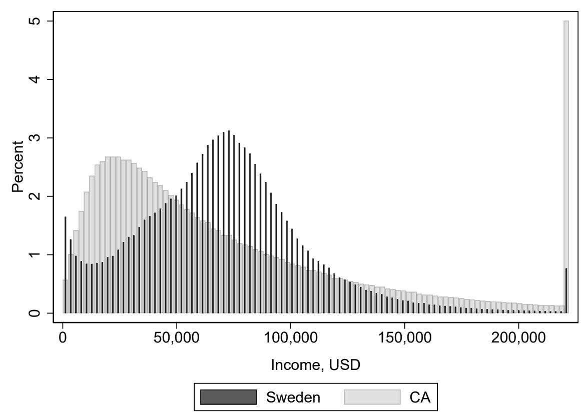
(d) Infant Mortality



(e) Maternal Mortality

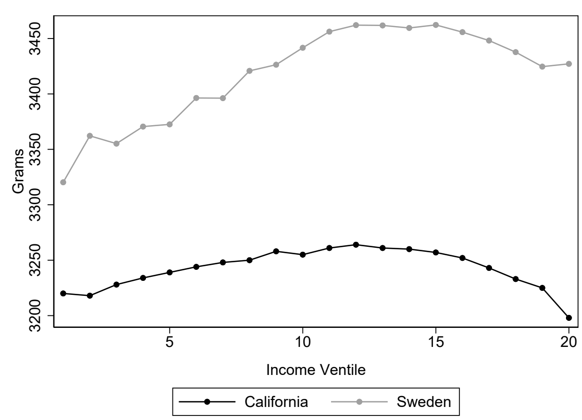
Notes: Figure plots infant and maternal health outcomes for births to first-time mothers in California and Sweden between 2007-2016 averaged within income bins corresponding to ventiles, deciles, or quintiles of the family income distribution in each birth year. Averages are separated into subgroups based on maternal race and ethnicity. See text for more details. All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

Figure C12: Family Income Distributions in California vs. Sweden

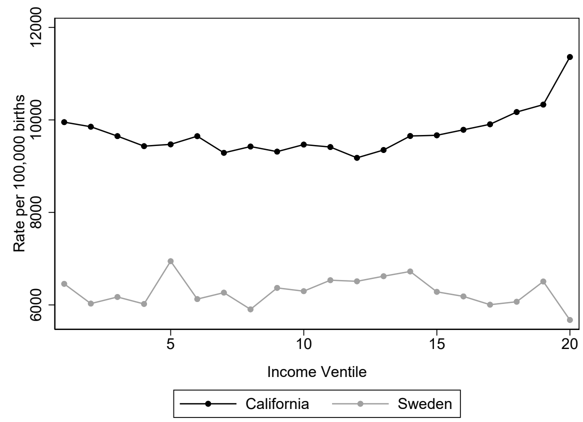


Notes: Figure plots histograms of the income distributions of our two samples of births to first-time mothers between 2007 and 2016 in California and Sweden. The distribution is truncated at the 95th percentile of the California income distribution. All results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

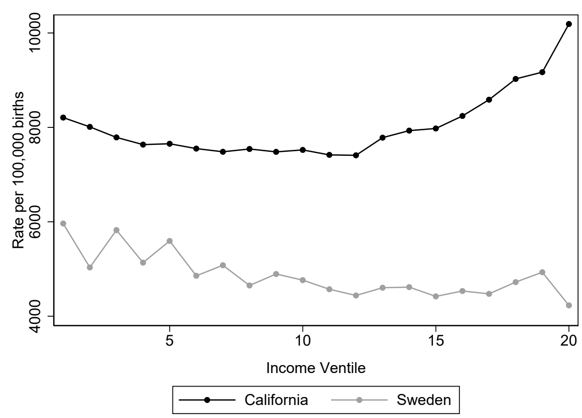
Figure C13: Infant and Maternal Health Income Gradients, Swedish Comparison using CA Percentiles



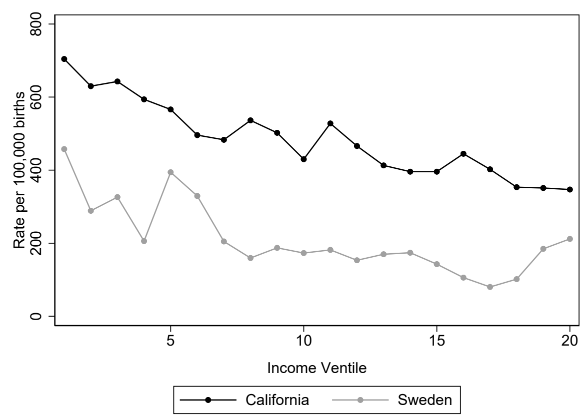
(a) Birth Weight (g)



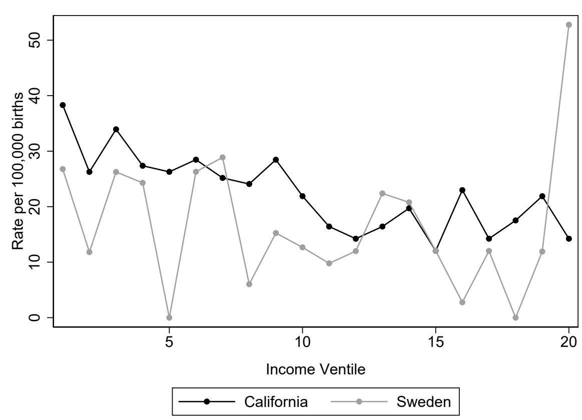
(b) Preterm Birth



(c) Low Birth Weight



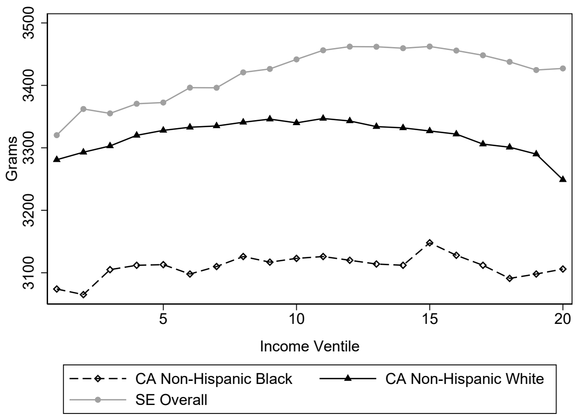
(d) Infant Mortality



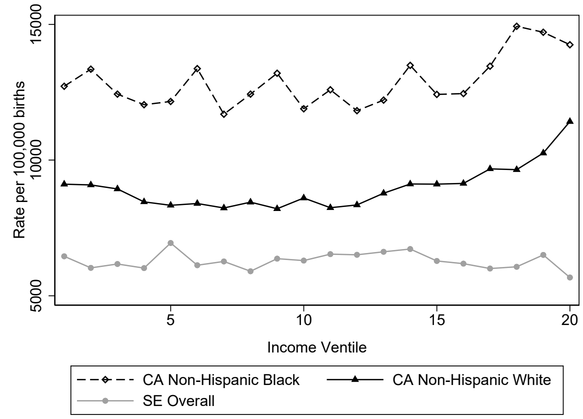
(e) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes based on births to first-time mothers in California and Sweden between 2007-2016 averaged within income bins corresponding to ventiles of the family income distribution in each birth year. The income bins are defined using the California income percentiles by birth year. See text for more details. All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.

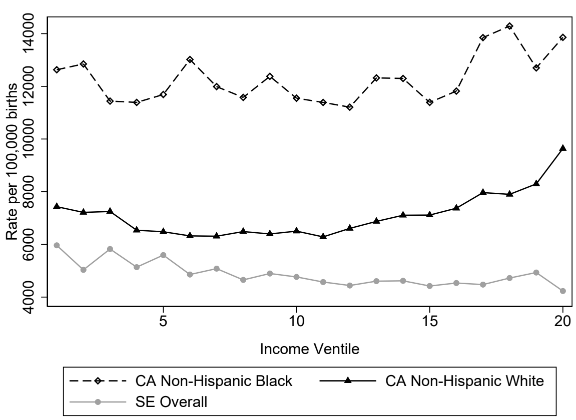
Figure C14: Infant and Maternal Health Income Gradients by Racial and Ethnic Groups, Swedish Comparison using CA Percentiles



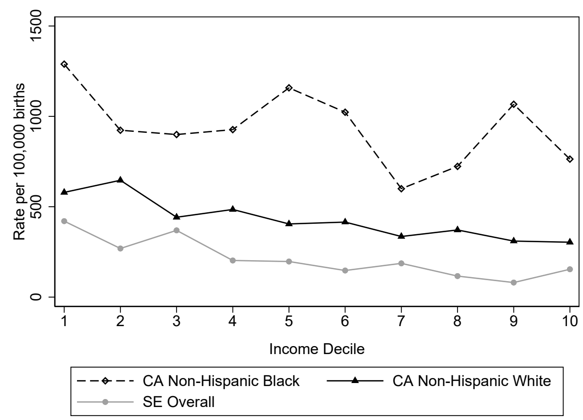
(a) Birth Weight (g)



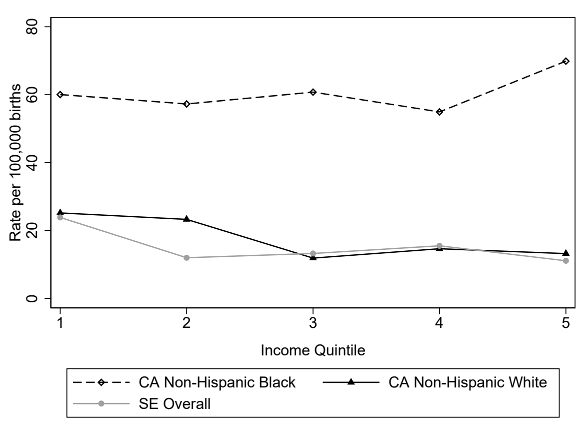
(b) Preterm Birth



(c) Low Birth Weight



(d) Infant Mortality



(e) Maternal Mortality

Notes: Figure plots infant and maternal health outcomes based on births to first-time mothers in California and Sweden between 2007-2016 averaged within income bins corresponding to ventiles, deciles, or quintiles of the family income distribution in each birth year. The income bins are defined using the California income percentiles by birth year. Averages are separated into subgroups based on maternal race and ethnicity. See text for more details. All California results were approved for release by the U.S. Census Bureau, authorization number CBDRB-FY25-0462.