Love in the Time of Zika*

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Abstract

We study how an aggregate fertility decline shapes women's labor-market behavior and family formation, and whether these behavioral adjustments contribute toward sustaining the fertility decline. Brazil's late-2015 disclosure of severe fetal risks from Zika sharply raised the perceived cost of pregnancy, despite the virus causing mild symptoms in most adults. We link administrative birth and marriage records with labor-force survey data and compare changes across areas using three complementary measures of Zika exposure: publicized case prevalence, environmental suitability for the *Aedes aegypti* mosquito, and Google search activity. Across measures, births fell by 10.7 percent in the most exposed areas and did not subsequently rebound, indicating that many missing births were foregone rather than postponed. Women's employment and earnings rose beginning nine months after the health emergency declaration, averaging a post-Zika increase of 1.55 percentage points in employment and 43.6 reais in earnings. Family formation also changed: divorces increased by 11.8 percent, on average, while marriages rose by 4.0 percent with roughly a one-year lag. Together, the persistent changes in births, work, and relationships are consistent with a dynamic process in which adjustments following the initial fertility shock may help sustain lower fertility. More broadly, our findings show how aggregate fertility reductions, rather than individual birth events, can reshape women's labor-market trajectories and family formation, with implications for understanding persistent fertility declines worldwide.

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1 Introduction

Individual childbearing decisions have lasting consequences for women's lives. Motherhood is associated with persistent earnings penalties, changes in hours and occupations, and widening gender pay gaps (Adda et al., 2017; Kleven et al., 2019a; Sieppi and Pehkonen, 2019; Berniell et al., 2021; Cortés and Pan, 2023; Machado et al., 2024). Fertility, childrearing, and household obligations shape marriage, marital stability, and family formation (Becker et al., 1977; Vuri, 2003; Dahl and Moretti, 2008; Jena et al., 2011; Gobbi et al., 2026; Doepke et al., 2023; Bau, 2021; Bau et al., 2026). Yet evidence centered on individual childbearing decisions tells us less about what happens when fertility declines across a population, reshaping labor markets and household structure in ways that may help sustain the decline. In countries across the income spectrum, fertility rates have fallen sharply and often remained low, while female labor-force participation has risen. Brazil is emblematic of this transition: total fertility declined from more than six births per woman in the 1960s to well below replacement level today, while women's labor-force participation rose from about 20 percent in the 1970s to more than 50 percent in recent years (World Bank, 2025). Do fewer births relax time and mobility constraints enough to raise women's employment and earnings? Do changes in fertility incentives alter marital decisions, relationship stability, and household structure? And if fertility declines change work and family formation, can these responses make the initial decline in births more persistent?

Answering these questions is empirically challenging because fertility, work, and family formation are jointly determined. Women with stronger labor-market preferences may delay or forgo childbearing, marry later, or select different partners. Women with stronger preferences for children may marry earlier or reduce their labor supply. These choices make it difficult to distinguish the effects of fertility from the preferences, constraints, and relationship dynamics that shape fertility itself (Rosenzweig and Wolpin, 1980; Becker et al., 1977; Doepke and Kindermann, 2019). Moreover, most existing evidence concerns an individual family having an additional child, often in high-income contexts. To understand the consequences and *persistence* of *aggregate* fertility *declines*, we need variation across labor and marriage markets rather than individual families, reductions rather than additional births, and enough time to observe whether fertility remains low as work and family choices adjust.

We address this identification challenge by leveraging Brazil's Zika epidemic as a sudden, geographically uneven shock to the perceived cost of pregnancy. The Zika virus spread rapidly through Brazil in the mid-2010s and caused mild or no symptoms in most adults, but infection during pregnancy posed severe risks to fetal development (Brasil et al., 2016; Mlakar et al., 2016; Haby et al., 2018; Codeço Coelho et al., 2017). Public awareness of these fetal risks rose sharply in late 2015, after unusual clusters of microcephaly were identified in October and Brazil declared a national public health emergency in November; concern was reinforced when the World Health Organization declared a public health emergency of international concern in February 2016. Unlike pandemics such as COVID-19, Zika did not trigger broad economic shutdowns or widespread restrictions on work and mobility. The primary policy response instead focused on mosquito control and public information campaigns. This makes Zika an unusually clean setting in which health-related fetal risk changes women's childbearing behavior without directly disturbing aggregate labor demand or broader macroeconomic conditions.

The perceived fetal risks from Zika led women to delay or avoid pregnancies, producing large fertility declines in exposed regions (Marteleto et al., 2017, 2020; Marteleto and Dondero, 2021; Lautharte and Rasul, 2026; Rangel et al., 2020; Ryu, 2020). We identify these responses by combining administrative birth records with three independent measures of Zika exposure: publicized local case prevalence, environmental suitability for the *Aedes aegypti* mosquito, and municipality-level Google search intensity for "Zika." We then contribute to the broader literature on childbearing and fertility along three dimensions. First, we move from changes in fertility within an individual family to an aggregate fertility shock operating across local labor and marriage markets. Second, rather than studying birth events or additional children, we study a reduction in fertility, the relevant margin for understanding worldwide declines in birth rates. Third, we trace the dynamics of adjustment after the initial fertility shock, examining whether missing births are merely postponed or persist as women's employment, earnings, and relationship choices change. Our analysis therefore connects the initial decline in births to subsequent changes across fertility, work, and family domains in a middle-income economy.

We find three main results. First, using monthly administrative birth records linked to three measures of Zika exposure, we show that fertility fell sharply in high-exposure areas beginning nine months after Brazil's national health emergency declaration. Across exposure measures, births fell by 10.7 percent in the affected areas, with the timing consistent with pregnancy avoidance rather than termination. This decline was not followed by a compensating rebound, resulting in five percent fewer babies born between the announcement of the national emergency and the end of 2019. The decline was concentrated among women without children, resulting in 21.7 percent fewer new mothers in that same time period. These missing births were foregone, not simply postponed.

Second, women's labor-market outcomes improved in high-exposure areas. Using quarterly microdata from the nationally representative *Pesquisa Nacional por Amostra de Domicílios Contínua* (PNAD-C), we find that women's employment rose an average of 1.5 percentage points over the post-Zika period. This increase began roughly nine months after the fertility shock, closely tracks the gestational window. This timing supports the interpretation that the labor-market effects operate through changes in fertility rather than direct effects of the epidemic itself. Monthly earnings increased by an average of 43.6 reais, roughly 5.5 percent of mean pre-epidemic earnings for women ages 20 to 34, with gains emerging gradually. Employment and earnings gains persisted even after the initial fertility decline, consistent with the possibility that avoided births changed women's labor-market trajectories rather than only their short-run time constraints. Taken together, these patterns provide an aggregate counterpart to evidence on individual child penalties and show the effects of fertility reductions rather than birth events: when births fall across exposed labor markets, women's employment and earnings rise.

Third, family formation also changed in high-exposure areas. Using annual municipality-level administrative data from the Brazilian Institute of Geography and Statistics (IBGE), we find that divorces increased by 11.8 percent after the Zika shock, while marriages rose by four percent with roughly a one-year lag. These patterns are consistent with a broader adjustment in relationship formation and dissolution following the initial fertility shock, rather than a fertility response confined to births alone. One interpretation is that reduced fertility and stronger labor-market attachment changed women's outside options and bargaining power within relationships, enabling some women to exit unsatisfactory unions or form new matches.

The coexistence of persistently missing births with changes in work and relationships over subsequent years is consistent with a dynamic process in which the choices made after the initial fertility shock alter the conditions governing subsequent childbearing. The timing and geography of Zika allow us to identify whether broader shifts in Brazilian marriage and divorce accelerated where fertility fell most sharply (Instituto Brasileiro de Geografia e Estatística, 2023; Herre et al., 2020; OECD, 2024). To our knowledge, this is the first paper to use the Zika epidemic to study marriage and divorce responses, and one of the few to link an aggregate fertility shock to changes in both labor and marriage markets in a middle-income country.

The persistence of fertility declines is especially important because fertility, work, and family formation are not repeated static choices. They are often made at critical stages of the life cycle, when individuals are choosing partners, deciding whether to have children, and establishing labor-market trajectories. A temporary shock to the perceived cost of pregnancy can therefore have consequences beyond the period of the shock itself. By delaying or avoiding pregnancy, women may enter or remain attached to work, couples may reassess childbearing plans, and individuals may learn whether their preferences over children, work, and family life are compatible. These adjustments can place women and couples on new trajectories in which later fertility remains lower even after the original health risk has faded.

Our analysis takes place against the backdrop of long-run changes in women's economic roles and family formation. Globally, female labor-force participation has risen steadily, but remains below male participation in virtually all countries. Gender earnings gaps have narrowed but remain large and persistent (Goldin and Mitchell, 2017; Bertrand et al., 2010; Blau and Kahn, 2017). Brazil's labor market has followed these patterns, while its fertility, marriage, and divorce patterns have shifted markedly (Morchio and Moser, 2026; Danzer and Zyska, 2023; Bassi and Rasul, 2017; La Ferrara et al., 2012). Our findings suggest that aggregate fertility declines can do more than reduce births mechanically: by changing women's work and relationship choices, they may alter the conditions shaping later fertility decisions. Where women face large child penalties and family formation remains closely tied to childbearing, even temporary changes in fertility incentives may have persistent consequences.

A central theme of the child-penalty literature is that parenthood is a key point at which gender gaps in labor-market outcomes widen. Administrative evidence from high-income countries shows that men's and women's earnings trajectories are similar before the first child but diverge sharply afterward, as women's earnings and hours fall and occupational choices shift toward more flexible or family-compatible work (Angelov et al., 2016; Kleven et al., 2019b; Sieppi and Pehkonen, 2019; Adda et al., 2017; Bertrand et al., 2010; Cortés and Pan, 2023). Evidence from developing and middle-income countries points to similar patterns, with motherhood associated with reduced labor force participation, greater informality, and larger earnings penalties where childcare systems and labor protections are weaker (Agüero and Marks, 2011; Cáceres-Delpiano, 2012; Heath, 2017; Berniell et al., 2021; Agüero et al., 2020; Kleven et al., 2019a). At the same time, a robust literature increasingly highlights the importance of intra-household bargaining and preference alignment in determining whether a child is born, and whether a marriage occurs or persists (Doepke and Kindermann, 2019; Goldin, 2026; Ashraf et al., 2026; Siow, 1998; Lee and McKinnish, 2018). We integrate and extend these literatures by tracing how labor-market and family adjustments unfold after an exogenous shock to child-bearing risk nudges families away from their original path.

Together, these contributions help us understand why aggregate fertility declines may have lasting consequences, as the effects of fewer births need not simply mirror the effects of additional children. When many women in the same place forgo or delay a birth at once, the effects can reach beyond those who avoid a pregnancy: employers who expect fewer of their young female workers to take leave may hire and pay them differently, a thinner flow of new mothers may shift how women bargain at home and in the market, and marriage and divorce may respond to the same change in the perceived cost of children. Because such channels operate on all women of childbearing age, they can make the aggregate response larger (or smaller) than the sum of individual child penalties in the micro literature. Magnified aggregate responses would offer one potential explanation for why fertility rates remain low after the initial source of decline has faded. Our findings therefore speak to broader debates over the interaction between demographic transitions, gender inequality, and family formation.

2 Background: Zika, fertility, marriage, and work

2.1 The Zika Epidemic

The Zika virus induces mild, short-lived symptoms in adults. Roughly 80 percent of infected people are asymptomatic; the symptomatic experience mild cold-like symptoms, and more serious complications are rare. However, when women are infected during pregnancy, the disease can be devastating to fetuses. Rates of adverse outcomes are 30 to 40 percentage points higher among exposed than unexposed fetuses, and brain abnormalities are common. In one study on Zika-affected pregnant women in Rio de Janeiro, 42 percent of live babies born to Zika-positive women had "grossly abnormal clinical and/or brain imaging," and four of those had microcephaly (Brasil et al., 2016).

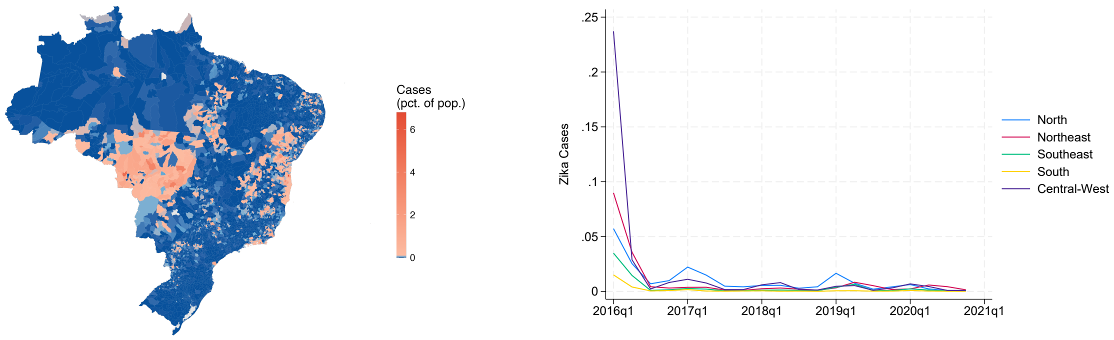
The first case of Zika was confirmed via RT-PCR in May 2015, but the potential for devastating effects on fetuses was not widely known until November 2015. As symptoms were primarily observed among adults in the early stage, Zika was initially considered benign. Specialists first reported a correlation between Zika and microcephaly in October of 2015, and Brazil's Ministry of Health declared a national public health emergency in November 2015. This marked the first widespread awareness of Zika's threat to the development of fetuses. In December of 2015, the Ministry of Health launched a national plan to combat the virus, which included an informational campaign targeted at pregnant women and women of childbearing age, and a website and mobile app with case prevalence across districts (Secretaria de Vigilância em Saúde, Ministério da Saúde, 2016). As Zika spread within and beyond Brazil, the World Health Organization declared a public health emergency of international concern in February 2016.

A growing body of clinical and demographic evidence documents that the Zika epidemic posed severe risks to fetal health and generated large behavioral responses in fertility. Early medical studies linked maternal Zika infection to microcephaly and other serious congenital

Figure 1: The Geographic and Temporal Spread of Zika Cases

(a) Map of Zika Cases

(b) Zika Cases by Region over Time



Notes: Zika case data are from the SINAN. The map in Panel 1a shows Zika case load per capita by municipality. Municipalities in blue are below the 90th percentile in case incidence, while those in red are at or above the 90th percentile. The five geographic regions shown in Panel 1b are the official regions defined by IBGE.

abnormalities, including evidence of Zika virus present in fetal brain tissue (Brasil et al., 2016; Mlakar et al., 2016). Subsequent research highlighted that even asymptomatic infections posed substantial threats to fetal development and contributed to fetal losses (Haby et al., 2018; Codeço Coelho et al., 2017). As information about these risks spread, fertility fell sharply in regions experiencing higher Zika transmission, with studies consistently documenting large declines in births in high-incidence municipalities (Marteleto et al., 2017, 2020; Rangel et al., 2020; Lautharte and Rasul, 2026; Ryu, 2020). These declines were driven not only by fetal health shocks but by households strategically delaying or avoiding pregnancy in response to perceived fetal risk (Marteleto et al., 2017; Lautharte and Rasul, 2026; Rangel et al., 2020). For these reasons, recent research has increasingly employed Zika as a natural experiment, exploiting the geographic spread of the virus and variation in transmission risk to identify the causal impacts of fertility changes on household behavior (Marteleto et al., 2017, 2020; Marteleto and Dondero, 2021; Lautharte and Rasul, 2026; Rangel et al., 2020; Ryu, 2020).

Figure 1 indicates substantial variation in Zika prevalence across both time and space. The Northeastern state of Pernambuco is often considered the original epicenter of the Zika outbreak. When official case reports began in the first quarter of 2016, however, per-capita cases were the highest in the Central-West region, a landlocked agricultural area that is less densely-populated. Cases were lowest in the temperate states of the South, and in the Southeast (which includes the major population centers of Rio de Janeiro and São Paulo). Throughout the country, reported cases peaked in early 2016. With the exception of the low-population density Amazonian North, which reported small outbreaks in 2017 and 2019, cases fell to near zero by early 2017, and remained there throughout the period shown.

This geographic and temporal identifying variation created by the Zika virus allows us to study the effects of fertility on labor and marriage market outcomes, as its mild symptoms in adults make it likely to affect fertility without directly affecting work behavior. Subsequent research has shown that the Zika epidemic led to a decrease in fertility in Brazil, findings that we replicate below with novel data and identification.

2.2 Fertility, Women's Work, and Family Formation

Our primary outcomes center on fertility, female employment and earnings, and marriages and divorces. We situate our analysis in a context where fertility rates worldwide have been falling steadily over the past several decades. As recently as the 1950s, the global average total fertility rate (i.e., number of children per woman over her lifetime) was roughly five children per woman, but by 2023 it had dropped to around 2.3 children per woman. This decline is also clearly visible in Brazil. In 1960, Brazil's total fertility rate was about 6.05 children per woman. Over subsequent decades, fertility fell rapidly: by 1991 it was down to around 3.0, by 2000 roughly 2.4, and by 2010 about 1.9 children per woman. In the most recent data (2023), Brazil's fertility rate stands at around 1.6 births per woman (World Bank, 2025). Existing literature has identified several drivers of fertility adjustments in Brazil that mirror drivers in other countries, including the expansion of social programs and shifting cultural norms (Danzer and Zyska, 2023; Bassi and Rasul, 2017; La Ferrara et al., 2012). Thus, Brazil's trajectory mirrors the global trend: from large families once typical to well below "replacement level" in the 21st century, suggesting a dramatic demographic shift with long-term implications.

Concurrently, across the world, female labor force participation has gradually increased over recent decades, although women continue to participate at substantially lower rates than men. According to recent estimates, around 49 percent of women globally are in the labor force, reflecting both rising educational attainment and ongoing constraints related to child care and social norms. Brazil further reflects these global patterns. In the 1970s, only about 20 percent of Brazilian women were economically active, whereas in more recent years, female labor force participation in Brazil has been around 53 percent, compared to roughly 73 percent for men (World Bank, 2025). Thus, while Brazil has experienced large gains in women's labor market involvement, persistent gender gaps remain, perhaps driven in part by unequal household responsibilities, diverging acceptance of compensating differentials in the labor market, and continued barriers to formal employment (Morchio and Moser, 2026; Machado et al., 2024; Khanna et al., 2025).

Household survey data, available in the PNAD-C, sheds light on general employment patterns for men and women in Brazil beginning in 2012. Figure A4 compares education levels of men and women both in and out of the labor force, in 2017. Women have generally attained higher levels of education, and men and women in the labor force have attained higher levels of education than those not in the labor force. This figure also compares the industry in which men and women work. Construction, transportation, and agriculture are industries primarily driven by male labor, while women tend to hold jobs in hospitality, education, and health and social services. Reflecting these education and industry trends, women are far more likely than men to work in occupations such as teaching, service, and retail.

Figure A5 shows the adjustment in the distribution of earnings for men and women between 2012 and 2019. Men's earnings remained relatively steady, but female earnings increased, primarily in the middle of the distribution. Hence, the gender pay gap reduced throughout this period, though it remains high at more than 30 percentage points in the first quarter of 2019.

Marriage patterns around the world have shifted markedly in recent decades, with most countries experiencing later marriage, lower marriage rates, and rising divorce (Herre et al., 2020). While registered marriages have declined in recent years, divorces have become more common (albeit with variation across contexts), reflecting legal reforms that simplified the process and broader social changes (Herre et al., 2020; OECD, 2024). Brazil exhibits similar trends. Over the past two decades, the number of legal divorces has risen sharply, and the average duration of marriage before divorce has fallen. At the same time, cohabitation, which has been recognized in Brazil by law as a type of marriage for the past thirty years, has increased. These trends may indicate both greater acceptance of separation and changing gender norms (Instituto Brasileiro de Geografia e Estatística, 2023; Esteve et al., 2016). Together, these trends point toward a gradual decoupling of family formation from traditional marital institutions and a continued diversification of household structures.

Changes in fertility, women's work, and marriage are also likely to affect patterns of time use, particularly the extent to which childcare and household responsibilities constrain labor supply. Figure A6 summarizes trends in the share of individuals reporting that they were unable to work due to childcare or household duties, separately by age group and gender. Following the onset of the Zika epidemic, we observe notable declines among younger women in the share reporting that childcare or housework prevented them from working, while no comparable changes appear for older women, who had likely already completed fertility. By contrast, younger men exhibit a modest increase in reports of childcare-related work constraints, although the scale of this change is considerably smaller than that for women. These patterns are consistent with fertility declines reducing childcare-related barriers to women's labor supply, while only marginally altering men's time allocation.

3 Data Description

3.1 Zika Exposure

Our empirical design combines a common temporal shock—the November 2015 declaration of a national public health emergency—with cross-sectional variation in local Zika exposure. Our preferred exposure measure is publicized local case prevalence. We obtain municipality-level case counts from Brazil's *Sistema de Informação de Agravos de Notificação* (SINAN) and calculate cases per capita in the first quarter of 2016 (Ministério da Saúde, 2020). Government reports repeatedly used maps with discrete incidence categories to publicize the geographic concentration of Zika and highlight municipalities with especially high case prevalence (Ministry of Health of Brazil, 2017, Chapter 3, Figure 1, reproduced in Figure A1b). We use the 90th percentile of per-capita cases to approximate the distinction these maps made salient between the highest-prevalence areas and the rest of the country. Our resulting map closely resembles the geographic patterns in the government reports. We therefore interpret this measure as capturing not only realized local prevalence, but also whether the government publicly identified an area as facing particularly high Zika risk. Previous studies using case prevalence similarly find larger fertility declines in more affected areas (Rangel et al., 2020; Codeço Coelho et al., 2017; Marteleto et al., 2017).

Reported case prevalence may reflect differences in local surveillance and medical infrastructure as well as underlying Zika incidence. These local characteristics could also predict fertility, labor-market outcomes, or family formation. We address this concern by examining pre-epidemic trends and by estimating the same specifications with two complementary exposure measures that do not rely on reported case counts.

Our second measure, Zika suitability, captures predetermined geographic variation in environmental suitability for the *Aedes aegypti* mosquito, the primary vector for Zika (Faria et al., 2017; Messina et al., 2016). Unlike reported cases, suitability does not depend on local diagnosis, reporting, or behavioral responses to the epidemic. It therefore provides a more plausibly exogenous measure of transmission risk, although it does not directly capture whether residents perceived that risk as salient. We classify municipalities above the 90th percentile of suitability as high exposure. Appendix Figure A2a shows the resulting classification.

Our third measure uses Google search activity to capture local awareness and concern about Zika. The municipality-level index measures searches containing the term "Zika" relative to all Google searches (Google Trends, 2018).[1] Unlike mosquito suitability, this measure directly captures whether residents sought information about the epidemic, although search activity may also reflect local characteristics correlated with internet access. We classify a geography as high exposure if it recorded any Zika-related searches during the fourth quarter of 2015. Appendix Figure A3a shows the resulting classification.

The three measures capture complementary dimensions of Zika exposure. Mosquito suitability measures underlying transmission risk, publicized case prevalence combines realized incidence with government-generated salience, and Google searches measure active information seeking. Their geographic classifications differ accordingly: the search measure identifies high-exposure areas more evenly across Brazil than either cases or suitability. High- and low-exposure areas also differ modestly in observable characteristics, particularly population size under the search-based classification. We therefore examine pre-trends and specifications that account for baseline demographic differences. Despite their distinct sources and limitations, the three measures produce similar patterns in our main results.

3.2 Primary Outcomes

We measure municipal-level births using administrative births data, the *Sistema de Informações Sobre Nascidos Vivos* (SINASC), which records data on every birth in Brazil, including the municipality of maternal residence and delivery (Ministério da Saúde, 2023). We collapse this data to the municipal level by mothers' municipality of residence, and merge it with the Zika exposure measures discussed above. In this way, we create a municipal-level dataset at the monthly frequency, that includes all births within a municipality and the mothers' corresponding exposure to Zika.

The employment dataset we consider, the *Pesquisa Nacional por Amostra de Domicílios-Continua* (PNAD-C), is a rotating panel household survey conducted at a quarterly frequency, which is nationally representative of Brazilians age 15 and above (Instituto Brasileiro de Geografia e Estatística, 2024). These data measure labor force participation and earnings, as well as the respondent's state of residence and type of municipality. These geographic data allow us to aggregate our measures of Zika exposure to 146 distinct regions that we refer to as "estrato."[2]

[1] We thank Hal Varian for personally sharing the Google search data.

[2] The PNAD-C identifies the following potential geographic locations of survey participants: (i) different

We then link each PNAD-C respondent to the Zika exposure measure of their respective region. The result is an individual-level dataset measured at the quarterly frequency.

We obtain annual counts of marriages and divorces by municipality from *Sistema de Estatísticas Vitais* (System of Vital Statistics) maintained by the Brazilian Institute of Geography and Statistics (IBGE). These administrative records, reported at the municipality-year level, cover all civil marriages and legally-registered divorces in Brazil. The System of Vital Statistics provides comprehensive national coverage, allowing us to track changes in marital formation and dissolution over time. Because the data are available only at the annual frequency, our analysis of marriage and divorce is at the municipality-year level, complementing our higher-frequency fertility and labor-market analysis (Instituto Brasileiro de Geografia e Estatística, 2023).

4 Estimation Strategy

Across outcomes, we use an event-study difference-in-differences design that compares changes in areas with high and low Zika exposure around Brazil's November 2015 declaration of a national public health emergency. We measure exposure in three complementary ways. First, publicized case prevalence captures realized incidence and its local salience. Using available case data, we approximate the classification used in government maps to identify areas with elevated prevalence. Second, mosquito suitability captures predetermined geographic variation in transmission risk. Third, Google search activity captures where residents actively sought information about Zika, providing another measure of local salience. Because these measures capture different combinations of transmission risk, realized prevalence, and public awareness, consistency across them strengthens the interpretation of the results.

We begin by estimating the reduced-form effect of Zika exposure on fertility using monthly municipality-level birth counts:

$$Births_{m,t} = \gamma_m + \delta_t + \sum_{t=Jan.2015}^{Sep.2015} \left(\alpha_t \times \text{Treated}_m\right) + \sum_{t=Nov.2015}^{Dec.2018} \left(\beta_t \times \text{Treated}_m\right) + \varepsilon_{m,t}, \quad (1)$$

where m indexes municipalities and t indexes months. $Births_{m,t}$ is the number of births to women ages 20–34 in municipality m and month t. For each exposure measure, Treated_m identifies municipalities classified as having high Zika exposure. Municipality fixed effects, γ_m, absorb time-invariant differences across municipalities, while year-by-month fixed effects, δ_t, absorb shocks common to all municipalities in each month. The coefficients α_t and β_t therefore trace monthly differences between high- and low-exposure municipalities relative to October 2015, the month before the national emergency declaration.

We next estimate the reduced-form effect of Zika exposure on individual employment and

types of municipalities within each state (e.g. capital municipality, metropolitan areas neighboring the capital, municipalities in other metropolitan areas, and other municipalities) that serve as survey stratum, (ii) 26 state capitals, (iii) 26 states excluding their capitals, and (iv) the federal district, i.e. national capital. We construct 146 disaggregated regions at the stratum level using the municipality categories where every municipality is fully contained in a PNAD-C region. We also construct 53 "PNAD-C regions" identified by categories (i) through (iii), and use these for robustness.

earnings outcomes observed quarterly in the PNAD-C:

$$L_{i,j,q} = \gamma_j + \delta_q + \sum_{q=2014q1}^{2015q3} \left(\alpha_q \times \text{Treated}_j\right) + \sum_{q=2016q1}^{2018q4} \left(\beta_q \times \text{Treated}_j\right) + \varepsilon_{i,j,q}, \tag{2}$$

where i indexes women ages 20–34, j indexes the 146 estrato regions identifiable in the PNAD-C, and q indexes quarters. $L_{i,j,q}$ denotes employment or monthly earnings for woman i in region j and quarter q. For each exposure measure, Treated_j identifies regions classified as having high Zika exposure. Region fixed effects, γ_j, absorb time-invariant differences across regions, while quarter fixed effects, δ_q, absorb shocks common to all regions. The coefficients α_q and β_q trace quarterly differences in labor-market outcomes between women in high- and low-exposure regions relative to the fourth quarter of 2015, the omitted quarter.

Finally, we estimate the reduced-form effect of Zika exposure on family formation and dissolution. Because marriages and divorces are observed annually, we use the following municipality-by-year specification:

$$M_{m,k} = \gamma_m + \delta_k + \sum_{k=2014}^{2015} \left(\alpha_k \times Treated_m\right) + \sum_{k=2017}^{2023} \left(\beta_k \times \text{Treated}_m\right) + \varepsilon_{m,k}, \tag{3}$$

where m indexes municipalities and k indexes years. $M_{m,k}$ denotes the log number of marriages or divorces across all age groups in municipality m and year k. For each exposure measure, Treated_m identifies municipalities classified as having high Zika exposure. Municipality fixed effects, γ_m, absorb time-invariant differences across municipalities, while year fixed effects, δ_k, absorb shocks common to all municipalities. The coefficients α_k and β_k trace annual differences in marriage or divorce between high- and low-exposure municipalities relative to 2016, the omitted year.

Across specifications, the α coefficients describe differences between high- and low-exposure areas before the emergency declaration, while the β coefficients describe how those differences changed afterward. Estimates are measured relative to October 2015 for fertility, 2015 quarter 4 for labor-market outcomes, and 2016 for marriage and divorce. The estimation sample excludes the state of Pernambuco, as its peak of Zika infections occurred prior to the declaration of the public health emergency.[3] Standard errors are clustered at the level at which exposure is assigned: the municipality for fertility and family formation, and the PNAD-C region for labor-market outcomes.

Interpreting the β coefficients as reduced-form effects of Zika exposure requires that high- and low-exposure areas would have followed similar trends in the absence of the epidemic and that no other contemporaneous changes differentially affected high-exposure areas. The pre-period α coefficients provide evidence consistent with parallel trends. The design also assumes limited spillovers between high- and low-exposure areas. Migration, information diffusion, or

[3]Pernambuco is often considered the epicenter of the Zika virus and, indeed, many studies that estimate fertility effects of the Zika virus consider Pernambuco to be the only treated area (Rangel et al., 2020). However, the epidemic began in Pernambuco in early- to mid-2015 and our identification relies on the timing of fertility responses in reference to the public health announcements in October of 2015. Accordingly, we omit Pernambuco from our main analysis and rely on responses in areas with later exposure to the virus. Appendix Figure A12b shows robustness to including Pernambuco as a treated area.

transmission across areas could expose the comparison group to Zika. Differential migration is less concerning given the rapid conception response implied by the monthly birth data,[4] while other spillovers would generally make our estimates relative exposure effects and attenuate the estimated differences between groups.

The labor-market and family-formation specifications identify reduced-form effects of Zika exposure. To interpret the initial changes in employment, marriage, and divorce as consequences of fertility reductions, we must assume that Zika affected these outcomes primarily through its immediate effect on childbearing. We can directly test whether Zika reduced fertility, but we cannot fully rule out other channels linking Zika exposure to labor- and marriage-market outcomes. The timing of the responses helps distinguish these channels. Direct health or economic effects should appear relatively soon after the emergency declaration. Effects operating through pregnancy may emerge during the final trimester, while effects associated with avoided births should become most visible around the expected date of birth, roughly nine months after the declaration. We therefore examine whether changes in employment, earnings, marriage, and divorce follow the timing implied by the initial fertility response. Over longer horizons, however, the direction of influence may run both ways: subsequent changes in work and family formation may help sustain the fertility decline.

5 Results

5.1 The Impact of Zika on Fertility

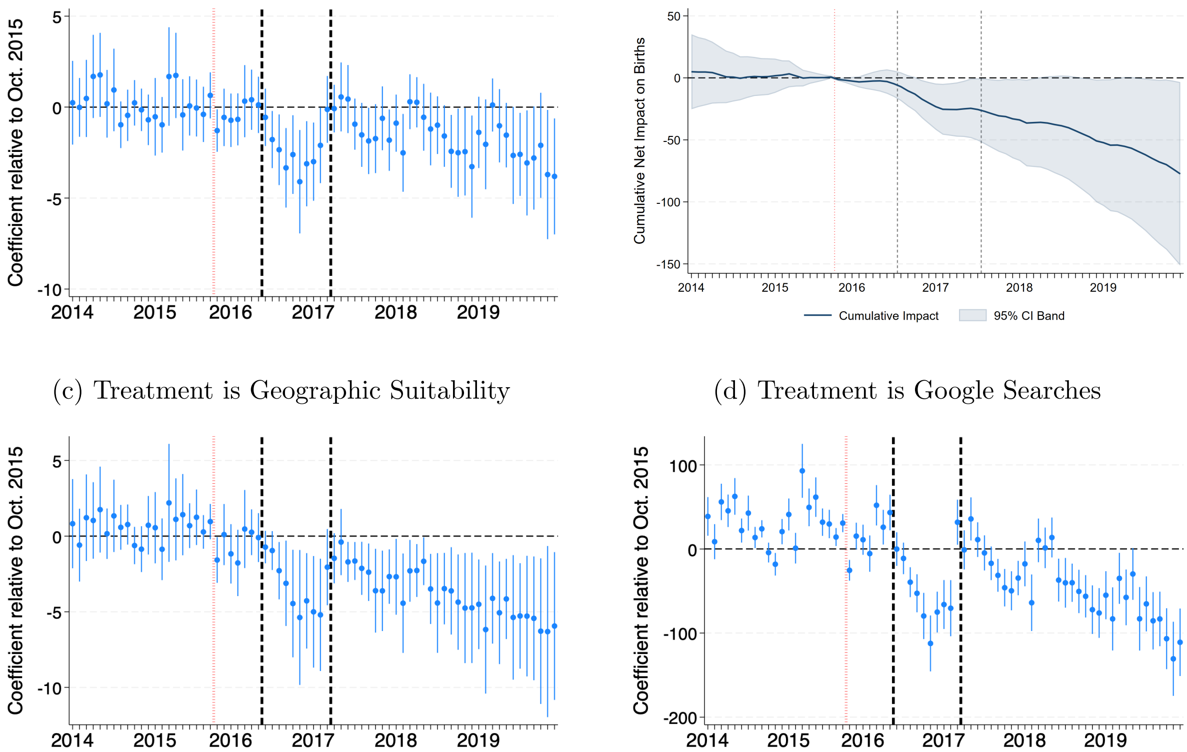
Figures 2a, 2c, 2d show the impact of Zika on the total number of births within each municipality, estimated with specification (1). Each coefficient estimate measures the difference between high and low Zika exposure municipalities in the average monthly decline in births among women between the ages of 20 and 34, relative to October 2015. Thus, estimates below zero represent fewer babies born in areas hardest hit by Zika. Figure 2b aggregates the quarterly estimates calculated using our preferred treatment variable, Zika cases, to describe the cumulative fertility adjustment following the Zika shock.

To aid interpretation, we add three vertical reference lines to each panel. The first (red) line marks our omitted month, October 2015, immediately before the declaration of the national emergency. We then plot a line nine months after the emergency was declared, corresponding to a typical gestational period when the initial shock might begin to affect births. A second line is placed nine months after cases fall back to near-zero, indicating the effective end of the epidemic. At that point, as Zika became endemic at much lower rates, births may return to prior levels—or even overshoot them—as parents resume postponed childbearing.

The estimates show relative declines in fertility in high-exposure municipalities beginning nine months after the declaration of the national emergency. Coefficients prior to the declaration of the national emergency are not statistically different from zero, providing reassurance that the parallel trends assumption is valid. Similarly, the coefficient estimates in the nine months following the declaration of the national emergency are small and not statistically different from zero. These patterns suggest minimal termination of pregnancies that were in utero

[4] We do not detect meaningful impacts on migration in difference-in-differences specifications.

Figure 2: Monthly Impact of Zika Virus on Births



(a) Treatment is Zika Cases

(b) Cumulative Effects with Cases Treatment

(c) Treatment is Geographic Suitability

(d) Treatment is Google Searches

Notes: All specifications include year-by-month and municipality fixed effects. Standard errors are clustered at the municipality level. The sample is restricted to women ages 20-34. The outcome is births per month measured at the municipality level. Panel 2b measures the cumulative effects on births with the Zika cases treatment. The red dotted line marks the omitted period: October 2015, the last month before the declaration of the national emergency. The first black vertical line marks nine months after the declaration of the national emergency, to allow for the lagged fertility response. The second black vertical line marks nine months after the end of the epidemic. Births data are from the SINASC, 2015-2018, while case data are from the SINAN, geographic suitability data are from Messina et al. (2016), and Google search data are from Google Trends data.

when the health emergency was declared. There is, however, a large and statistically significant decline in births beginning nine months after the declaration of the national emergency. The average monthly fall in births over the period was 10.7% (3.44 births per month over an average of 32.11 births per month before 2016). Fertility remains at this low level for about six months before recovering in April of 2017, and declining again, albeit by a smaller margin, in subsequent months. Measuring exposure with Zika cases (Figure 2a) and Zika suitability (2c) clearly identifies these patterns, and measuring exposure with Zika awareness (Figure 2d) shows a consistent but more volatile pattern in fertility responses.

Births in high-exposure areas remain below births in low-exposure areas after the end of the epidemic. The cumulative estimates in Figure 2b suggest that there is not a "rebound" or "overshooting" of births, in aggregate. Calculations based on these cumulative estimates suggest that 4.8 percent fewer babies are born in the hardest hit areas between October 2015 and December 2016, and 5.6 percent fewer babies are born between October 2015 and December

2019, than there would have been absent the epidemic. The proportional decline in births to *new* mothers is even larger, with 15 percent fewer babies born to women without older children by December 2016, and 21.7 percent fewer by December 2019.[5] Thus, women are reducing rather than delaying fertility, and fewer women are becoming mothers. The pregnancies that did not occur in the year following the declaration of the national health emergency had still not occurred by the end of 2019. As a result, there were fewer infants and toddlers in municipalities with high Zika exposure.

We show robustness to our treatment thresholds in Appendix B.2 by estimating the effects with alternative definitions of treatment. Panel A7b shows the estimated effects of the Zika virus on monthly births when we define treated municipalities as those above the 75th percentile of the respective treatment variable. In Panel A7c, we estimate the effects using continuous treatment measures. In Figure A8, we show robustness to mother's age by estimating the effects of Zika on monthly births for samples of women in different age groups (20–29, 30–39). Figure A9 shows robustness of the cumulative fertility results to treatment definition, birth parity, aggregate age group, and the inclusion of Pernambuco in the sample.

5.2 Zika's Impact on Women's Work And Family Formation

The previous section shows clear fertility declines in municipalities hardest hit by Zika. We now turn to the corresponding consequences for the labor-market. We focus on labor-market behavior of the group most exposed to the fertility declines: women aged 20-34. We use two measures of labor supply from the PNAD-C: a binary indicator of any employment during a reference period and monthly earnings (measured in reais).

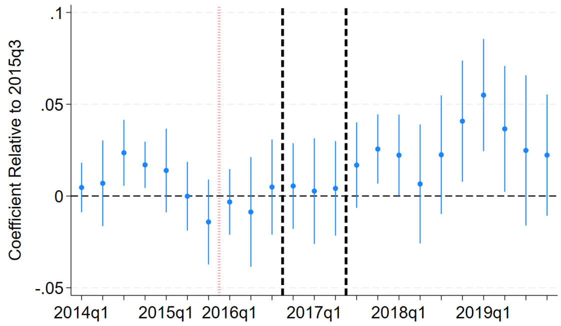
Employment. Figure 3 shows meaningful and sustained increases in female labor-force participation after the arrival of Zika. The figure presents the coefficient estimates resulting from Equation 2 when the outcome variable is an indicator of whether the respondent was employed in the reference period. The positive and significant coefficients beginning in the fourth quarter of 2016 suggest that women's employment is, on average, 1.55 percentage points higher during the period of fertility declines in the areas hardest hit by Zika (Figure 3a). These employment increases seem to persist throughout the period, even after the end of the epidemic.

Maternity leave and employment protection policies in Brazil may play a role in the timing of this employment increase. The initial uptick in employment, beginning in the third quarter of 2016, is consistent with women choosing to avoid pregnancy in the peak months of the Zika epidemic in areas that were hardest hit. Women working in the formal sector in Brazil are covered by a fully paid maternity leave that lasts for four months in the private sector and six months in the public sector. The increases in employment of two to three percentage points between the fourth quarter of 2016 and the last quarter of 2017 are consistent with fewer women taking maternity leave in that period. The longer-term increase in employment that begins in 2018 may reflect further nuance of employment protection: women may choose to leave the labor force altogether once their maternity benefits have been exhausted, and the end of employment

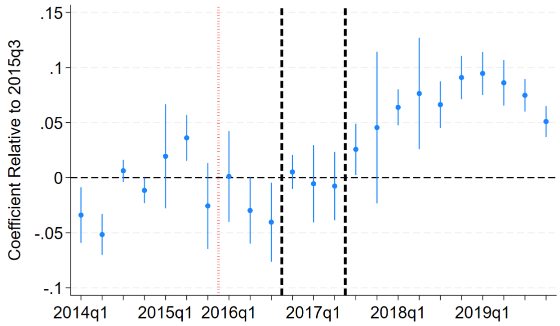
[5] We find these estimates by dividing the cumulative treatment effect, shown in Figure 2b, by the average cumulative number of babies born in low Zika-intensity areas between October 2015 and the end date in question. To calculate the impact on new mothers, we conduct the same exercise with the estimates shown in Figure A9b.

Figure 3: Quarterly Impact of the Zika Virus on Employment

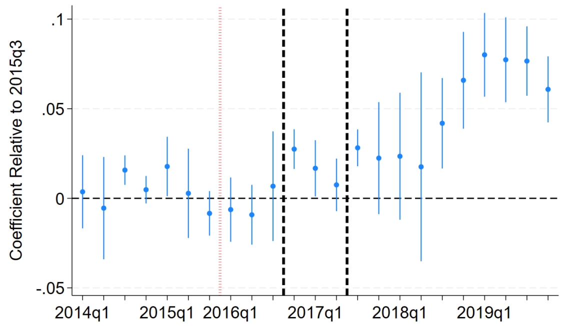
(a) At the Estrato Level



(b) At the State Capital Level



(c) At the State Capital and non-Capital Level



Notes: All specifications include year-by-month and PNAD-C region fixed effects. Standard errors are clustered at the region level. Outcomes are measured at the individual level. "Employment" is a binary indicator of whether the individual reported any work in the reference month, generally the month prior. The omitted period (red dotted line) is 2015q4, the quarter of the declaration of the national health emergency. The black lines mark 2016q2 (between six and nine months following the declaration of the national health emergency) and 2017q2 (Between six and nine months following the end of the epidemic).

protections after five months of giving birth may facilitate employers engaging in selective firing. Furthermore, employers may be more likely to increase their hiring of women if they expect fewer women to take maternity leave.

This employment response is meaningful in magnitude. The child penalty literature provides a potential benchmark, as our fertility response is concentrated among women without prior children. The estimated 21.7 percent cumulative decline in first children between October 2015 and December 2019 translates to 6,075 fewer new mothers between the ages of 20 and 34 per estrato. The estimated 1.55 percentage point increase in employment implies an additional 2,682 employed women between the ages of 20 and 34 in that same geographic area.[6] Accordingly, our estimates imply 0.44 additional female workers for every avoided first birth. Kleven et al. (2025)

[6]We calculate these numbers at the estrato level, which is the smallest geographic area identifiable in the PNAD. There are, on average, 173,000 women between the ages of 20 and 34 in each estrato according to the 2010 census, and 27,995 births to new mothers of that same age between October of 2015 and December of 2019 according to the SINASC.

estimate a scaled child penalty in employment for Brazil of 0.368, with an unscaled penalty of about 25 percentage points (their Figure 11). Our estimate exceeds this, and four dynamics could account for the difference. First, women who avoid pregnancy after learning about fetal risk need not resemble the average new mother; if they are more attached to the labor market, they face larger penalties. Second, as family formation adjusts, women leaving a union have reason to work whether or not they avoided a birth; some of what we measure may run through household dissolution rather than through fertility.[7] Third, men may have increased their labor supply with fewer children. Finally, and unlike the private penalty borne by an individual mother, part of the response may operate through labor demand. Formal-sector employers in Brazil bear the cost of a four-month paid maternity leave and cannot dismiss a worker from the confirmation of pregnancy until five months after birth. A fall in the expected fertility of women aged 20 to 34 lowers the expected cost of employing any woman in this group, not only those who avoid a birth, and can raise hiring across the whole age group – an aggregate response larger than the sum of individual penalties.

We show robustness to our results on employment in Appendix B.3. Figure A10 shows robustness to alternative definitions of treatment (Panels A through C), as well as controlling for differential time trends by municipality-level demographics (Panel D). Further, it is notable that increases only begin nine months after the declaration of the national health emergency. This supports the hypothesis that the employment impacts of Zika are not direct, but are primarily a result of the corresponding fertility decline.

Monthly Earnings. Figure 4a shows increases in women's earnings that peak at around 100 reais in 2019, or about 12.4 percent of average earnings among women between the ages of 20 and 34 in the third quarter of 2015. The average increase in earnings in the post-Zika period is 43.6 reais. The figure presents coefficient estimates from Equation 2 when the outcome is women's reported monthly earnings. These increases in women's earnings persist through 2018 and beyond, remaining higher than before in Zika regions, perhaps as cumulative births are lower. This suggests a potential structural change in women's earnings capacity.

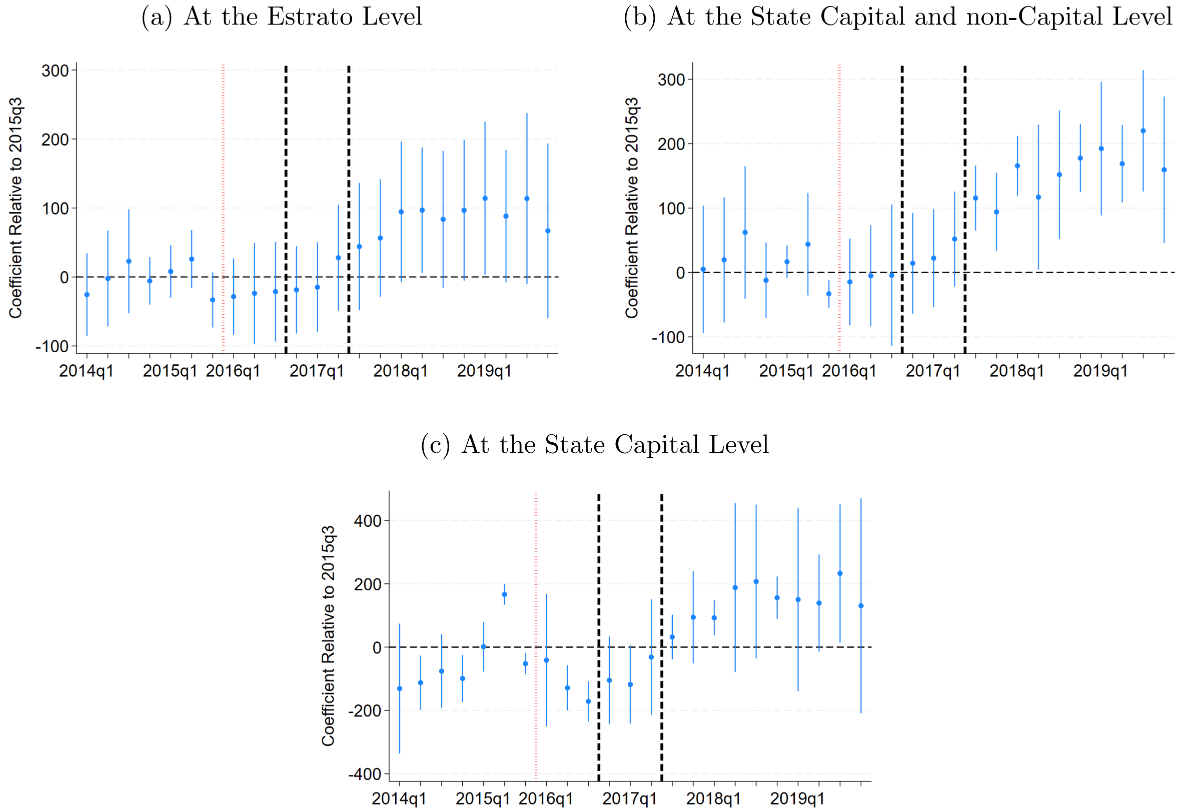
Like the employment results, the timing of these increases in earnings may be influenced by maternity leave and employment protection policies available to women working in the formal sector. Fully-paid maternity leave protects women's earnings in the months leading up to and immediately after birth, while employment protections protect their job. As a result, the earnings impact of lower fertility may not be noticeable for over a year following the declaration of the epidemic. Figure 4 is consistent with this hypothesis: long-term earnings gains begin to manifest in the second quarter of 2017, consistent with the nine-month fertility window and five-month employment protection for mothers.

The earnings response combines entry into work with a gain in average earnings among those working. Sixty percent of the estimated earnings increase is due to entry alone, while the remainder is due to a rise of about 1.9 percent in average earnings among employed women.[8]

[7] Consistent with this, Kleven et al. (2025) find a marriage penalty in Brazil larger than the child penalty.

[8] The average estimated increase in monthly earnings between November 2015 and December 2019 is 43.6 rais, including zeros for women who do not work, against a pre-period mean of 942 reais. The 60 percent due to entry alone is calculated by applying the 1.55 percentage point rise in employment to conditional mean earnings of

Figure 4: Quarterly Impact of the Zika Virus on Monthly Earnings



Notes: All specifications include year-by-month and PNAD-C region fixed effects. Standard errors are clustered at the region level. Outcomes are measured at the individual level. "Monthly Earnings" are defined as all earnings on the main, second, and other jobs in the reference month, generally the month prior. The omitted period (red dotted line) is 2015q4, the quarter of the declaration of the national health emergency. The black lines mark 2016q2 (between six and nine months following the declaration of the national health emergency) and 2017q2 (Between six and nine months following the end of the epidemic).

This intensive-margin increase combines any change in earnings for women already working with a change in the composition of those who work, since the women drawn into employment after an avoided first birth need not resemble incumbents. A positive intensive margin is notable because a pure increase in labor supply would, if anything, push wages down. It is instead consistent with a shift in labor demand: perhaps as the expected cost of employing young women falls with their expected fertility, employers compete for them on wages as well as hiring, raising pay for those already in work.

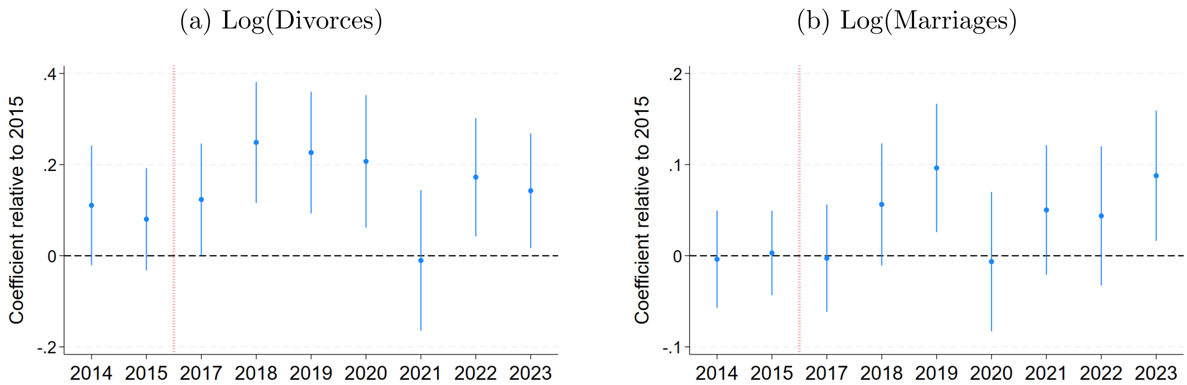
We show robustness to our results on labor earnings in Appendix B.3. Figure A11 shows robustness to alternative definitions of treatment (Panels A-C), and controlling for differential time trends by municipality-level demographics (Panel D). Figure A12 includes state-by-year fixed effects to account for potential regional shocks that may affect the labor market.

1,690 reais. The remainder is a rise of 1.9 percent in average earnings among employed women.

Marriages and Divorces. Figure 5 presents the estimated coefficients from Equation 3 when the outcomes are the log number of marriages and the log number of divorces. Figure 5a shows that divorce rates begin to rise in 2017, peak in 2018 and 2019, and subsequently decline, reaching levels roughly 20 percent higher in high-exposure Zika areas relative to low-exposure Zika areas at the peak. Between 2016 and 2019, divorces rose by 11.8%, on average. Marriage rates also increase in Figure 5b, but their rise lags that of divorces by roughly one year, with an average increase of 4% between 2016 and 2019. Appendix B.4 shows robustness to the Zika virus's effect on marriages and divorces by using alternative definitions of treatment and including a set of controls shown in Figure A13.

Our research design is agnostic regarding the causal direction of these responses in employment and household formation. One interpretation of these results is that reduced fertility and improved labor market opportunities enhanced women's ability to exit or delay certain unions. Alternatively, reduced fertility could have a direct effect on marital unions. Some unions formed prior to the national health emergency may have been with the express objective of having children; when the epidemic encouraged these partners to re-evaluate having children, they may also have re-evaluated marriage and employment (Coles and Francesconi, 2011; Siow, 1998; Díaz-Giménez and Giolito, 2013; Becker et al., 1977; Lee and McKinnish, 2018).

Figure 5: Annual Impact of the Zika Virus on Divorces and Marriages



Notes: All specifications include year and municipality fixed effects. Standard errors are clustered at the municipality level. Outcomes are annual log marriages and log divorces measured at the municipality level. The omitted period (red dotted line) is 2016, since the national emergency was declared at the end of 2015. Municipality-level marriage and divorce data are from Instituto Brasileiro de Geografia e Estatística (2023), 2014-2023.

The rise in both divorces and marriages is consistent with the Zika shock making fertility preferences more salient within relationships and prompting conversations that may otherwise have been difficult or socially costly. By making pregnancy avoidance more publicly legitimate, the shock may also have increased women's effective control over fertility decisions, especially for women who had reservations about childbearing but faced pressure from partners, families, or social norms. Couples who discovered mismatched preferences over childbearing may have been more likely to separate, while couples with aligned preferences may have been more willing to formalize unions once more open discussion surfaced their compatibility regarding childbearing.

6 Conclusion

Our findings demonstrate that the Zika epidemic led to a measurable fertility decline in Brazil. The resulting cumulative reduction in births was accompanied by persistent increases in women's labor market earnings and employment, as well as notable adjustments in marriage and divorce. Together, these results contribute to the broader literature on fertility, labor supply, and family formation by providing evidence that reductions in fertility influence women's employment opportunities and relationship dynamics, and may do so in ways that cement the original fertility decline. Unlike previous studies that focus on long-run fertility transitions or policy-driven fertility shifts, our paper leverages a sharp and plausibly exogenous public health shock to isolate the childbearing-, labor- and marriage-market effects of a sudden increase in health-related fetal risk. With this, we offer rare and credible insight into the dynamics between fertility choices, family formation, and women's economic trajectories.

These findings have important implications for understanding ongoing and future demographic change. If temporary fertility declines driven by a health shock can meaningfully increase women's labor force participation and earnings, more persistent fertility declines—such as those observed across Europe, East Asia, and Latin America—may have even larger cumulative effects on women's lifetime labor supply, earnings potential, and economic independence. In many middle- and high-income countries, fertility rates have already fallen below replacement, and concerns about population aging, shrinking labor forces, and fiscal sustainability are increasingly central to policy debates. At the same time, falling fertility may enhance women's participation in paid work, accelerate the closing of gender gaps, and reshape intra-household bargaining power, with downstream effects on marriage, divorce, and household structure.

Our evidence also suggests that fertility reductions are not simply delayed births that eventually "catch up," but may translate to fewer births overall. If this is indeed the case, then long-run demographic change may not only shrink cohorts entering the labor market, but may also permanently shift women's economic roles. In contexts where childcare systems remain underdeveloped, and the motherhood penalty is large, fertility declines may further amplify women's formal employment and earnings, contributing to long-run gender convergence—although potentially widening inequalities between women with children and those without.

These results also help interpret the broader consequences of the sustained fertility declines now underway across much of the world. Much of the existing literature has focused on individual-level fertility shocks that identify how an additional child affects women's labor supply. In contrast, we study a setting in which fertility declines at the cohort and geographic level, resulting in fewer births in the aggregate rather than variation in fertility across otherwise similar individuals. Our findings show that when fertility falls at this broader scale (as seen worldwide), women's observed labor market trajectories shift upward, with sustained increases in employment, earnings, and formal-sector participation. At the same time, family formation responds measurably, with changes in both marriage and divorce rates following the fertility decline. Taken together, these results suggest that aggregate fertility transitions may be accompanied by persistent changes in women's employment and earnings outcomes, as well as adjustments in the timing and structure of family formation, even over relatively short horizons.

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Appendix

A Zika Data and Measurement

We consider three measures of the intensity of the Zika virus: Zika cases per capita, environmental suitability for the mosquito that carries the Zika virus, and an index that measures the frequency of Zika-related Google searches relative to all Google searches within a municipality. We refer to these measures as Zika cases, Zika suitability, and Zika searches. Each measure begins as a continuous variable; in this appendix, we first describe that continuous variable, and then how we select the threshold that defines "high" Zika intensity versus "low" Zika intensity for each measure.

A.1 Zika Cases

Zika case data, separately reported by municipality, are available from SINAN between 2016 and 2020. The highest measured frequency of non-zero case incidence occurred in the first quarter of 2016, when 2,353 out of 5,570 municipalities reported positive Zika cases. In the second quarter of 2016, only 1,857 municipalities reported non-zero case incidence. Figure 1b in the main text shows that this temporal pattern held across geographic regions.

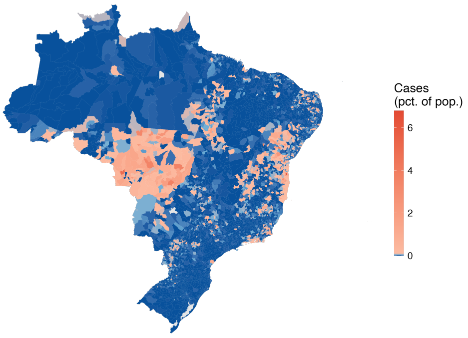
As a time-invariant measure of Zika exposure, we use reported cases as a percent of population in the peak quarter of 2016q1. Figure 1a in the main text presents this measure, with the municipalities facing the lowest exposure in dark blue and those facing the highest exposure in dark red. We also consider different methods of determining a time-invariant measure of cases, such as the case incidence reached in each municipality in 2016q2, or the highest case incidence attained within each municipality throughout the period. We find a strong correlation between these various measures and choose cases as a percent of the population in 2016q1 for clarity of interpretation.

Figure A1 shes light on the criteria we used to select the threshold at which a municipality was considered "high-intensity" versus "low-intensity," according to the cases measure. Figure A1a reproduces Figure 1a from the main text, showing our time-invariant measure fo Zika exposure. We juxtapose this with Figure A1b, which shows a map that was released during the epidemic by the Brazilian government as part of their national information campaign to spread awareness about and combat Zika. The government repeatedly released such maps using these exact discrete incidence categories to publicize the geographic concentration of Zika and highlight municipalities with especially high case prevalence. The color selection and thresholds they chose emphasized municipalities with more than 300 cases per thousand inhabitants as high-risk. We use the 90th percentile of our time-invariant cases to approximate this threshold; municipalities in a red hue in Figure A1 are above the 90th percentile while municipalities in a blue hue are below. Figure A1c shows the CDF of our time-invariant measure of Zika cases, including all municipalities that reported non-zero cases. The red line represents the salience threshold at the 90th percentile of this distribution, which is the threshold we use to distinguish whether a municipality suffered high- or low-Zika intensity. We show robustness of our results to this choice of threshold.

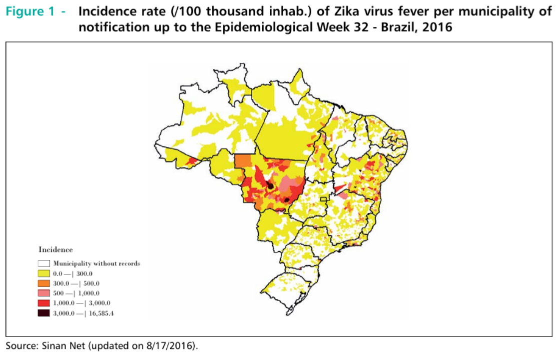
To aggregate geographically to the 53 regions available in the PNAD-C, defined by states

Figure A1: Threshold for Zika Cases Selection emphasizes Salience

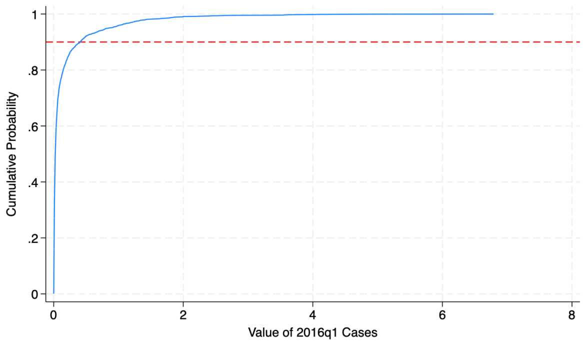
(a) Map of Authors' Measure of Zika Cases



(b) Map from Brazilian Government



(c) CDF of Municipal-level Zika Cases



Notes: Zika case data are from the SINAN. The map in Panel A1a shows Zika case load per capita by municipality. Municipalities in blue are below the 90th percentile in case incidence, while those in red are at or above the 90th percentile. Panel A1b is a map of cases released by the Brazilian government as part of its national information campaign to combat the spread of Zika (Secretaria de Vigilância em Saúde, Ministério da Saúde, 2016, Figure 5) (Ministry of Health of Brazil, 2017, Chapter 3, Figure 1). Figure A1c shows the cdf of our Zika cases measure over municipalities, highlighting the 90th percentile cutoff.

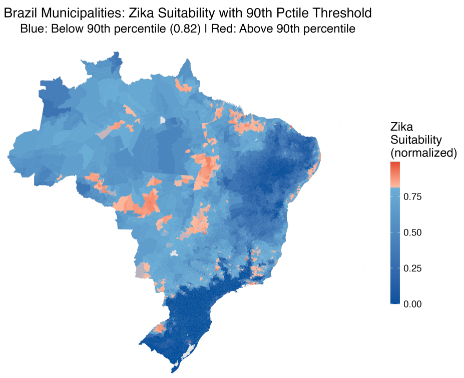
and their capitals, we calculate a time invariant measure of case incidence within a region as a percent of the aggregate population across all municipalities within a region. We then classify regions with high-Zika intensity using the same threshold that we do for municipalities: a region is high-intensity when its case incidence is higher than the 90th percentile of all municipalities with non-zero case incidence.

A.2 Environmental Suitability for Aedes Aegypti Mosquito

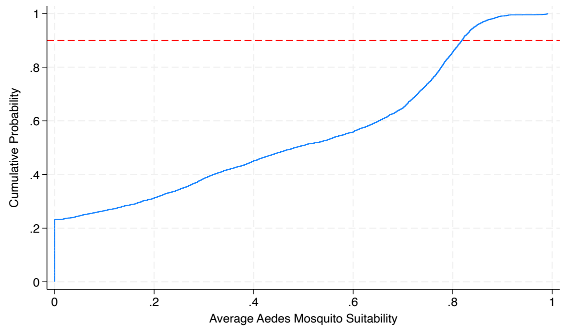
Gridded geographic data on land suitability for the Aedes aegypti mosquito is available as a raster dataset. We aggregate the raster data to the municipality level, by overlaying shape files with municipality boundaries in 2015 and calculating the mean suitability of the grid cells within each municipality, weighting cells from the raster by their relative area within each municipality. This allows us to get a municipality level average suitability measure. We use this municipality-level suitability for treatment assignment. In the map below, blue areas have the lowest geographic suitability for the Zika-carrying mosquitoes, while red areas have the highest suitability. The color changes from blue to red at the 90th percentile of Zika suitability – the threshold we use to distinguish high-Zika intensity areas from low-Zika intensity areas. Figure A2b shows the distribution of Zika suitability. The red horizontal line lies at the 90th percentile cutoff that we define to be the treatment threshold. We choose this cutoff at the point where the CDF flattens out so that high-Zika intensity areas have not only the highest, but also similar susceptibility to the virus. We show robustness of our results to this choice of threshold.

Figure A2: The Geographic Spread of Environmental Suitability

(a) Zika Suitability



(b) CDF of Municipal-level Zika Suitability



Notes: The map in Panel A2a shows normalized Zika suitability by municipality. Municipalities in blue are below the 90th percentile in suitability, while those in red are at or above the 90th percentile. Panel A2b shows the cdf of municipalities, highlighting the 90th percentile cutoff.

A.3 Google Searches

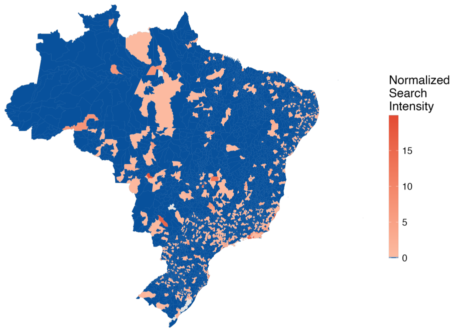
We use a municipality-level index measuring the frequency of Google searches that include the word "Zika," relative to all Google searches (Google Trends, 2018). Figure A3 shows that Zika search intensity reaches its peak in the fourth quarter of 2015, driven by searches in November of 2015–consistent with the timing of the declaration of the state of national emergency in November 2015. Accordingly, we consider municipal-level search intensity in the fourth quarter of 2015 as our time-invariant measure of Google search intensity.

Concerns may arise that this search measure reflects access to internet more than it does concern about Zika. We therefore conduct robustness checks limited to the 1,042 municipalities that ever report any search for Zika, as we are thus sure that these municipalities have access to the internet. The results look broadly the same when we limit the sample in this way, alleviating the concern that our findings are driven purely by access to technology.

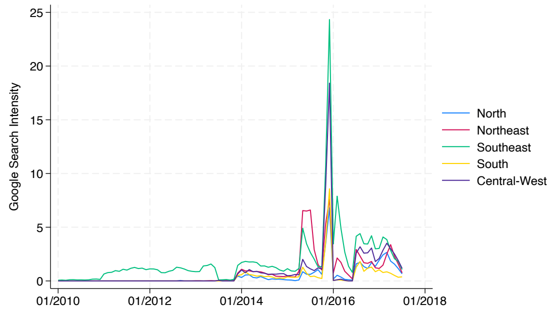
To aggregate geographically to the 53 regions available in the PNAD-C, defined by states and their capitals, we calculate a time invariant measure of google searches by averaging the search index 2015q4 across all municipalities within the region.

Figure A3: The Geographic and Temporal Incidence of Google Searches

(a) Map of Google Searches



(b) Google Searches by Region over Time

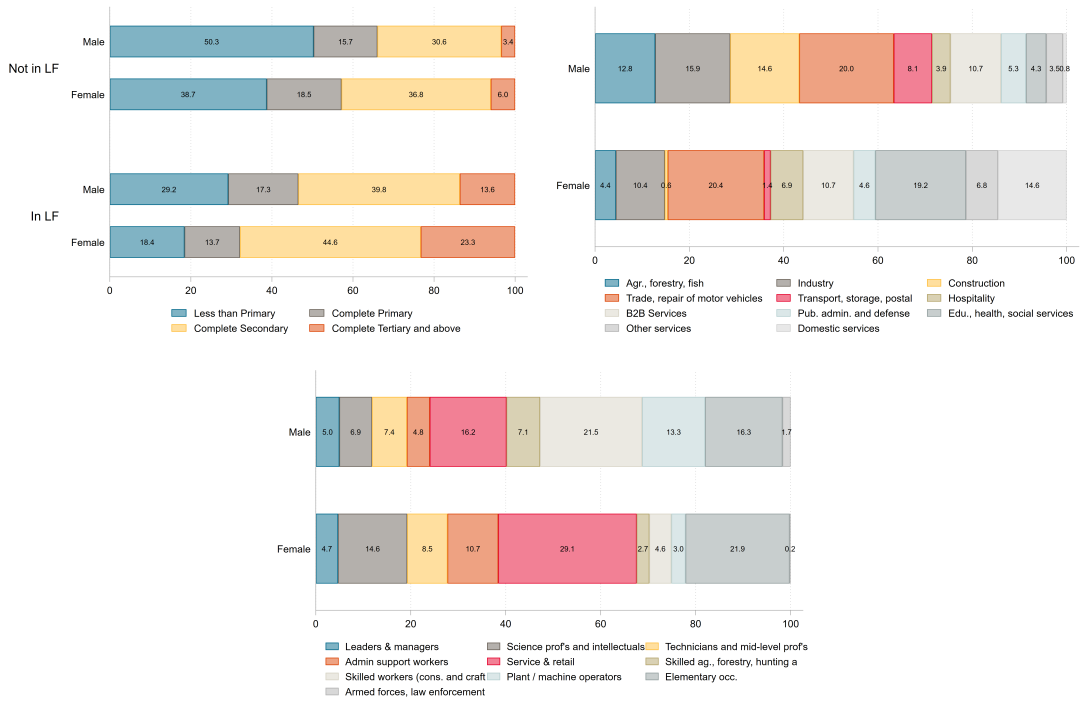


Notes: Google Search data come from Google Trends. The map in Panel A3a shows relatively prevalence of Zika searches by municipality. Municipalities in blue are those with zero searches in 2015q4, while those in red experienced non-zero searches for Zika in that quarter. The five geographic regions shown in Panel A3b are the official regions defined by IBGE. Panel A3b plots average monthly searches for Zika by region normalized by population.

B Additional Figures and Robustness

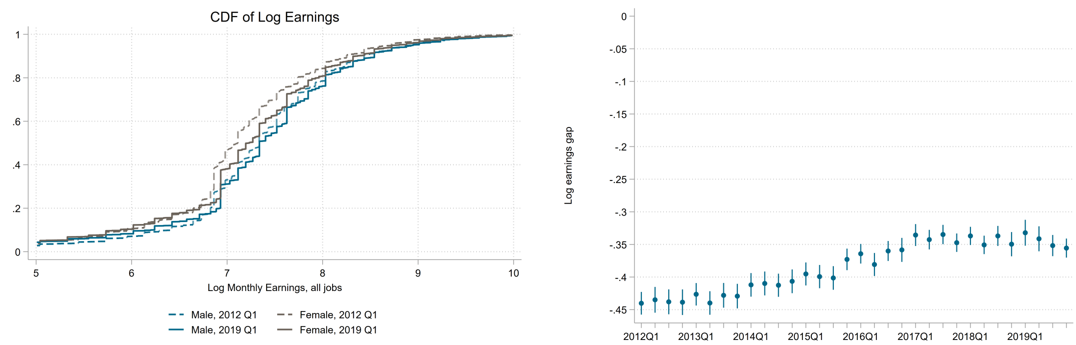
B.1 Descriptive Background

Figure A4: Women and Men in the Workforce: Education, Industry, and Occupation



Notes: Data from PNAD-C. Includes all individuals 15-49 from pooled 2016 waves.

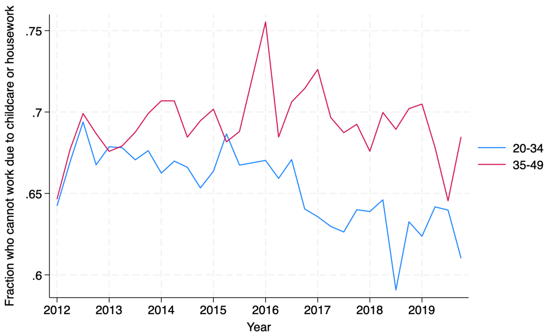
Figure A5: Women's Earnings and the Gender Pay Gap



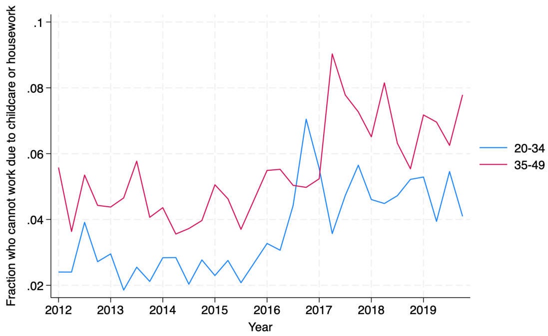
Notes: Left panel shows unconditional log earnings of men and women in 2012q1 and 2019q2. Right panel shows regressed log earnings on education, age, age squared, fully interacted occupation and industry FEs, stratum FEs, and survey wave FEs. Plotted coefficients are the interaction of female and year-quarter indicators. SEs clustered by stratum and survey wave. Source: PNAD-C.

Figure A6: Fraction of People Not Working who Cannot Work due to Childcare or Housework by Age Group & Gender

(a) Women



(b) Men

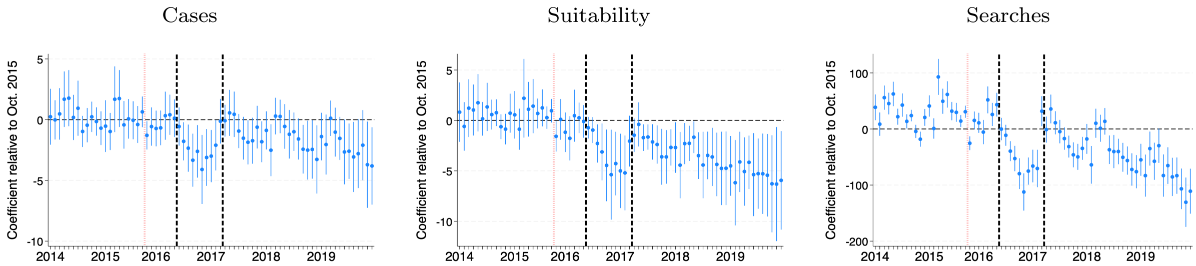


Notes: Sample is restricted to people ages 20-49 who are not working. Among the sample of people who are not working, we measure the share of this population who cannot work in the following week, if offered a job, due to childcare or housework obligations, PNAD-C, 2012-2019.

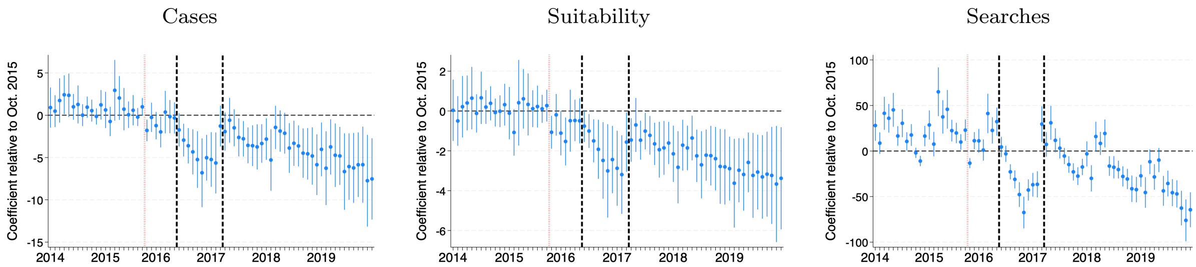
B.2 Zika's Effect on Fertility

Figure A7: Zika Impact on Monthly Births, Various Treatment Measures

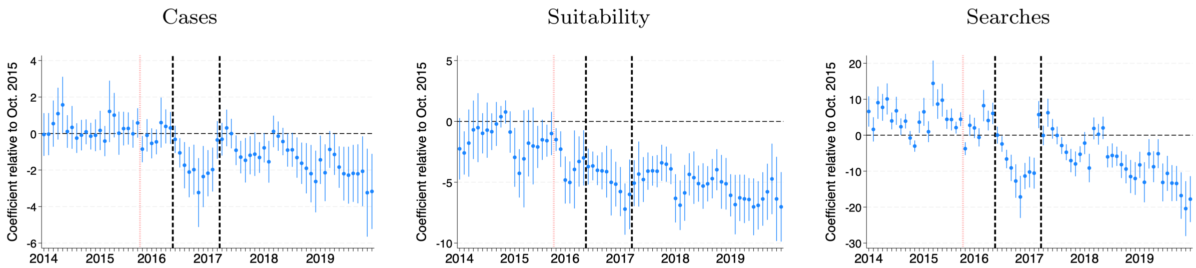
(a) Binary Indicator, Threshold 90th percentile



(b) Binary Indicator, Threshold 75th percentile



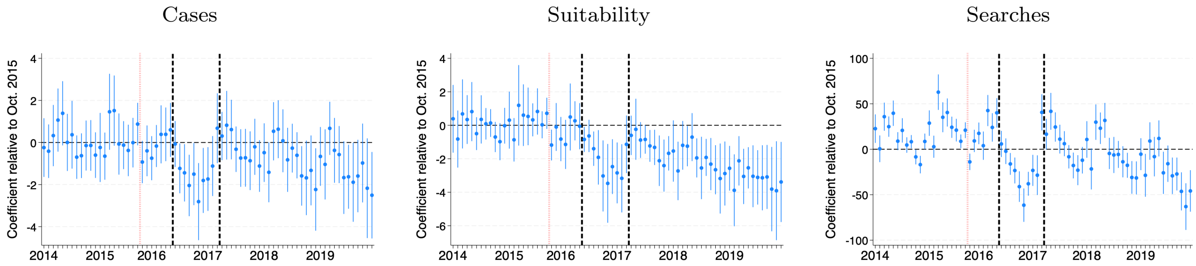
(c) Continuous Treatment Measure



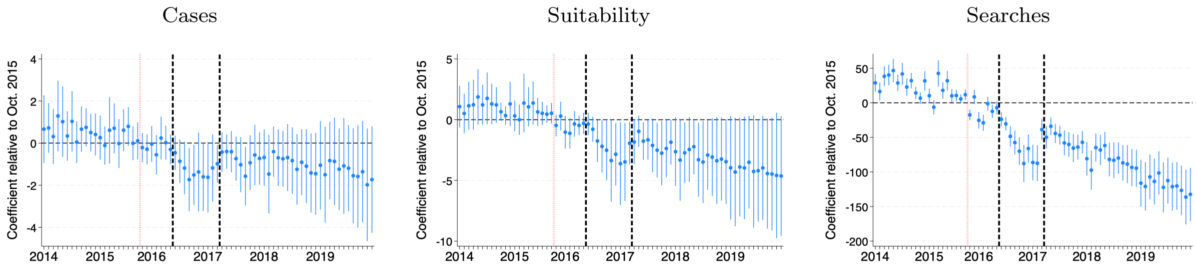
Notes: This figure compares the results from the fertility regressions using three alternative measures of high Zika intensity: a binary indicator with a threshold at the 90th percentile, a binary indicator with a threshold at the 75th percentile, and a continuous treatment measure.

Figure A8: Zika Impact on Monthly Births, By Mother's Age Group, 10 year groups

(a) Mother Aged 20–29



(b) Mother Aged 30–39

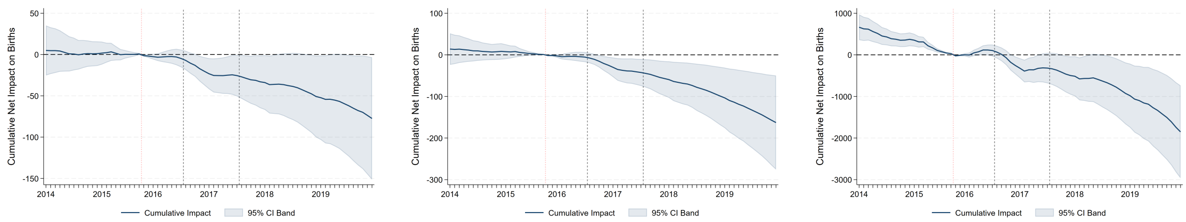


Notes: This figure compares the results from the fertility regressions using our preferred binary measure of Zika intensity (municipalities above the 90th percentile), estimated separately for mothers aged 20–29 (Panel A8a) and 30-39 (Panel **??**) at the onset of the epidemic, using SINASC data.

Figure A9: Zika Impact on Cumulative Fertility

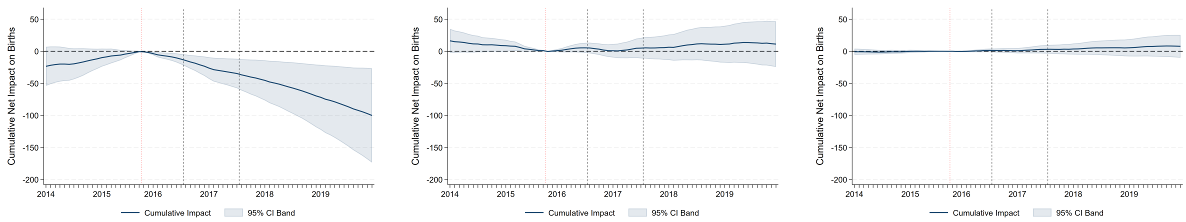
(a) Women 20–34

Cases | Suitability | Searches



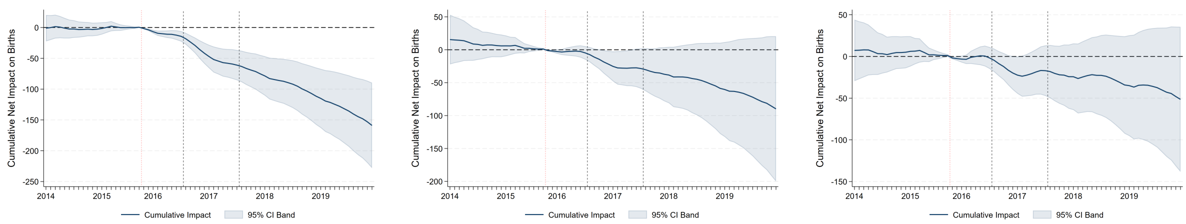
(b) Birth Parity

No Children | One or Two Children | Three or more Children



(c) Robustness: Pernambuco Treatment and Age Group (Cases Treatment)

Women 20–34, Pernambuco Treated | Women 20–44 | Women 15–39

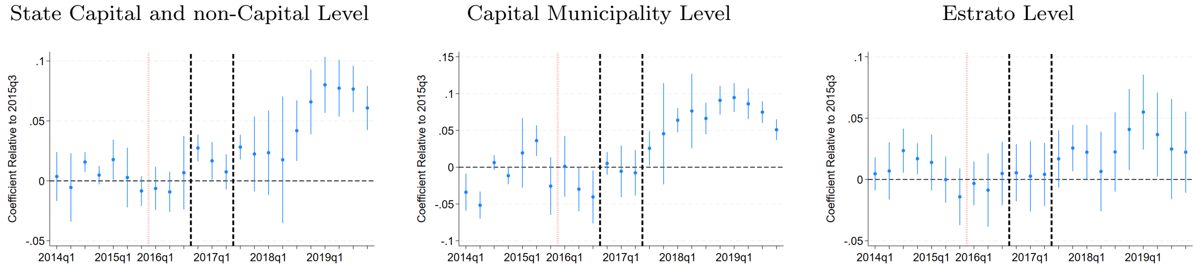


Notes: This figure plots event study estimates of the impact of Zika on cumulative fertility using birth records from the SINASC. Panel A9a shows results for women ages 20–34 in 2015 with Pernambuco omitted from the sample, using three alternative treatment measures of high Zika intensity: confirmed cases, ecological suitability, and Google searches, each defined as a binary indicator for municipalities above the 90th percentile. Panel A9b uses the preferred case-based 90th-percentile treatment measure, and shows results for women between the ages of 20 and 34 in 25 at different birth parities. Panel A9c uses the cases treatment, and the first figure plots the regression estimates on an alternative sample including Pernambuco (classified as treated). The second and third figures in Panel A9c show the estimates on cumulative fertility for women ages 20–44 and 15–44 respectively, and omit Pernambuco from the sample.

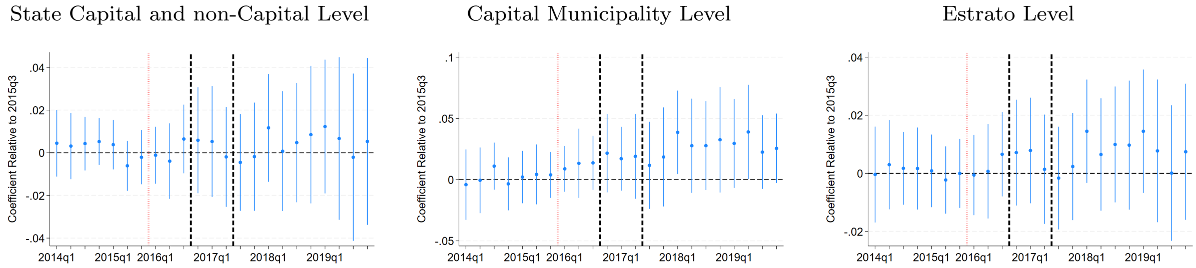
B.3 Labor-market Effects

Figure A10: Zika Impact on Employment Status, Robustness

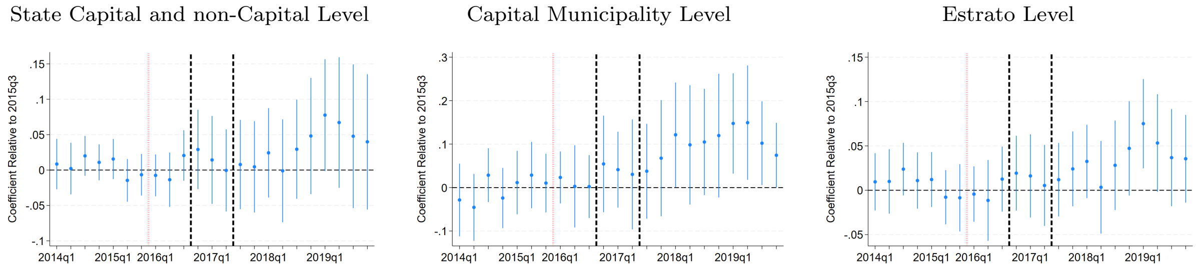
(a) Binary Indicator, Threshold 90th percentile



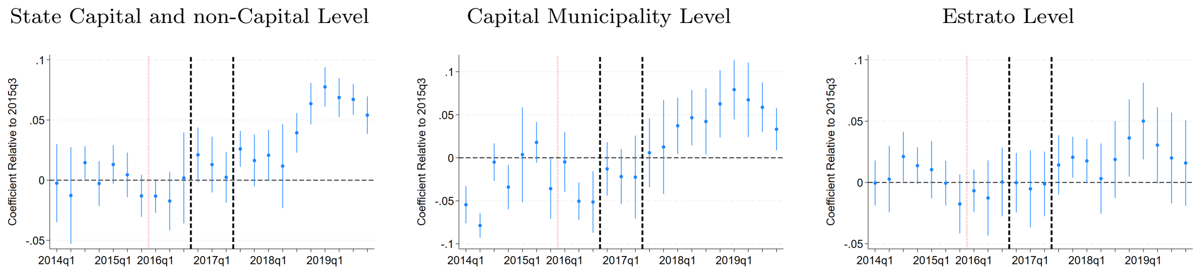
(b) Binary Indicator, Threshold 75th percentile



(c) Continuous Treatment Measure



(d) Binary Indicator, Threshold 90th Percentile, With Controls

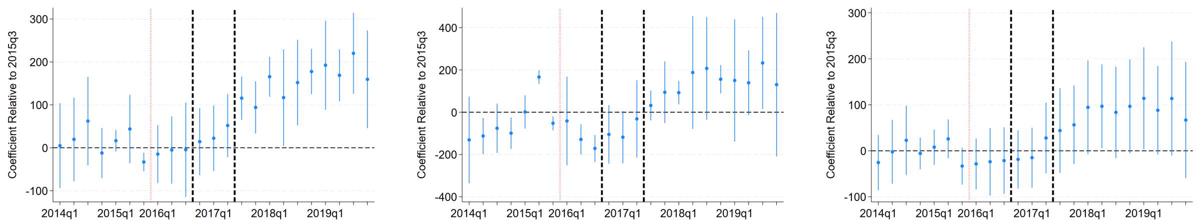


Notes: This figure shows robustness of employment labor regressions. Panels A10a through A10c use three measures of high-intensity Zika at each level of geographic variation available in the PNAD-C: our preferred binary measure with a threshold at the 90th percentile, a binary measure with a threshold at the 75th percentile, and the continuous measure. Panel A10d controls for time-by-demographic interactions for each municipality's educational structure, age structure, rural composition, and average monthly income, as measured in the 2010 census.

Figure A11: Zika Impact on Monthly Income, Robustness Across Treatment & Controls

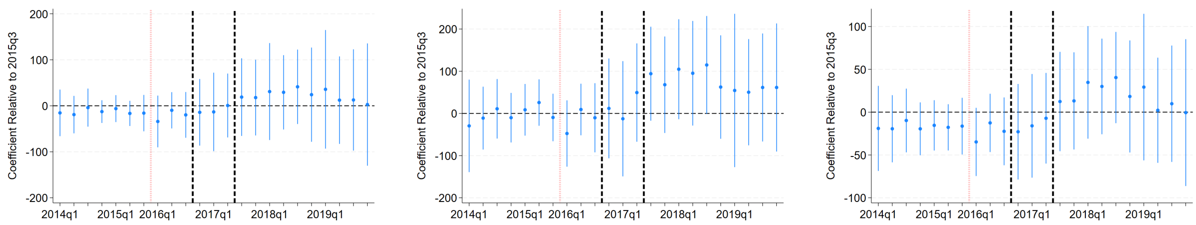
(a) Binary Indicator, Threshold 90th percentile

State Capital and non-Capital Level | Capital Municipality Level | Estrato Level



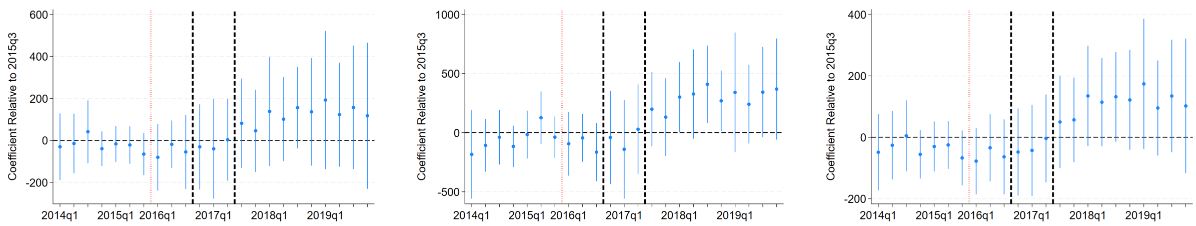
(b) Binary Indicator, Threshold 75th percentile

State Capital and non-Capital Level | Capital Municipality Level | Estrato Level



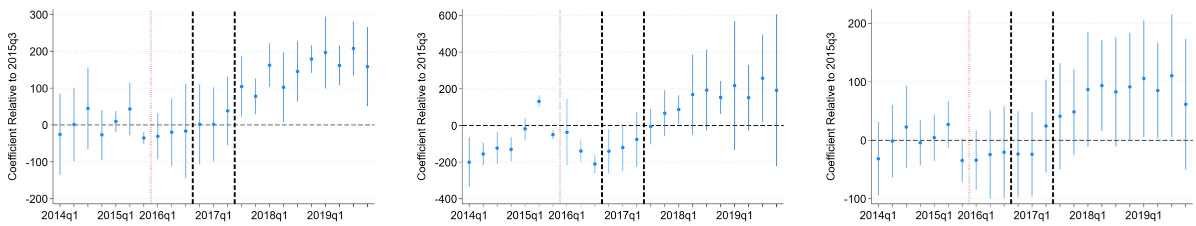
(c) Continuous Treatment Measure

State Capital and non-Capital Level | Capital Municipality Level | Estrato Level



(d) Binary Indicator, Threshold 90th Percentile, With Controls

State Capital and non-Capital Level | Capital Municipality Level | Estrato Level

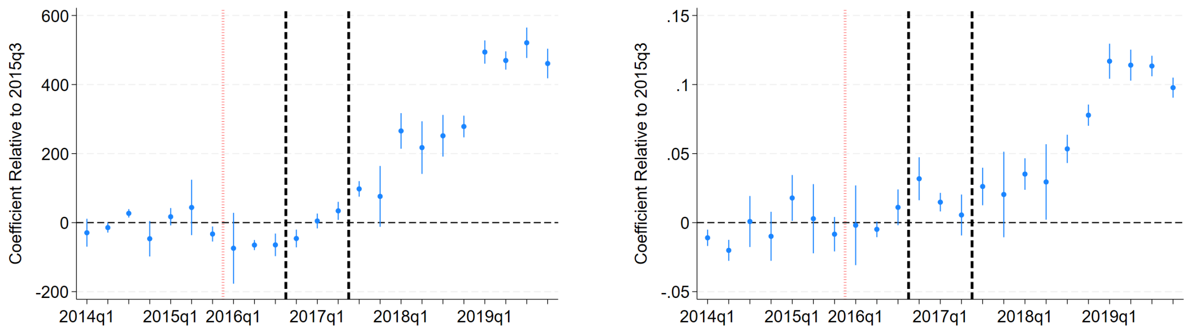


Notes: This figure shows robustness of monthly income labor regressions. Panels A11a through A11c use three measurements of Zika intensity at each level of geographic variation in the PNAD-C: our preferred binary measure with a threshold at the 90th percentile, a binary measure with a threshold at the 75th percentile, and the continuous measure. Panel A11d controls for time-by-demographic interactions for each municipality's educational structure, age structure, rural composition, and average monthly income, as measured in the 2010 census. Educational structure is the share of 20–34 year-olds who completed upper secondary schooling; age structure is the population share aged 20–34; rural composition by the share of the population living in rural areas; and average monthly income is reported directly in the 2010 census.

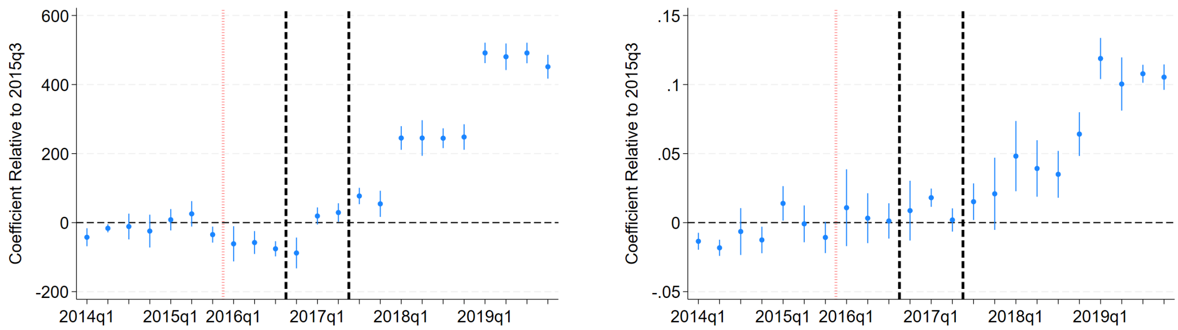
Figure A12: Zika Impact on Labor Outcomes, State-by-Year Fixed Effects and Pernambuco

Monthly Income Employment

(a) Excluding Pernambuco, With State-by-Year Fixed Effects



(b) Pernambuco Treated, With State-by-Year Fixed Effects



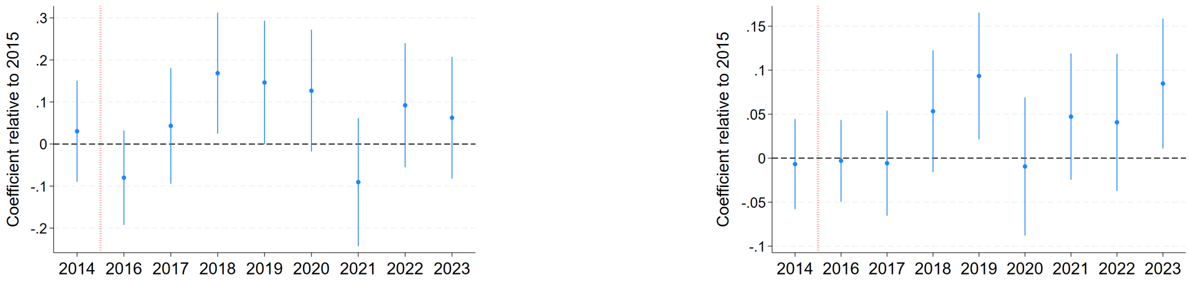
Notes: This figure shows the robustness of the labor results to including state-by-year fixed effects and to the classification of Pernambuco, using the preferred binary measure of high Zika intensity (municipalities above the 90th percentile). The left column reports estimates for monthly income and the right column for employment. Panel A12a omits Pernambuco from the sample and adds state-by-year fixed effects. Panel A12b classifies Pernambuco as treated and adds state-by-year fixed effects. All regressions are run at the state-by-capital level of aggregation.

B.4 Zika's Effect on Marriage and Divorces

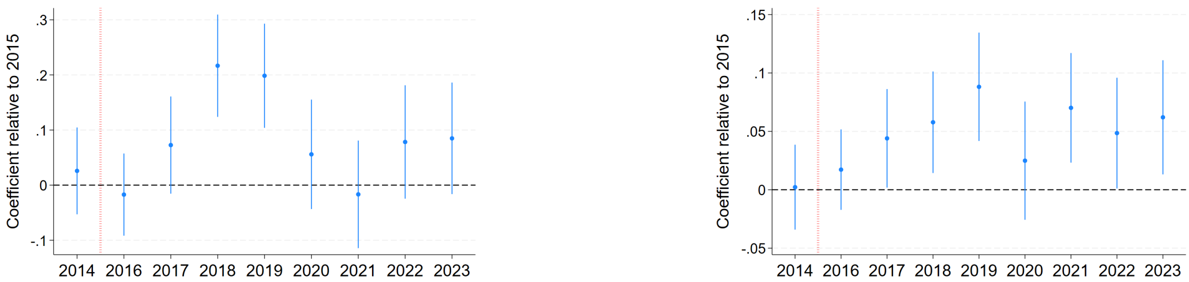
Figure A13: Zika's Impact on Divorce & Marriage, Robustness

Log Divorces | Log Marriages

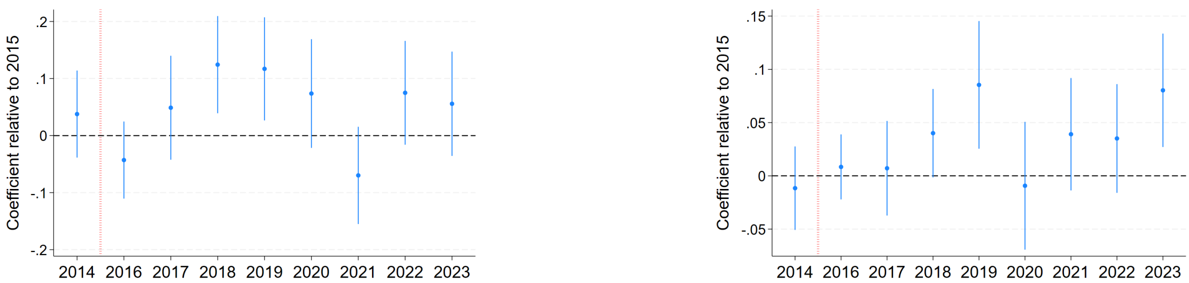
(a) Binary Indicator, 90th Percentile



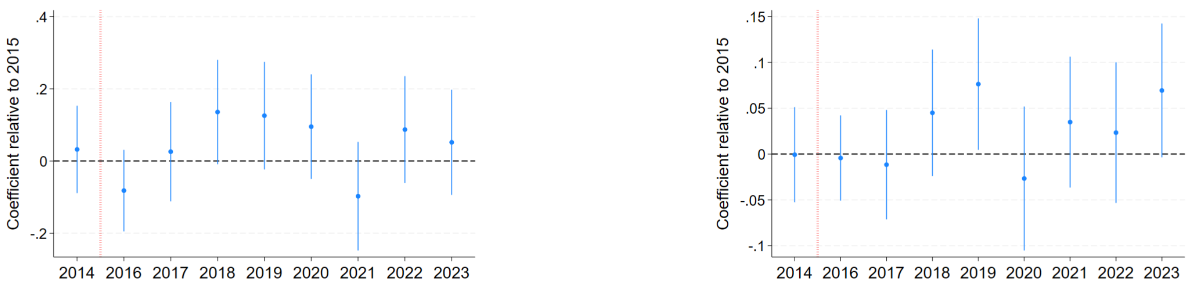
(b) Binary Indicator, 75th Percentile



(c) Continuous Treatment Measure



(d) Binary Indicator, Threshold 90th Percentile, With Controls



Notes: Panels (a)–(c) vary the definition of high Zika intensity (binary indicator at the 90th percentile, binary indicator at the 75th percentile, and a continuous measure). Panel (d) uses the preferred binary 90th percentile definition and controls for differential time trends by municipal-level demographics by including time-by-demographic interactions for each municipality's educational structure, age structure, rural composition, and average monthly income, as measured in the 2010 census. Educational structure is measured by the share of 20–34 year-olds who completed upper secondary schooling; age structure by the population share aged 20–34; rural composition by the share of the population living in rural areas; and average monthly income is reported directly in the 2010 census.