

Fertility Decision-Making under Risk:

Evidence from a Difference-in-Differences Study in Brazil

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3 June 2026

NEKN01

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Abstract

Below-replacement fertility rates have become a global phenomenon, with an increasing share of countries entering or reaching ever lower fertility levels. This paper makes two distinct contributions to the subject of fertility decline. First, it introduces a multicausal classification and mechanism model called VESPER, which organises key drivers of fertility decline into six categories commonly discussed in the literature: Values, Economics, Social, Partner, Environment, and Risk. Second, it empirically tests the risk dimension by examining whether a 2018 fertility awareness campaign conducted in Brazil affected the General Fertility Rate (GFR) in ten municipalities where it was conducted. A Difference-in-Differences analysis focusing on women aged between 15 and 49 years, using municipal and year fixed effects across 5,565 municipalities, covering the period 2010 to 2024, was conducted. The results indicate that the campaign did not generate a positive GFR effect in the treated municipalities relative to the untreated municipalities, which we argue was due to the confounding effects of the COVID-19 pandemic on the post-treatment years. We argue that the paper's findings highlight the need to reconsider the scope, scale, and duration of future fertility awareness campaigns.

Keywords: Below-replacement fertility, decision-making under risk, Difference-in-Differences analysis, fertility awareness campaign, VESPER model.

Acknowledgements

We would like to thank our supervisor, Erik Wengström, for his assistance and guidance throughout the course of our work. We would also like to thank the head of Sweden's public investigation into below-replacement fertility rates, Åsa Hansson, for her insights and recommendations. We would like to thank the panel who participated in Lund Population Day 2026 for providing inspiration for some of the points raised in this paper. We thank the panellist Aleksander Giwerzman, who was kind enough to share recommended articles in the field of infertility. We would also like to thank our fellow LUSEM master's students, as well as our friends and family, for their valuable input and suggestions. Finally, we would like to thank the Brazilian statistical authorities for making high-quality data readily available for this study. Each of you has contributed in a unique way to make this work possible.

Table of Contents

1. Introduction	1
1.1 Background	3
1.2 “Fertility in Motion” – A Brazilian Case Study	5
1.3 Research Purpose	7
1.4 Delimitations	8
1.5 Outline of the Paper.....	8
2. Literature Review.....	9
2.1 Fertility Measurements and Family Size.....	9
2.2 Education, Career, and Opportunity Costs.....	9
2.3 Socioeconomic and Structural Determinants	10
2.4 Social Influences	11
2.5 Fertility Misperception and Risk of Postponement.....	12
2.6 Information and Education Interventions.....	13
3. VESPER – A New Framework	15
3.1 Theoretical Prediction	18
4. Methodology	19
4.1 Research Approach	19
4.2 Research Design.....	20
4.2.1 Baseline DiD with No Controls	20
4.2.2 DiD with Controls	22
4.2.3 Event Study	23
4.2.4 Robustness Checks.....	23
4.3 Data Collection Method	26
4.3.1 Outcome Variable	26
4.3.2 Control Variables	27
4.4 Limitations	30
5. Results	31
5.1 Data Analysis	31
5.2 Parallel Trends Assumption	33
5.3 Difference-in-Differences Results.....	36
5.4 Event Study Results	40
5.5 Robustness Checks Results	43

6. Analysis and Discussion	50
6.1 Difference-in-Differences Analysis	50
6.2 Event Study Analysis	53
6.3 Robustness Checks Analysis	54
6.4 Discussion	55
7. Conclusion.....	61
7.1 Research Aims and Findings.....	61
7.2 Practical Implications	62
7.3 Limitations	62
7.4 Future Research.....	63
References	64
Appendix A – Tables	72
Appendix B – Figures.....	77
Appendix C – STATA, Data & Contact.....	86
Appendix D – AI Statement.....	87

List of Tables

Table 1: VESPER Model	16
Table 2: Summary Statistics – Pre-Treatment Period	31
Table 3: Parallel Trends	35
Table 4: Difference-in-Differences Results – Dependent variable: GFR	36
Table 5: Event Study Results – Dependent Variable: GFR	40
Table 6: Robustness Checks Results — Dependent Variable: GFR.....	43
Table 7: Treated Municipalities in Brazil	72
Table 8: Robustness Check 2 – Results: DiD Estimates. Dependent Variable: GFR.....	72
Table 9: Variable Overview	73
Table 10: Placebo-Treated Municipalities	75
Table 11: Summary Statistics – Treated & Placebo Municipalities – Pre-Treatment Period..	76
Table 12: AI Tool and Usage Description	87

List of Figures

Figure 1: Global Variation in TFR 2024	3
Figure 2: Treated Municipalities in Brazil	7
Figure 3: Annual GFR 2002–2024 Treated and Control Municipalities	33
Figure 4: Annual GFR 2010–2024 Treated and Control Municipalities	34
Figure 5: DiD Estimates by Specification 2010–2024	38
Figure 6: Event Study With and Without Controls	42
Figure 7: Robustness Check 2 – DiD Estimates	45
Figure 8: RC6 – Conley-Taber Placebo Distribution – Full Control Pool	48
Figure 9: RC 6 – Conley-Taber Placebo Distribution – Restricted Control Pool	49
Figure 10: Treated- & Comparable Large Municipalities, Annual GFR 2010–2024	77
Figure 11: Placebo Sample & Remaining Control Municipalities, Annual GFR 2010–2024	77
Figure 12: Robustness Checks – DiD Estimates	78
Figure 13: Education Shares 2002–2024	78
Figure 14: Log GDP per Capita 2002–2024	79
Figure 15: Union Rate 2002–2024	79
Figure 16: Racial Composition of Women aged 15–49 2002–2024	80
Figure 17: Religious Composition 2002–2024	80
Figure 18: Age Distribution of Women aged 15–49	81
Figure 19: Annual GFR Treated Capitals 2002–2024	81
Figure 20: Education Share Distribution in 2017	82
Figure 21: Log GDP per Capita in 2017	82
Figure 22: Union Rate Distribution in 2017	83
Figure 23: Racial Composition Distribution in 2017	83
Figure 24: Religion Share Distribution in 2017	84
Figure 25: Difference in GFR between Treated and Control Municipalities 2002–2024	84
Figure 26: Monthly GFR Treated and Control Municipalities 2002–2024	85
Figure 27: Monthly GFR Treated and Control Municipalities 2010–2024	85

1. Introduction

Around the world fertility rates, measured as the number of children born per woman, are decreasing and at an accelerating pace (Bloom et al. 2025). In rich and poor countries, in the global North and South, in egalitarian and unequal nations, for almost every axis of comparison we see the same decreasing fertility trend (Roser, 2014). For many years different explanations were provided to explain falling fertility rates: The demographic transition, correlations between business cycles and family formation, gender gaps to name just a few commonly cited ones (Begall & Hiekel, 2025; Bellido & Marcén, 2016; Roser, 2023). However, with the passage of time monocausal explanations such as these seem to have less explanatory power, raising the need for new frameworks to try to explain the trend of falling fertility rates. The economic consequences of below-replacement fertility, ranging from contracting gross domestic product (GDP) levels, lower growth rates, and increasing fiscal pressures from pension and healthcare demands on a shrinking tax base, make the subject highly relevant for economic research. The interest in this subject has never been higher. In many countries public investigations are attempting to explain the reasons for and consequences of falling fertility rates, and both media and laypeople are increasingly exploring the issue (Yanatma, 2026; Burn-Murdoch, 2026; Parham, 2025).

This paper makes two contributions. First, we introduce the VESPER model, a multicausal framework that organises the key drivers of fertility decline into six categories: Values, Economics, Social, Partner, Environment, and Risk. Second, we empirically test the risk dimension of VESPER using a Difference-in-Differences analysis of a 2018 fertility awareness campaign, conducted across ten Brazilian municipalities. In what follows, we describe the campaign and our research purpose, review the existing literature, present the VESPER framework, and then detail our empirical strategy and results.

The key point of this investigation is whether information that updated people's risk perception of postponing having children changed their fertility decisions. Specifically, whether the intervention in the form of the fertility awareness campaign changed enough people's risk perceptions that they decided to have children at an earlier point in their lives, which would translate into more registered births. We investigate Brazil over the period 2010–2024, using municipal-level data from Brazilian statistical and health authorities. Using a series of controls, we conducted a Difference-in-Differences, event study and robustness check tests to analyse whether the intervention changed the number of births on a municipal level using the standard fertility measurement General Fertility Rate (GFR).

The setup of this study has limitations. Notably, we investigate municipalities at an aggregate level rather than individuals, and that the fertility awareness campaign we evaluate may have had spillover effects to our control municipalities. We do not have a random treated group, as the ten treated municipalities were specifically selected by the campaign organisers. However, we argue, given the available data, that our approach is reasonable despite these identified limitations. The mechanism examined is whether exposure to the fertility awareness campaign in the ten treated municipalities contributed to higher birth levels by altering perceptions of the risks associated with postponing childbirth. This is compared with Brazilian municipalities that were not targeted by the intervention, where risk perceptions may not have been updated to the same extent in 2018, the identified treatment year used in this study.

Our results indicate that the fertility awareness campaign in the ten treated municipalities did not result in a higher level of births compared to the control municipalities that were not exposed to the intervention. We identify the COVID-19 pandemic as a key component counteracting the potential birth effects of updated risk perceptions among people exposed to the fertility awareness campaign, which occurred in close conjunction with the treatment year that we investigate. We argue that the results from this study may have implications for the scope, scale and shape of future fertility awareness campaigns, and that the VESPER model framework introduced here could provide a useful conceptual tool for future research on below-replacement fertility rates.

1.1 Background

Historically, birth rates have fluctuated within and differed between countries (Dattani et al. 2025). However, the phenomenon of below-replacement Total Fertility Rate (TFR), often calculated as 2.1 children per woman needed to sustain the population level, has in recent years become global (Ritchie & Arriagada, 2026; WHO, n.d.). TFR is calculated as the sum of age-specific fertility rates, usually referring to women aged 15 to 49 years, or five times the sum if data are given in five-year age groups (WHO, n.d.). The TFR can differ between countries depending on mortality rates and life expectancy, meaning that one nation might need a TFR of 2.1 children per woman, while another requires 2.3 to sustain its population level. However, due to health improvements, most nations have a replacement TFR of 2.1 children per woman (The Demographic Future of Humanity, 2025, 00:12:32). In 2026, a majority of the world's population live in a country with below-replacement TFR, meaning that the population of the country is projected to decrease with time (Ritchie & Arriagada, 2026). Many more countries are projected to reach below-replacement TFR, and many of the ones already below-replacement are projected to fall further still (Mercatus Center, 2026). A below-replacement TFR does not just imply a decreasing but also an ageing population, meaning a higher share of the populace will be older (Lee & Mason, 2014).

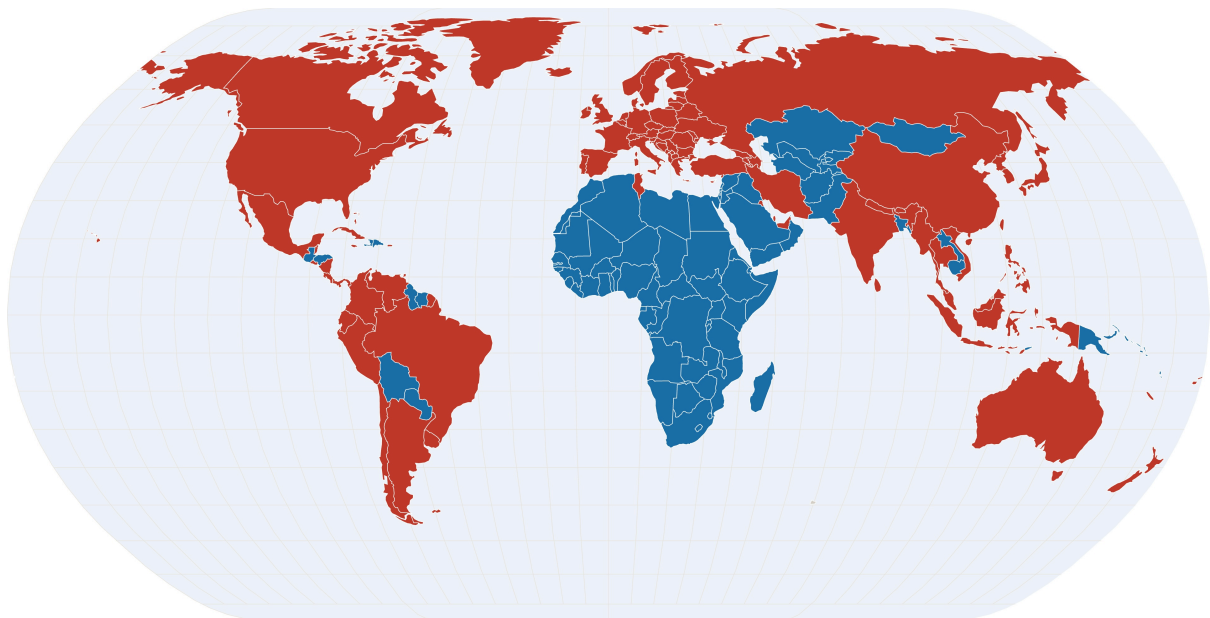


Figure 1: Global Variation in TFR 2024

Figure 1 shows the TFR, in which 2.1 is defined as the replacement rate. Countries in red have a TFR below the replacement rate, while countries in blue have a TFR equal or above the replacement rate. We can see that below the replacement rate TFR is a truly global phenomenon, with countries on every continent being affected.

Source: WPP (n.d.).

For many years the trend of falling fertility rates was explained by a series of factors; the demographic transition, with increases in life expectancy and health has resulted in a gradual shift from larger families to smaller ones, cost of living, in particular increasing housing costs, tensions between career advancement and family formation to name just a few (Adeste, 2026; Guirola & Hospido, 2024; Roser, 2023). However, as an increasing number of countries with heterogeneous profiles, ranging in family policy generosity, gender equality, housing costs etc. enter below-replacement TFR, the most commonly cited explanations for declining fertility are not necessarily rendered incorrect, but may be insufficient on their own. Increasing immigration is often raised as a solution to the issue of low fertility rates, by stabilizing or increasing national population levels (Peri, 2020). However, as growing evidence points to a convergence in fertility rates between immigrant and native populations, meaning immigrants also tend to reach below-replacement TFR, and as countries that have traditionally been a source of immigrants also reach below-replacement TFR, immigration is increasingly viewed not as a solution to below-replacement fertility, but rather as a mitigating factor (Estévez & Rotkirch, 2026). In other words, as TFR is falling globally, the long-term sustainability of immigration as a population stabilizing policy becomes less obvious as more countries enter population decline and ageing simultaneously.

The consequences of an ageing and depopulating world are both numerous and significant for a host of different areas of consideration. For the sake of brevity, however, we focus here on a limited set of economic implications. This is not to suggest that these are necessarily the most important consequences, but rather to delimit the scope of our inquiry. We can use the conclusions drawn from the Swedish public investigation into below-replacement fertility rates called “A Future with Children”, which can reasonably be transposed to different economies in the direction of effects if not in degree. These point to a major, future drop in the size of the economy measured by GDP if fertility rates remain below-replacement rate or decrease further still, ranging from drops between 13 percent to as high as 53 percent, depending on the range of below-replacement TFR, and different levels of immigration (Hansson & Lundberg, 2026). The rate of economic growth is also projected to be significantly lower if fertility rates remain below-replacement rate, and if they fall further still, ranging from decreases from a baseline growth rate, calculated as projected growth rates if the current demographics remain stable, of between 3 and 1 percent, which, compounded over time, results in massive differences in the size of the future economy (Hansson & Lundberg, 2026). Increasing strains on the public purse, with higher pension costs and health care outlays due to a higher dependency ratio, combined with a shrinking tax base, could result in major pressures, both in terms of demand for public

welfare services and the ability to supply these to an increasingly older population (Hansson & Lundberg, 2026). An ageing and decreasing population also have major implications for fiscal and monetary policy, with potentially lower real interest rates, falling asset prices, and the need for more risky financial asset allocations to get higher returns to name just a few (Hansson & Lundberg, 2026). These potential consequences are not exhaustive by any measure but point in the same direction. An ageing and decreasing population will be a major challenge for an increasing number of countries globally, with enormous implications going forward, making the subject highly relevant for economic research.

One aspect that is increasingly being raised as a key factor contributing to falling fertility rates is that the average age at which women give birth to their first child has increased (World Population Review, 2026). As both men and women have non-linear decreasing fertility with age, a higher share of people trying to conceive experience difficulties due to their older age of conception (Boxem et al. 2025). This has contributed to unplanned childlessness, whereby individuals who intended to have children either do not conceive or have fewer children than planned, a phenomenon further intensified by widespread misperceptions about the biological fertility window among both men and women (Shaw, 2025).

In response to these challenges, policymakers in many countries have introduced a selection of different family policies such as childcare provisions and welfare payments to families with children, but increasingly fertility awareness might be added to countries' family policy portfolio (Zhang et al. 2023). For example, from February 2026, the French government will start sending letters to French women and men aged 29 and above about declining fertility with age, encouraging those who want to have children to do so earlier, and to consider fertility preservation to increase their likelihood of future conception (Khatsenkova, 2026).

1.2 “Fertility in Motion” – A Brazilian Case Study

Brazil, the largest nation in South America in terms of economic, population and demographic size, is no exception to the trend of falling fertility rates, with a TFR in the year 2026 at around 1.6 children per woman (Britannica, 2026; IBGE, 2026). If the current TFR is sustained, each successive generation in Brazil will be approximately 25 percent smaller than the previous one, effectively locking in a structural population decline and an ageing population, a trend that would be further exacerbated if TFR declines continue. As noted above, Brazilians are no exception to the widespread misperceptions surrounding the fertility window and the biological determinants of fertility decline among both men and women. Therefore, in 2018, a fertility

awareness campaign, which provided information about the biological fertility window for men and women, as well as health factors that increase or decrease the likelihood of conception, was conducted in ten state capital municipalities by the Brazilian Society of Assisted Reproduction (SBRA) (Nakagawa, 2018). The campaign, called “Fertility in Motion”, aimed to raise awareness of age-related fertility decline, the limits of assisted reproductive technologies, and the risk of involuntary childlessness due to delayed childbearing (SBRA, n.d.).

Some key aspects of the SBRA-organised fertility awareness campaign include major public events attended by thousands of participants, as well as large indoor gatherings hosting up to 2,000 individuals at a time across the ten municipalities throughout 2018 (SBRA, n.d.). In conjunction with these large in-person events, a coordinated media campaign was implemented, generating over 100 mentions in major Brazilian media outlets, including G1 (Brazil’s largest digital media platform), *O Globo* (a leading national newspaper), and *Bom Dia Brasil* (one of the country’s largest morning news programmes), among others (SBRA, n.d.). In total, over 4 million Brazilian Reais, which corresponds to around 1.1 million USD using 2018 exchange rates, were spent on media advertising in the ten municipalities (SBRA, n.d.). The campaign also had a major social media presence, with large percentage growth rates in Facebook and Instagram followers, with a conservative estimate of over 200,000 people reached by social media campaigns (SBRA, n.d.). Finally, the campaign garnered endorsements from famous Brazilians such as the artist Ivete Sangalo (SBRA, n.d.).

During the course of 2018, “Fertility in Motion” became the largest fertility awareness campaign of its kind in Brazil up to that point (SBRA, n.d.). This makes the 2018 Brazilian fertility awareness campaign a unique case study for the effects on fertility rates by changing people’s risk perceptions, both in terms of its scale and emphasis. Specifically, the risk of postponing having children if one intends to have children at some point in life. To the authors’ knowledge, no follow-up study has been conducted about the impacts on fertility rates in the ten treated municipalities since the fertility awareness campaign was conducted in 2018, making this study potentially a unique contribution in this regard. Analysing the effects of the 2018 Brazilian fertility awareness campaign can also be policy relevant as more countries consider implementing future fertility awareness campaigns to boost their fertility rates.

In summary, the 2018 Brazilian fertility awareness campaign “Fertility in Motion” can be interpreted as an intervention designed to update perceptions of the risks associated with delaying childbirth, communicating that men and women face a lower probability of becoming parents if they postpone attempts to conceive. In this respect, the campaign can be understood as framing fertility choices as a form of decision-making under risk.

1.3 Research Purpose

The purpose of this study is to examine whether the 2018 fertility awareness campaign "Fertility in Motion", conducted by SBRA, resulted in more births in the ten treated municipalities compared to the rest of Brazil's municipalities (see Table 7 in Appendix A). Specifically, we examine whether the campaign's focus on the risks of postponing childbirth changed people's risk perceptions sufficiently that they decided to have children earlier, an effect that could manifest in three ways:

- A) A reversal from falling to increasing birth rates
- B) A stabilization of the birth rate
- C) A falling birthrate but at a smaller rate of decline

As outlined above, addressing misperceptions about the risks of biological fertility decline due to postponing childbearing requires targeted information and education. Given that the campaign lasted only one calendar year, and based on our reading of the literature reviewed below, we believe the most realistic effects would be scenarios B and C.



Figure 2: Treated Municipalities in Brazil

Figure 2 illustrates the ten municipalities that were exposed to the 2018 "Fertility in Motion" campaign in Brazil, which constitute this paper's defined treated municipalities.

Source: (SBRA, n.d.).

1.4 Delimitations

The primary time period investigated spans from 2010 to 2024, as the parallel trends assumption, a key precondition for our analysis, appears more plausible from 2010 onwards when comparing treated and control municipalities. For some graphical illustrations and descriptive analyses, we extend the period back to 2002, the earliest year for which sufficient data coverage across municipalities could be established. Data outside this range was either incomplete or missing, and any missing observations within 2002–2024 have been interpolated using adjacent year values. We focus on women aged 15–49, as this range captures the primary reproductive years and is standard in fertility research, and because annual births at the municipal level can be more directly and consistently linked to women than to men.

At this point, it is worth clarifying our general approach to the topic of falling fertility rates and the population of interest in this study. We take no stance on whether people should have children or how many, as we believe this to be a personal decision. Rather, this study is motivated by the concern that some people who want to have children may face barriers to realising that goal, including limited awareness of the risks associated with postponing childbirth. We therefore examine whether updated risk perceptions influence when such individuals believe they should try to conceive. Therefore, when we treat and discuss fertility choices going forward, we only concern ourselves with adults who intend, at some point in their life, to have children.

1.5 Outline of the Paper

We begin by reviewing the literature on declining fertility rates before introducing the VESPER model and using it to derive a theoretical prediction regarding the expected effects of the Brazilian fertility awareness campaign. This is followed by a presentation of the study's methodology, research question, hypothesis, and econometric model, alongside a description of the data and the empirical results. The findings are then discussed in relation to the broader literature on fertility decline. Finally, we conclude with a summary of our answers to the research question and hypothesis, the study's limitations, practical implications, and suggestions for future research.

2. Literature Review

2.1 Fertility Measurements and Family Size

When discussing fertility declines the focus is often on a decrease in the TFR, which has fallen below-replacement level in many countries, as discussed in the background section (Ritchie & Arriagada, 2026). Shaw (2025) decomposes the TFR into two components in a Micro Demographic Framework (MDF): The number of children per mother (CPM) and the total motherhood rate (TMR), providing additional insight into the dynamics of fertility developments. CPM measures the average number of children born to women who become mothers, based on current age-specific fertility rates, whereas TMR measures the proportion of women expected to become mothers over their reproductive lifetime, assuming current age-specific fertility persists. The MDF expresses the relation between those measures as $TFR = CPM \times TMR$, showing that overall fertility depends on how many women enter motherhood and how many children mothers have. According to Shaw (2025), while the CPM has remained relatively stable in recent decades, the TMR has declined sharply. This implies that a growing share of individuals remains childless, indicating that the overall fertility decline is primarily driven by rising childlessness rather than a reduction in family size. At the same time, there is evidence of a cohort fertility decrease among individuals in their twenties and early thirties, and a cohort fertility increase among individuals in their late thirties and early forties, suggesting that parenthood is increasingly delayed (Goldin, 2025). While some of this delay is offset by childbearing at older ages, postponement increases the risk of unintended childlessness due to the biological age-related decline in fertility.

2.2 Education, Career, and Opportunity Costs

One of the widely discussed factors explaining fertility decline is the relationship between female education, labour market participation, and fertility outcomes. Evidence shows that childlessness is particularly widespread among highly educated women, largely because they delay having children while advancing their careers (Goldin, 2025). Furthermore, the share of individuals attaining higher education has increased substantially in recent years (UNESCO, 2025). Rising female educational attainment and an increase in female labour force participation have resulted in a greater opportunity cost of childbearing (Goldin, 2025). In this context, Goldin (2025) highlights a key issue, “the mismatch problem”, arising from women’s increasing autonomy through economic opportunities, and the traditional institutional and

partnership structures regarding family formation. Without credible commitments from partners to share childcare responsibilities, as well as family supporting government policies, women often face a steep trade-off between their career and family. This trade-off is further reflected in the motherhood wage-gap, which indicates that mothers earn lower wages than comparable childless women over their lifetimes (Cukrowska-Torzewska & Matysiak, 2020; Goldin, 2014; Kleven et al. 2019). Additionally, the presence of “greedy jobs”, which are professions that pay disproportionately more for long and inflexible working hours, may result in specialization within a household, where one partner prioritizes career advancement while the other takes on a larger share of household responsibilities (Goldin, 2025; Treas, 2008). Related to this, Buber-Enns et al. (2013) draw on the “Rush Hour of Life” framework, describing a period between the mid-twenties and late thirties in which competing career and family demands create time pressure, leading individuals to continuously postpone parenthood, a pattern their findings suggest is a key driver of childlessness among the highly educated.

2.3 Socioeconomic and Structural Determinants

Another crucial factor in explaining fertility developments is the broader socioeconomic environment that people live within. A well-documented pattern highlighted in the literature is the negative relationship between per capita income levels and fertility (Goldin, 2025). More broadly, economic factors such as rising housing costs, and perceived as well as actual costs of raising children, are commonly associated with lower fertility. Childcare policy represents another structural determinant of fertility outcomes, as access to affordable and high-quality childcare is crucial for enabling work-life balance and has been shown to support both fertility levels and the timing of childbearing (Goldin, 2025; Hammarberg et al. 2017; UNFPA, 2025). This is particularly relevant for college-educated women, for whom accessible childcare offset some of the opportunity costs of childbearing (Brand & Davis, 2011). Beyond structural economic conditions, uncertainty and economic shocks also play an important role. Shaw (2025) emphasizes an association between economic shocks and fertility outcomes, suggesting postponement in fertility decisions due to present and future uncertainty. This reading is supported by research conducted by Comolli and Vignoli (2021), which indicates that an increase in public anxiety is directly associated with declines in birth rates approximately nine months later. This stresses that fertility responds not only to realized economic conditions, but also to expectations and risk perceptions among men and women.

2.4 Social Influences

Bernardi and Klärner (2014) argue that adopting a social network perspective is crucial for our understanding of fertility behaviour. They emphasize that social mechanisms shape individuals' beliefs and norms regarding childbearing, specifically the perception of having children and the associated opportunities and constraints, which in turn can affect reproductive decision-making. Empirical evidence by Lois and Becker (2013) supports this perspective, as they find a positive association between the number of network members (e.g. friends, family members, etc.) with young children and individuals' transition to parenthood, specifically for younger couples. This is explained by several underlying mechanisms such as individuals gaining insight into the multifaceted nature of parenthood through observing their peers as parents. People might feel greater social pressure to start a family, and the opportunity costs related to social ties, as the costs are lower when others in the network already have children, making the transition to parenthood more socially compatible and desirable.

However, social environments can also generate misperception in fertility-related beliefs. Bursztyn and Yang (2022) show that individuals' perceptions of other people's behaviour influence the shaping of their own attitudes and behaviour. Applied to fertility, this suggests that individuals exposed to social environments, such as friends and peers but also public figures, for whom childbearing occurs at a later age, may update their beliefs about what is normal or biologically feasible. When social environments misrepresent biological realities, this can result in decision-making about fertility timing based on incorrect information. Another related mechanism through which the social environment may influence fertility relates to technological use and media consumption. Hudson and Moscoso Boedo (2026) argue that part of the decline in teen fertility observed in 2007 in the US, England and Wales, can be explained by how young people spend their time together following the rise of smartphone usage. In particular, they show that young people increasingly spend less time socialising in person. This is consistent with earlier findings by Hornik and McAnany (2001), who show that increased television ownership reduced the time individuals spend socializing outside the home. The authors hypothesize that reduced in-person interaction may delay partner formation, which could in turn contribute to lower fertility.

2.5 Fertility Misperception and Risk of Postponement

Part of the literature examines the misperception about biological constraints and the timing of fertility. Fecundability, which is the probability of conception in a menstrual cycle, decreases with age for both women and men, though the decline for men is more modest (Rothman et al. 2013; Wesselink et al. 2017). The female age-related decline has been shown to be the dominant factor in determining a couple's fecundability decline (Zhang et al. 2024). However, a consistent finding is that individuals tend to hold incorrect information about both the duration of the fertility window and the pace of age-related fertility decline, even among those who actively try to conceive (García et al. 2015; Mu et al. 2019; Wainwright et al. 2025). In particular, women often overestimate the age range over which fertility remains high and underestimate how quickly it declines. For context, at 40 years of age the likelihood of a successful pregnancy is less than half that of women in their late 20s and early 30s, meaning that women's fertility drops non-linearly with time (Penzias et al. 2022). Men also experience a decrease in their fertility with age, although not as steep as for women. A 40-year-old male's sperm quality is significantly less compared to a 30-year-old male, and the quality of men's sperm decreases precipitously with age (Johnson et al. 2015). This misperception can directly affect reproductive timing, as individuals make fertility decisions under the false assumption that there is still enough time to conceive. These dynamics are particularly relevant for certain subgroups. For instance, Schmidt (2008) finds that higher risk tolerance is associated with delayed childbearing, which ultimately results in a higher likelihood of remaining childless. This applies specifically to highly educated, unmarried women.

Compounding this, Mu et al. (2019) find that women who rate themselves as highly knowledgeable about fertility, in fact, face higher fertility-related risk factors compared to women with actual, correct knowledge. This suggests that fertility misperception may be more consequential than the lack of information itself. Importantly, these misperceptions are not limited to women. Both men and women tend to overestimate how long fertility lasts, which can reinforce delayed childbearing decisions (Hammarberg et al. 2017).

Another aspect of fertility misperception involves in vitro fertilization (IVF) methods. The World Health Organization (2025) recognizes infertility as a disease that undermines individuals' right to decide the number, timing, and spacing of their children, as part of reproductive health and well-being. Due to increasing infertility, an increasing number of children are born through IVF. For example, around 5 percent of all children born in Sweden are conceived through IVF (Giwerzman et al. 2026). However, fertility treatments such as IVF

cannot fully offset biological decline in fertility. There remain large misconceptions regarding the likelihood of success when using assisted reproductive technologies. IVF is often perceived as a reliable safety net, yet around 30 percent of those who seek fertility treatment do not achieve a pregnancy, and IVF success rates are commonly overestimated by many who use the technology (García et al. 2015; Giwercman et al. 2026; Svanberg et al. 2006). Hammarberg et al. (2017) combine both dimensions and argue that the lack of knowledge about age-related decline, combined with optimistic beliefs about IVF success, could result in involuntary childlessness as people chose to deliberately postpone childbearing based on false assumptions.

2.6 Information and Education Interventions

The evidence of widespread misperception about fertility, outlined in the previous section, motivates policy interventions aimed at improving fertility education and awareness. A growing body of literature evaluates the effectiveness of fertility education. Bodin et al. (2021) find that fertility education is most effective when delivered at earlier stages of life, particularly during secondary education. At later ages, information about biological fertility constraints may be perceived as distressing, particularly among individuals who face factors involved in reproductive decision-making beyond their immediate control. This highlights the importance of both timing and framing of fertility-related education.

At the same time, other studies show that fertility education at a later stage is not ineffective. In fact, even a single online fertility education intervention can result in statistically significant improvements in fertility knowledge, although these effects tend to diminish over time (Maeda et al. 2018). Therefore, the study emphasises that repeated exposure to information could be effective. Furthermore, it also finds that fertility knowledge can potentially affect the timing of childbearing among people who already have a partner, as well as an increased attendance for fertility medical consultancy. García et al. (2015) underline that fertility education increases knowledge, although their findings suggest that the effect on the ideal age of childbearing was modest. Nevertheless, exposure to fertility-related topics can stimulate further interest and engagement in the subject, suggesting that fertility education has the potential to initiate a broader process of information-seeking and awareness. This is consistent with broader insights from behavioural economics. When individuals receive new information to update biased beliefs, it can result in meaningful changes in behaviour (Thaler, 2016). In the context of Brazil, evidence suggests that media-based information and the transmission of social norms, for

example, the portrayal of small family sizes in popular telenovelas, resulted in measurable changes in fertility behaviour (La Ferrara et al. 2012).

Overall, these findings suggest that fertility education and awareness interventions can play an important role in reducing fertility misperceptions and uncertainty, thus enabling informed reproductive decision-making based on accurate information. In fact, a growing body of literature is emphasizing the need for fertility awareness as a public health matter to empower informed reproductive decision-making among both men and women (Giwerzman et al. 2026; UNFPA, 2025).

To summarize, the empirical literature regarding the fall in fertility rates that we have outlined above suggests that no single factor by itself can be isolated as a key explainer for falling fertility rates. Rather, the different factors explored by previous research point to the phenomenon of falling and below-replacement fertility rates as being multicausal, with several factors occurring simultaneously and potentially interacting with one another. In the following section, we present a novel way to conceptualize the multicausal nature of below-replacement fertility rates.

3. VESPER – A New Framework

We now turn to a unique contribution of this paper, which is a model that seeks to provide a framework and understanding of the phenomenon and mechanism for below-replacement fertility rates. The model, which we call VESPER, was developed based on the findings in the literature review above. VESPER is an abbreviation that stands for “Values, Economics, Social, Partner, Environment, Risk”. It is both a way of classifying the key factors governing fertility decision-making and identifying a mechanism to explain how these contribute to the development of the TFR. A key part of VESPER is that it is a multicausal model, meaning that we do not claim that one of the compositional categories of factors is “the” key aspect governing the fall in fertility rates, which is something a monocausal model would argue for. Several, if not all, factors covered by the model can be at play simultaneously, with different intensities or degrees of importance depending on the country or place that is being evaluated regarding fertility rates. This means that some of the VESPER model components might be of greater importance in one location than in another, allowing for conceptual clarity but heterogeneous application of the framework. This is important as the phenomenon of below-replacement TFR has reached such a heterogeneous collection of countries that the need for a multicausal model seems necessary to understand and address the issue of below-replacement fertility rates.

The composite parts of the VESPER model mnemonic – Values, Economics, Social, Partner, Environment, Risk – are categories that, based on our research into the topic, cover most of the factors driving falling fertility rates globally. Although the presence of two Es can be a source of confusion, we deem the memorability of VESPER as a mnemonic to outweigh potential letter confusion. We acknowledge that the categories vary in their internal homogeneity. In particular, the Environment category is intentionally broad, grouping physical conditions such as environmental exposures, health behaviour and geographical factors, on the basis that these operate as short-term structural fertility constraints. We also acknowledge that there exist potential interaction effects between the identified categories in the VESPER model. However, we do not believe this to be a major issue as the ability to identify interactions between these categories might be of analytical value, and the VESPER framework allows for such analysis to be tested for in the future. The examples we will provide in Table 1 below are not exhaustive, but their grouping into one of these six categories of factors is, we believe, a useful and novel way to conceptualize the issue. The VESPER framework offers researchers, policymakers, and laypeople a new, easy way to remember and understand the factors and mechanism resulting in falling fertility rates around the world.

Table 1: VESPER Model

<i>Variable</i>	<i>Description</i>
V (Values)	People’s values around the timing and nature of childbearing, whether motivated by religion or secular considerations. For example, whether to have children within or outside of wedlock, if to have children before, during or after formal education, potential gender gaps regarding these value expectations etc. (Tartakovsky & Mizrahi, 2025).
E (Economics)	Material factors such as the cost of housing and buying a home, family welfare policies, access to childcare or the lack thereof etc. that motivate when people want to have children. (Goldin, 2025; Hammarberg et al. 2017; UNFPA, 2025).
S (Social)	Social coordination and influence around the timing of childbirth, motivated by factors such as the pregnancy of acquaintances, operating as a kind of social contagion, the fertility choices of role models, such as influencers and perceived people of importance, and the perceived “right” time to have children to be in line with one’s peers etc. (Bernardi & Klärner, 2014; Lois & Becker, 2013).
P (Partner)	Having or not having a partner at a given time, with the implication that most people seek not to just have children but also a family. Preferences for the kind of attributes a partner should have, whether looks, income, wealth, prospects, standing etc. Also consists of a reflexive component, that is how other people perceive a person’s attractiveness as a partner to have children with, whether a relationship turns out to be long term or not (da Silva Frost et al. 2024).
E (Environment)	The physical, spatial and geographical conditions that affect fertility. Such as the accumulating effects of microplastics, pollution, health habits such as smoking, the place where people want to have children etc. (Fiori et al. 2014; Giwerzman et al. 2026).
R (Risk)	The risk perception of people of postponing childbirth. Both as a function of lower biological likelihood to be able to conceive as one becomes older, but also of the likelihood of relationship formation. For example, an older man or woman seeking to have a child with a younger partner will be competing with peers and younger competitors for the same pool of partners. And as one gets older the factor of finding a partner that matches with one’s life can become more difficult with time, such as having similar habits, interests, priorities etc. that can result in a more difficult matching problem. It can also be that people have less time and energy as they get older to date and meet potential partners (Bodin et al. 2021; Maeda et al. 2018; Thaler, 2016).

VESPER Mechanism

With the advent of modernity, which is characterized by a host of disparate factors such as greater access to and quality of contraceptives, greater individual freedom regarding how and where to live, greater access to information and ideas, educational and professional opportunities, and many more items of consideration, having children has become more of a choice. Because of this, having children increasingly becomes an active decision for individuals, as opposed to an inactive decision, where having a child is not something one necessarily controls or decides, which can be motivated by one's values, economic conditions, social factors, having a partner, environmental factors, and risk perceptions. Whichever combination of these factors people consider or are affected by, if people are motivated or incentivized to postpone having children, then the biological factor and greater matching difficulty with age become more important. This means that as a greater number of people try to conceive later in life, a higher share of these will, for different reasons, fail to have children, resulting in involuntary childlessness.

If people were motivated to postpone childbearing with a false risk perception of their odds of having children later in life, then the risk component of VESPER corresponds to people's actual risk perception. That is, they are not aware of the actual risk they are taking by postponing having children. And, on a societal level, the risk that as the average age of attempting to conceive rises, a larger share of people will become involuntarily childless. This drives down the TFR, and, if the relative share of childless people reaches a certain point, falls below the replacement rate (Shaw, 2025).

3.1 Theoretical Prediction

The 2018 fertility awareness campaign “Fertility in Motion”, conducted by the SBRA in Brazil, which specifically focused on raising awareness of the risks of postponing childbirth for those who intended to become parents at some point in their life, in ten Brazilian municipalities, arguably changed the risk perceptions of the people who were exposed to the intervention. As outlined by the VESPER factors that motivate people’s childbearing choices, people in these ten municipalities might have been motivated by different things as to when to have children; saving for a downpayment to buy a home, waiting to find “the one”, by choosing to pursue education or work, wanting to have children later in life as this is seen socially as more “normal” and a host of other motivations.

Exposure to the campaign, which was extensive during the course of one calendar year in the ten selected municipalities, changed some of the inhabitants of these municipalities’ risk perceptions, potentially resulting in them having children at an earlier point than they intended before the campaign occurred. This would be expected to manifest in municipal-level fertility outcomes after the 2018 treatment year. Specifically, as higher birth rates than would have occurred in the absence of the campaign. In the Difference-in-Differences framework, this implies that treated municipalities should experience a positive, relative change in the outcome variable measuring births compared with Brazilian municipalities not exposed to the one-year fertility awareness campaign.

4. Methodology

4.1 Research Approach

This study adopts a quantitative, quasi-experimental research approach to evaluate the causal effect of the 2018 public fertility awareness campaign “Fertility in Motion” in Brazil. Specifically, it examines whether the campaign conducted in ten Brazilian municipalities influenced the GFR among women of reproductive age (15–49 years), by raising awareness of the risks associated with postponing childbirth. Therefore, we implemented a Difference-in-Differences (DiD) analysis complemented by an event study and robustness check tests. The treatment group consists of the ten municipalities in which the campaign was conducted, while all other Brazilian municipalities form the control group. The event is the launch and implementation of the campaign throughout the calendar year 2018. We aim to answer the following research question:

Research Question:

Did exposure to the 2018 "Fertility in Motion" campaign, through updated risk perceptions about postponing childbirth, have an impact on the GFR in treated Brazilian municipalities relative to untreated ones?

Hypothesis:

The 2018 fertility awareness campaign resulted in more births, measured by the GFR, among women aged 15-49 in the 10 treated municipalities compared to non-treated municipalities, after 2018.

Given the worldwide trend of falling fertility rates, we expect both the treated and control municipalities to follow a negative trend in GFR after 2018. However, if the campaign effectively raised awareness of the risks associated with postponing childbirth, treated municipalities would be expected to experience a smaller decline in GFR relative to control municipalities. In the DiD setup, this would translate into a positive treatment coefficient, reflecting that the campaign mitigated the pace of fertility decline for the treated municipalities compared to the counterfactual.

The key assumption of this empirical set-up is the parallel trends assumption (Angrist and Pischke, 2009). It implies that the outcome variable, the GFR, follows similar trends for both

the treated and control municipalities in the pre-treatment period and assumes that they would have continued to follow parallel trends in the post-treatment period, in the absence of the fertility awareness campaign. Under this assumption, any divergences in GFR between the groups in the post-treatment period can be interpreted as a causal result of the campaign. We also make a no-anticipation assumption, meaning that individuals in the treated municipalities did not adjust their behavior prior to the intervention. Since inhabitants were not informed about the fertility awareness campaign in advance, we assume that risk perceptions regarding postponed childbirth remained unchanged before the campaign was implemented.

4.2 Research Design

4.2.1 Baseline DiD with No Controls

The Difference-in-Differences framework compares changes in the development of an outcome, between a treated and an untreated group, both before and after an identifiable intervention (Angrist and Pischke, 2009). To estimate the causal effect of the 2018 Fertility Awareness Campaign, we use a DiD framework as a two-way fixed effects (TWFE) regression. The baseline specification is given by:

$$GFR_{mt} = \beta Treatment_{mt} + \gamma_m + \mu_t + \varepsilon_{mt} \quad (1)$$

- GFR_{mt} : General Fertility Rate
- $Treatment_{mt}$: Difference-in-Differences indicator
- γ_m : Municipality fixed effects
- μ_t : Yearly fixed effects
- m : Municipality
- t : Year
- ε_{mt} : Error term

The main outcome variable of interest is the GFR. It is a widely used measure of fertility, defined as the number of births per 1,000 women of reproductive age (15–49) in municipality m and year t (UNFPA, n.d.).

$$GFR_{mt} = \frac{births_{mt}}{women_{15-49_{mt}}} \times 1000 \quad (2)$$

This outcome variable allows for comparison between municipalities and over time. Using GFR rather than raw birth counts is important, since it accounts for differences in population size

between municipalities. This allows the comparison between treated municipalities consisting of large, state capitals with higher numbers of inhabitants, in contrast to the control units consisting mostly of smaller municipalities with lower numbers of inhabitants. Another benefit of using GFR instead of TFR is that we avoid having to tabulate more information, like mortality rates for women, that is necessary to construct a valid TFR measurement.

The event of interest is the launch of the fertility awareness campaign “Fertility in Motion” in 2018. We expect the campaign to affect fertility through changes in behaviour, and since pregnancies typically last around nine months, any effect on births shown through the GFR, should materialize with a biological lag. Consequently, the treatment is defined based on its exposure to the campaign and its timing. Since the campaign took place in 2018, we expect the first observable effects to appear from calendar year 2019 onwards. Therefore, the *Treatment* variable is constructed as an interaction between *Treated* municipality indicator and a *Post* campaign period indicator.

$$Treatment_{mt} = Treated_m \times Post_t \quad (3)$$

- $Treated_m = 1$ for the 10 campaign cities, 0 otherwise
- $Post_t = 1$ for all years from 2019 onwards, 0 otherwise

The coefficient of interest, the DiD estimate β , indicates the average change in fertility in treated municipalities after the campaign, relative to the control group. This estimate captures the aggregate effect of the campaign being conducted in a municipality, rather than the effect on individuals who were directly exposed to and acted upon the information provided.

The model includes both municipality and yearly fixed effects. Municipality fixed effects account for all time-invariant, unobserved characteristics of each municipality. Yearly fixed effects absorb any shocks or trends that are common across all municipalities in a given year. By including these fixed effects, the model isolates variation that is both time-varying and municipality-specific, which is crucial for identifying the causal impact of the campaign on fertility. Standard errors are clustered at the municipality level to account for within-municipality serial correlation, and are robust to heteroskedasticity.

In summary, the DiD design compares changes in fertility between treated and untreated municipalities before and after the campaign, controlling for municipality-specific trends and common time shocks. Given the parallel trend assumption, the changes in fertility in the control group approximate the counterfactual evolution of fertility in treated municipalities in the absence of the campaign.

4.2.2 DiD with Controls

The baseline DiD regression is augmented with a set of time-varying control variables that capture demographic and socio-economic differences within the female population across municipalities, which are not accounted for by fixed-effects. These controls serve two main purposes. First, they account for observable time-varying factors that may differentially affect fertility across municipalities, and thus, help strengthen the parallel trends assumption. Second, their inclusion allows the examination of the robustness of the main findings and improves the precision of the estimates by accounting for additional sources of variation in the outcome variable.

The DiD model with controls is specified as:

$$GFR_{mt} = \beta Treatment_{mt} + \lambda' X_{mt} + \gamma_m + \mu_t + \varepsilon_{mt} \quad (4)$$

- GFR_{mt} : General Fertility Rate
- $Treatment_{mt}$: Difference-in-Differences indicator
- X : Vector of time-varying Control Variables
- γ_m : Municipality fixed effects
- μ_t : Yearly fixed effects
- ε_{mt} : Error term

The coefficient of the control variables λ captures the conditional association between these characteristics and the GFR, holding fixed effects and all other variables constant. The DiD estimate continues to measure the average change in fertility in treated municipalities after the campaign, relative to the control group. The vector X_{mt} includes all additional control variables log GDP per capita, age structure, education levels, union status, religion composition, and racial composition among women aged 15-49 residing in each municipality used in the extended DiD analysis. The rationale for including each control variable is provided in Section 4.3.2.

Controls are introduced sequentially to assess the stability of the estimated treatment effect. In our first specification, economic conditions are accounted for by including log GDP per capita. In the second step, demographic structure is added by controlling for the distribution of women across age brackets. In addition, the third specification further includes human capital by adding education levels. Furthermore, socio-demographic composition is incorporated by adding religion and racial composition. Finally, the full specification adds the share of individuals living in a union with a partner and thereby combines all control variables used in this study.

4.2.3 Event Study

The analysis is further complemented by an event study specification. An event study traces differences between groups over time by estimating a separate coefficient for each period before and after a treatment (Cunningham, 2021). In this approach, the single post-treatment coefficient is replaced with a set of leads and lags around the campaign launch. This allows the treatment effect to vary over time. Specifically, the event study makes it possible to trace out the dynamic effects of the campaign on fertility and test the validity of the parallel trend assumption.

The event study regression has the following form:

$$GFR_{mt} = \gamma_m + \mu_t + \sum_{k=-9, k \neq -1}^5 \beta_k (1 [Relative Time_{mt} = k] \times Treated_m) + \lambda' X_{mt} + \varepsilon_{mt} \quad (5)$$

The Indicator Function ($1 [Relative Time_{mt} = k]$) equals one when the year corresponds to the relative time period k . Hence, the interaction of this indicator function with the treated dummy equals 1 for treated municipalities in the relative period k . The reference period ($k = -1$) is the year immediately before the effective post-treatment period, and is omitted as well as normalized to zero, making 2018 the reference year.

4.2.4 Robustness Checks

To assess the validity of the empirical strategy and the robustness of the main findings, several robustness checks (RC) are conducted. These tests examine whether the results are sensitive to alternative assumptions, sample restrictions, and different specifications.

RC 1: Placebo Treatment Date

First, a placebo test is performed using a fake treatment date set in 2015, before the actual campaign was conducted. The baseline model, including controls, is re-estimated using only pre-event data to avoid any contamination from the real intervention. This test checks for pre-existing differences in trends between the treatment and control group, thereby validating the identifying assumption. Under the parallel trend assumption, no significant treatment effect is expected. The placebo treatment variable is constructed analogously to the main treatment indicator of the baseline analysis by interacting treated municipalities with a post-2015-time dummy.

RC 2: Leave One-Treated Out

A second robustness check examines whether the estimated treatment effect is driven by any single treated municipality. To assess this, the treated municipalities are excluded one-by-one. The model is re-estimated after each exclusion. If the coefficient remains stable in sign, magnitude, and statistical significance after their removal, it suggests that the main results are not mainly driven by any specific, treated municipality, but instead reflect a broader pattern across all treated municipalities.

RC 3: Restricted Control Group of Comparable Large Municipalities

To address concerns that the full control group of Brazilian municipalities is highly heterogeneous and may differ substantially from the treated units, an additional robustness check is implemented using a smaller, more comparable set of urban municipalities. Specifically, the control group is restricted to ten large municipalities, comprising state capitals and major non-capitals cities similar to the treated municipalities (see Table 10 in Appendix A). These municipalities were chosen based on population size, as our ten treated municipalities are large state capitals, and the comparable municipalities are of similar size. Table 11 in Appendix A presents the average values of the variables used in the analysis separately for each of the ten more comparable municipalities and the ten treated ones. It shows that these twenty cities are broadly comparable across most observable characteristics. The baseline model is re-estimated using this revised control group. Given the smaller number of clusters, inference is based on wild cluster bootstrap standard errors. This specification allows for assessing whether the main results are sensitive to the composition of the control group. If the estimated effects remain stable in sign and statistical significance, this strengthens confidence in the baseline findings.

RC 4: Placebo Sample of Comparable Large Municipalities

Another robustness check uses a placebo sample consisting of ten municipalities that are similar to the treated ones, which have already been used in the previous robustness check (see Table 10 in Appendix A). The baseline model with control variables is re-estimated on this alternative set-up. This test helps to determine whether the main results are driven by underlying structural characteristics of large urban municipalities rather than by the campaign itself. Finding a significant effect on this placebo setup would raise doubts about the causal interpretation of the main findings.

RC 5: Population-Weighted Estimation

In the baseline specification, all municipalities receive equal weight in the estimation, regardless of their size. Although the GFR adjusts for population size, its precision varies with municipality size. In smaller municipalities, a single additional birth can lead to large fluctuations, making the measure more volatile than in larger municipalities. To address this concern, the fifth robustness check re-estimates the baseline specification using population weights, where each municipality is weighted by the number of women (aged 15-49). This assigns greater weight to municipalities with more precise fertility data, allowing us to test whether the results are sensitive to measurement precision and the influence of larger municipalities.

RC 6: Conley-Taber Randomization Inference

A final robustness check addresses a methodological limitation of this study. Standard clustered standard errors rely on asymptotic approximations, which assume a large number of clusters (Conley & Taber, 2011). In settings with a small number of treated units, this assumption might not hold. As the sample of this study consists of a relatively small number of ten treated municipalities, the precision of the estimates might be overstated. Conley and Taber (2011) address this by implementing a randomization inference approach for DiD settings with a small number of treated units and a large number of control units, which provides more reliable hypothesis testing and confidence intervals.

This approach is implemented as the final robustness check of this study. In particular, each control municipality is used as a placebo treatment unit, and the main specification is re-estimated. This is repeated one-by-one for every control municipality. This procedure generates an empirical distribution of placebo treatment coefficients that would be expected by chance in the absence of the intervention. A Conley-Taber p-value is then computed as the proportion of control municipalities that exhibit a placebo effect at least as large as the estimated treatment effect in the main specification.

This test is implemented in two versions. In the first version, all control municipalities are used. In the second version, only the ten more structurally comparable municipalities, already used in previous robustness checks, are considered (see Table 10 in Appendix A). The second version is implemented because Conley and Taber (2011) highlight the importance of treatment and control groups being drawn from the same population. Due to the structural differences in treatment and control group, this cannot be guaranteed in the first version. Nevertheless, due to the small size of the restricted control group, the results need to be interpreted with caution.

4.3 Data Collection Method

This paper uses panel data which is primarily compiled from two sources. Information on births was collected from the Brazilian Ministry of Health (Ministério da Saúde). The remaining data was obtained from the Brazilian Institute of Geography and Statistics (Instituto Brasileiro de Geografia e Estatística or IBGE), including demographic, economic, and socio-economic data. The data sources, originally provided in Portuguese, were translated into English. To ensure consistency across sources, the data has been downloaded in Brazilian CSV format. Standardized municipality codes ensure consistent and accurate merging of all datasets at the municipal level. The period considered in this paper spans from 2002 until 2024, representing the time frame with the greatest overlap in datapoints across all data sources, minimizing the need for extrapolation. However, it must be noted that the number of municipalities in Brazil has changed, but only by a small amount. From 5,507 in 2000, 5,565 in 2010, to finally 5,571 in 2022. These changes are relatively minor and are therefore not expected to affect the panel structure outcome.

The final dataset is constructed as a panel on a harmonized set of municipality codes to ensure consistency across data sources over time. It includes the 5,565 municipalities, defined in the 2010 Census, which essentially serves as the baseline of the analysis conducted in this paper. State-level and Federal District aggregates, in total 27 units, that were automatically included in the raw data downloads of municipal data, were excluded to maintain a consistent municipality-level panel. We aggregated the data to an annual level, since we cannot deduce a staggered intervention of the fertility awareness campaign conducted in 2018. For a detailed data description of each variable, see Table 9 in Appendix A.

4.3.1 Outcome Variable

The main outcome variable in this paper is GFR, which is self-constructed, as described in the previous section. It measures the number of births per 1,000 women aged between 15-49. GFR serves as an indicator of fertility behaviour, as it tracks birth patterns (IBIS, n.d.). For context, using the age range 15-49 for births per 1,000 women, a GFR of 60 is roughly equivalent to a TFR of 2.1. The variable is constructed based on birth records obtained from the Brazilian Live Birth Information System (Sistema de Informações Sobre Nascidos Vivos, or SINASC) for the period 2002–2024 (Ministério da Saúde, 2026). Birth counts are assigned to municipalities based on the mother’s place of residence. The variable is constructed to reflect the total number

of births per municipality at the month-year level. It further incorporates the number of women in the age of 15-49 recorded in each municipality.

This information is obtained from census data for the years 2000, 2010, and 2022, providing population count for various age groups at the municipal level (IBGE, n.d.a; IBGE, n.d.b). The relevant age groups are aggregated to obtain the total number of women of reproductive age in each municipality. Since the population data used is only available for census years, linear interpolation between census years, as well as linear extrapolation from 2022 to 2024, are applied to construct a consistent time series. For a graphical illustration of the outcome variable, see Figures 3 and 4 in Section 5.2 for an annual illustration, and Figures 26 and 27 in Appendix B for a monthly illustration.

4.3.2 Control Variables

All control variables exhibit meaningful variation over time and are consequently not fully absorbed by fixed effects, which only account for time-invariant characteristics. Therefore, their inclusion alongside the fixed effects is essential to capture time-varying differences across municipalities and will give additional insights into factors driving fertility developments. Thereby, it was important to avoid including variables that may have been affected by the treatment, which would risk absorbing part of the treatment effect, and thus, bias the estimates (Angrist and Pischke, 2009). The included controls reflect slow-moving structural and demographic characteristics that are not expected to be meaningfully altered by the awareness campaign, mitigating potential concerns about bad controls.

Economic Development

Economic development is captured by GDP per capita at the municipality level. The variable is transformed using the natural logarithm to ensure comparability across municipalities of different sizes. GDP data is obtained from IBGE (n.d.c), which reports GDP at current prices, in thousands of Brazilian Reais, for the years 2002–2024 at the municipal level. Population data is sourced from IBGE tabela 6579, which provides estimates of the resident population for the period from 2001 to 2025. However, the values for the years 2022 and 2023 are missing in the available dataset on IBGE. Therefore, these were constructed using linear interpolation based on the available values for the years 2021 and 2024. GDP per capita is calculated by dividing total municipal GDP by the corresponding population estimation per municipality (IBGE, n.d.c; IBGE, n.d.d).

The variable is included to account for differences in economic conditions between municipalities, as living standards and access to economic opportunities are closely linked to fertility outcomes (Ma et al. 2025). Typically, higher levels of economic development are associated with lower fertility rates, due to higher opportunity costs of childbearing and differences in socio-economic conditions (Roser, 2014). This is particularly relevant as the ten treated municipalities are, on average, more economically developed than the control municipalities (see Table 2). For a graphical illustration of the economic development variable, see Figures 14 and 21 in Appendix B.

Age Structure

To account for changes in the age composition of women across municipalities over time, the model includes controls for the shares of women aged 15-49 across four-year age groups for the group of interest. The data is obtained from IBGE Census tables providing counts by age at the municipal level via the Census 2000, 2010, and 2022 (IBGE, n.d.a; IBGE, n.d.b). The variable captures differences in fertility behaviour across age groups and ensures that changes in GFR are not driven by shifts in the age distribution of women across the municipalities. There is a well-established relationship between age and fertility for both men and women, whereby fertility tends to decline as age increases (Giwerzman et al. 2026). For a graphical illustration of the age cohort variable, see Figure 18 in Appendix B.

Education

A control for educational attainment is included to capture differences in fertility development between treatment and control municipalities related to residents' educational levels. The data is obtained from IBGE (n.d.e, n.d.f, n.d.g) using census data from 2000, 2010, and 2022, focusing on women aged 15-49 at the municipality level. Values for the years between censuses are constructed using linear interpolation, while the values for 2023 and 2024 were obtained through extrapolation. Due to differences in classification across the three censuses, the education categories are harmonized into four consistent groups, by aggregating categories from the 2000 Census to match the classifications used in later years. Education is a key determinant of fertility behaviour, as higher levels of education are typically associated with lower fertility (Roser, 2014). For a graphical illustration of the education variable, see Figure 20 in Appendix B.

Union Status

Union status measures the share of women aged 15-49 living with a spouse or partner in each municipality. The data is obtained from IBGE (n.d.h, n.d.i) Tabela 2466 (Census 2000) and IBGE Tabela 1539 (Census 2010 and Census 2022). To construct a consistent time series for the entire time frame, we applied linear interpolation between the census years and extrapolated to 2024. The variable is included as a proxy for partnership formation, which is closely related to fertility outcomes as people living in a relationship tend to have more children than singles (Kuang et al. 2025). It captures differences in fertility outcomes across municipalities arising from variation in the share of women living in unions, which has evolved over time. For a graphical illustration of the union status variable, see Figures 15 and 22 in Appendix B.

Religion

Religious composition at the municipal level is constructed using IBGE (n.d.j, n.d.k, n.d.l) data from tabela 2470 (Census 2000), tabela 1206 (Census 2010), and tabela 10183 (Census 2022). Due to data limitations, religion is measured for the total population per municipality and assumed to be representative for women aged 15-49. Linear interpolation and extrapolation are used to construct a complete time series. The analysis focuses on the largest religious groups; Roman Catholics, Evangelicals, and individuals reporting no religion, which together account for approximately 93 percent of the Brazilian population (IBGE, 2025). Religious composition in Brazil has changed substantially over time, and this control variable accounts for such time-varying municipal-level developments. Religion is an important determinant of fertility norms and behaviour, as different religious groups are associated with varying attitudes toward family formation and reproductive decisions (Chvaja et al. 2026). For a graphical illustration of the religion variable, see Figures 17 and 24 in Appendix B.

Racial Composition

To reflect demographic heterogeneity across municipalities, a racial composition control is included. The data is sourced from Census 2000 (tabela 2468), Census 2010 (tabela 3193), and Census 2022 (tabela 10185), for women aged 15-49 (IBGE, n.d.m; IBGE, n.d.n; IBGE, n.d.o). The Census data is converted into a time series using linear interpolation and extrapolation. The variable capture differences in population structure that may be correlated with socio-economic conditions and fertility behaviour, as well as group-level differences in fertility between racial categories (Henkel et al. 2025). For a graphical illustration of the racial composition variable, see Figures 16 and 23 in Appendix B.

4.4 Limitations

While the applied DiD method provides a powerful quasi-experimental approach for estimating causal effects, it remains subject to methodological limitations. The key identifying assumption of the method is the parallel trends assumption. It implies that in the absence of the campaign, the treatment group and control group would have followed a similar GFR development over time. However, this assumption cannot be directly tested, as the counterfactual outcome is unobserved. Although pre-treatment trends can be examined, there is no guarantee that parallel trends would have persisted in the absence of treatment. Consequently, the validity of the assumption cannot be confirmed. In addition, the control variables are based on census data, which requires interpolation and extrapolation. As a result, the true values are not directly observed, introducing measurement uncertainty. This approach smooths year-to-year variation in the variables and may obscure relevant dynamics. Another key data limitation is that we cannot identify whether the fertility awareness campaign was staggered in each municipality during 2018, meaning we use annual data for each of our tests. If the campaign was staggered any potential monthly effects will be lost in our methodological setup.

Furthermore, the analysis is conducted at the municipal level rather than the individual level, so the characteristics of women giving birth cannot be directly observed. For instance, relationships between control variables such as GDP per capita and fertility outcomes are inferred from municipal averages, which may obscure the true relationship between individual circumstances and fertility decisions. Updated risk beliefs regarding delayed childbirth and their effects on birth outcomes cannot be tracked at the aggregate level and may not accurately capture individual-level relationships. Another complicating factor is that the setup of the fertility awareness campaign created potential spillover effects on other municipalities. For example, social- and traditional media appearances cannot be siloed to only the ten treated municipalities. This could potentially bias the treatment effect estimate toward zero, meaning that any true effect of the campaign on the treated municipalities would not be visible in our analysis. This means that we do not have a clear identification of the treatment effect on the ten treated municipalities as compared to our control municipalities, meaning any potential campaign effect might go undetected in our analysis. Related to this is the fact that the ten treated municipalities were not randomly selected by the campaign organizers, meaning that the intervention does not constitute a clean natural experiment with randomly assigned treatment.

5. Results

5.1 Data Analysis

To assess the comparability of the treatment and control groups, mean values across the key variables used in the analysis, described in the methodology section above, are compared. The comparison is based on the full sample pre-treatment period covering time frame from 2010 to 2017. The sample consists of 44,505 observations in total, with the treatment group (10 municipalities) comprising 80 observations and the control group (5,553 municipalities) comprising 44,425 observations.

Table 2: Summary Statistics – Pre-Treatment Period

	<i>Control</i>				<i>Treated</i>			
	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>	<i>Mean</i>	<i>SD</i>	<i>Min</i>	<i>Max</i>
GFR (Annual)	52.9	14.1	5.7	244.9	50.2	3.4	42.6	56.7
Births (Annual)	436	1,243	3	42,809	49,729	45,572	18,321	176,487
Women 15–49	7937	22,101	189	580,154	975,679	847,248	365,461	330,1784
ln(GDP per Capita)	9.57	0.72	5.8	13.6	10.51	0.4	9.7	11.3
Edu: No Primary	0.42	0.116	0.1	0.9	0.209	0.038	0.1	0.3
Edu: Primary	0.217	0.031	0.1	0.4	0.198	0.013	0.2	0.2
Edu: High School	0.282	0.073	0	0.6	0.385	0.019	0.3	0.4
Edu: Degree	0.081	0.042	0	0.4	0.208	0.049	0.1	0.3
Religion: Catholic	0.729	0.138	0.1	1	0.567	0.06	0.5	0.7
Religion: Evangelical	0.211	0.104	0	0.9	0.268	0.055	0.1	0.4
Religion: None	0.053	0.048	0	0.6	0.118	0.044	0	0.2
Union Share	0.530	0.048	0.2	0.7	0.469	0.021	0.4	0.5
Race: Mixed	0.467	0.212	0	0.9	0.395	0.147	0.1	0.6
Race: Black	0.069	0.055	0	0.6	0.107	0.073	0	0.3
Race: White	0.449	0.239	0	1	0.484	0.177	0.2	0.8
Race: Indigenous	0.006	0.035	0	0.9	0.002	0.001	0	0
Race: Asian	0.008	0.009	0	0.1	0.012	0.005	0	0
N	44,425				80			

Panel 2010–2017. Annual GFR = monthly GFR × 12. Number of observations: 8-year time period.

10 treated municipalities, 5,553 control municipalities.

Source: Ministério da Saúde, IBGE and authors' calculations.

Table 2 presents these descriptive summary statistics, reported separately for the treatment and control groups. It shows that while treated municipalities and control municipalities are on average similar in some dimensions, they also show differences in others. Treated municipalities have a somewhat lower mean annual GFR (50.2) compared to control municipalities (52.9), suggesting that the treated municipalities' baseline fertility level is lower

than the Brazilian average. In addition, these groups differ in several socio-economic characteristics, as reflected in the averages of the control variables. For instance, the treatment group has a considerably higher average log GDP per capita (10.51 vs. 9.57) as well as higher educational attainment. It exhibits a higher share of women with a university degree, and a lower share of women without education or incomplete primary education, compared to the control group. In terms of racial composition, the two groups are broadly similar, with both the treatment and control municipalities showing a comparable distribution across racial categories.

These differences between the two groups indicate that they are not directly comparable when only comparing a DiD baseline. This underscores the importance of including time-varying control variables in the extended DiD specification to account for potential confounders that may affect fertility trends differently across municipalities. A graphical analysis further shows the treatment group overlaps with a substantial number of control municipalities in terms of observable characteristics, see the graphs with distributions for each variable in Appendix B. Therefore, the existing differences between the two groups are not considered to pose a major concern for the analysis.

5.2 Parallel Trends Assumption

Establishing parallel trends regarding the development of GFR between the ten treated municipalities and the control municipalities is, as previously noted, key in order to confidently be able to run our tests (Cunningham, 2021). A good start is to visually check whether there seems to be a parallel trend, in which 2002 is the earliest year we can start the visual analysis from. We begin by plotting annual GFR between 2002–2024 with corresponding trendlines.

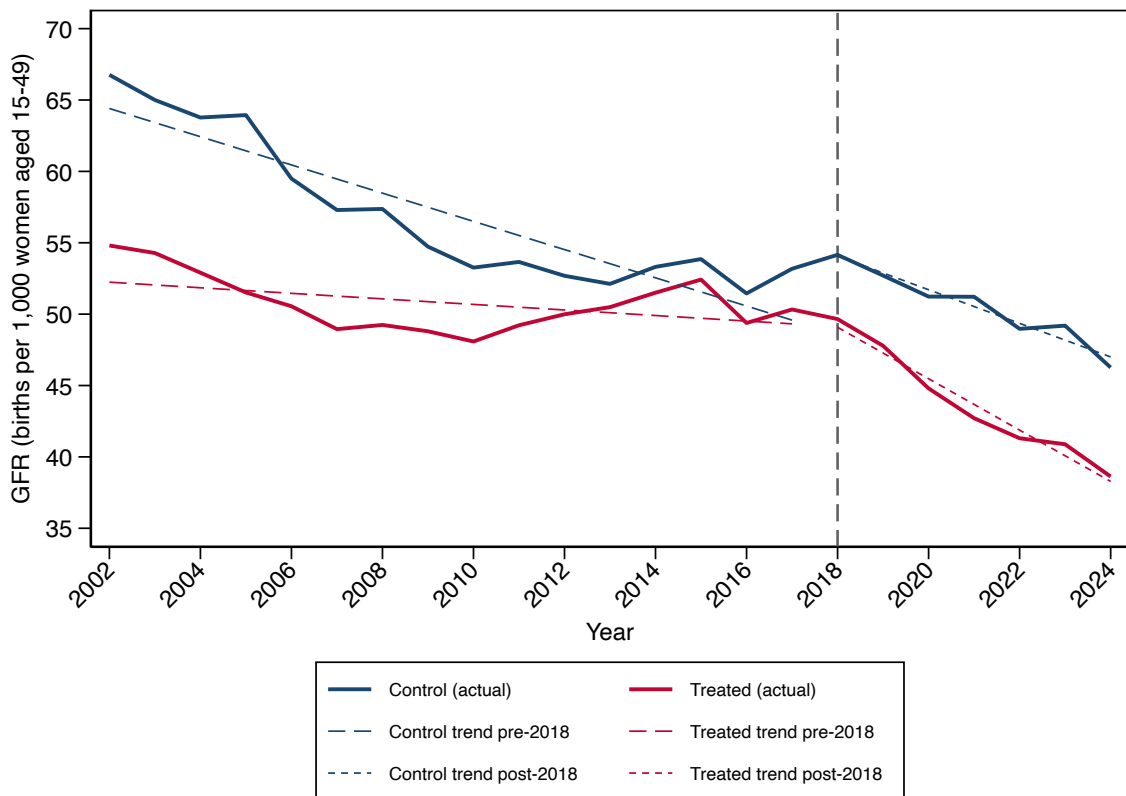


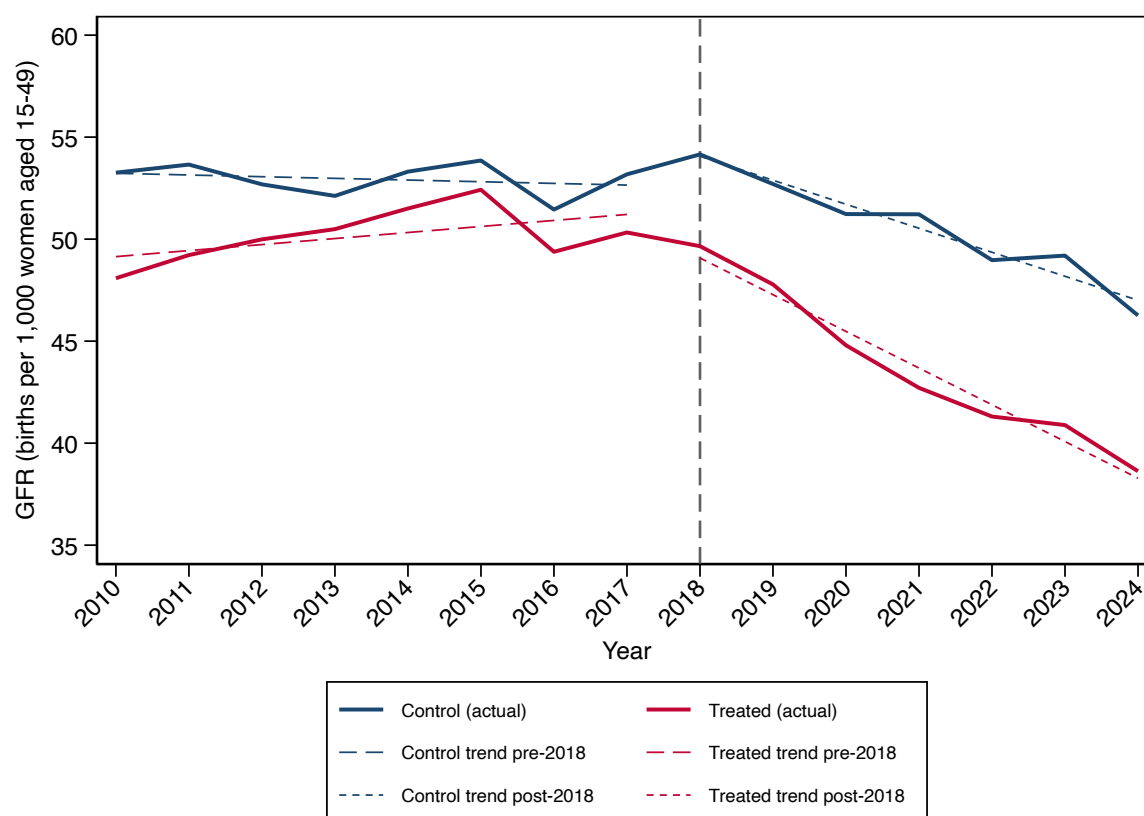
Figure 3: Annual GFR 2002–2024 Treated and Control Municipalities

The dashed, vertical black line represent the treatment year 2018, while the red and blue dashed lines show fitted lines for the pre-and post 2018 periods, respectively. We can note a downward sloping trend for both treated and control municipalities. However, the slopes seem to differ.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

Figure 3 above shows that, while both treated and control municipalities saw declining GFR between 2002–2018, the slope for the control municipalities seems to be steeper compared to the ten treated municipalities. However, from around 2010 onwards the trend lines seem to be more in line with each other, indicating a potential structural break in the development of GFR. We proceed by plotting annual GFR from 2010–2024 for both treated and control municipalities.

Figure 4: Annual GFR 2010–2024 Treated and Control Municipalities



Same setup as for Figure 3 but with a more truncated timeline 2010–2024.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

From a visual perspective, the Figure 4 timeline 2010–2022 seems to illustrate parallel trends in the years leading up to the treatment year 2018 in the development of GFR between the ten treated and control municipalities. We note that the post 2018 trends look similar but with slightly different slopes for the GFR. This visual inspection suggests two alternative timelines for assessing the potential presence of parallel trends in the pre-treatment period leading up to 2018, namely 2002–2017 and 2010–2017. We proceed by formally testing both timelines for parallel trends. Specifically, the test asks whether GFR in the treated municipalities was moving at a different rate compared to the control municipalities. This is implemented by interacting the treatment indicator with a linear time trend and testing whether the coefficients on this interaction term are statistically different from zero. Essentially, it tests whether the gap between treated and control municipalities was growing or shrinking over the pre-treatment period. A significant coefficient would indicate that that the two groups were already on diverging trajectories before the campaign took place.

There are two things to note about the setup of the parallel trends test. One aspect is that, as has been noted previously above, the number of municipalities changed by a small amount during the 2002–2017 timeline. We therefore test each timeline using the number of municipalities present in the year 2002 (which will use the 2000 municipal census specification) and 2010 (which will use the 2010 municipal census specification). Secondly, we will test both excluding and including our controls. Since our main research focus on the development of GFR with our controls in mind, the control tests must be significant to proceed with the remaining tests.

Table 3: Parallel Trends

<i>Municipal Code</i>	<i>Number</i>	<i>Start</i>	<i>End</i>	<i>Controls</i>	β	<i>S.E</i>	<i>P-Value</i>
2000	5507	2002	2017	None	0.734	0.096	0.000
2000	5507	2002	2017	Full	-0.202	0.265	0.446
2010	5565	2010	2017	None	0.377	0.100	0.000
2010	5565	2010	2017	Full	-0.165	0.467	0.723

Source: Ministério da Saúde, IBGE and authors' calculations.

Table 3 shows that, unconditionally on our controls, parallel trends between treated and control municipalities are not supported. However, conditional on our controls, we find no evidence to reject the *conditional* parallel trends assumption between both groups. Moreover, we can clearly see that the 2010–2017 timeline indicates a potentially stronger parallel trend compared to the 2002–2017 timeline. We therefore decided to conduct our DiD, event study, and robustness check tests using the 2010–2024 timeline.

5.3 Difference-in-Differences Results

In total we conducted six DiD tests, starting with a baseline test which did not include any controls, and subsequently adding one control variable at a time. The coefficients naturally change with the addition of further controls. However, the size and direction of change is of key interpretational interest for our analysis.

Table 4: Difference-in-Differences Results – Dependent Variable: GFR

	(1) <i>Baseline</i>	(2) <i>+Economic</i>	(3) <i>+Demographic</i>	(4) <i>+Education</i>	(5) <i>+Social</i>	(6) <i>Full</i>
Treatment	-4.287*** (0.469)	-3.767*** (0.482)	-2.869 (2.687)	-2.266 (2.923)	-2.549 (2.497)	-2.736 (2.502)
ln(GDP Per Capita)		1.837*** (0.221)	1.622*** (0.220)	1.849*** (0.215)	1.701*** (0.212)	1.542*** (0.208)
Women 15–19			0.001 (0.001)	0.001** (0.001)	0.001* (0.000)	0.001* (0.000)
Women 20–24			-0.001** (0.001)	-0.001* (0.001)	-0.001 (0.001)	-0.001 (0.001)
Women 30–34			0.001* (0.000)	0.000 (0.001)	0.000 (0.001)	0.000 (0.001)
Women 35–39			-0.004*** (0.001)	-0.004*** (0.001)	-0.003*** (0.001)	-0.003*** (0.001)
Women 40–44			0.002** (0.001)	0.001 (0.001)	0.001 (0.001)	0.001 (0.001)
Women 45–49			-0.001 (0.000)	-0.000 (0.000)	-0.000 (0.000)	-0.000 (0.000)
Edu: No Primary				12.623*** (2.866)	8.750*** (2.896)	11.522*** (3.2860)
Edu: Primary				-12.555*** (3.885)	-9.269*** (3.765)	-10.431*** (3.701)
Edu: Degree				88.062*** (4.056)	78.076*** (4.012)	76.349*** (3.955)
Religion: Evangelical					-23.640*** (4.174)	-24.455*** (4.140)
Religion: None					-17.542*** (3.358)	-14.311** (3.358)
Race: Mixed					23.672*** (2.751)	24.455*** (2.700)

Race: Black					-5.992 (5.992)	-4.018 (4.921)
Race: Indigenous					15.159 (12.391)	16.816 (12.635)
Race: Asian					75.476*** (14.229)	72.768*** (14.068)
Union Share						68.613*** (5.787)
Constant	51.797*** (0.000)	33.692*** (2.182)	38.971*** (2.239)	26.120*** (2.829)	24.289*** (3.357)	-11.730 (4.479)
R ²	0,7415	0,7421	0,7438	0,7554	0,7585	0,7604
Within R ²	0,0002	0,0027	0,009	0,054	0,066	0,074
Observations	83446	83446	83446	83446	83446	83446
Clusters (Codmun)	5565	5565	5565	5565	5565	5565

All specifications include municipality and year fixed effects. Standard errors (clustered at municipality level) in parentheses.

** $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Source: Ministério da Saúde, IBGE and authors' calculations.

In Table 4 above, we can note the most important results before delving into more detail in the analysis section below. For each of these we are interpreting the coefficients as a unit of children per woman aged 15-49, that is the GFR. A +1 means GFR increases by one, and -1 means GFR decreases by one. Another important note is that, as we are using municipal fixed effects, our control coefficients should be interpreted as the effect on GFR by a change in the control within a municipality. The coefficients for our (2-6) DiD tests should be read as controlling for whichever control variable is present. The treatment coefficient for our 10 treated municipalities is +/- whichever value in comparison to the control municipalities.

We can see that the baseline DiD without controls shows a significant, negative treatment coefficient. Meaning that the treated municipalities had about -4.28 smaller GFR as compared to the control municipalities. When adding the economic control variable log GDP per capita, the treatment coefficient decreases but is still a negative -3.77 GFR. Adding demographic, education and race controls result in a further decrease in the negative coefficient, ranging from -2.27 to -2.87, however these results are not significant. It is worth noting that the standard errors increase quite significantly from DiD (3) onwards, something we will discuss in more detail in the analysis section below.

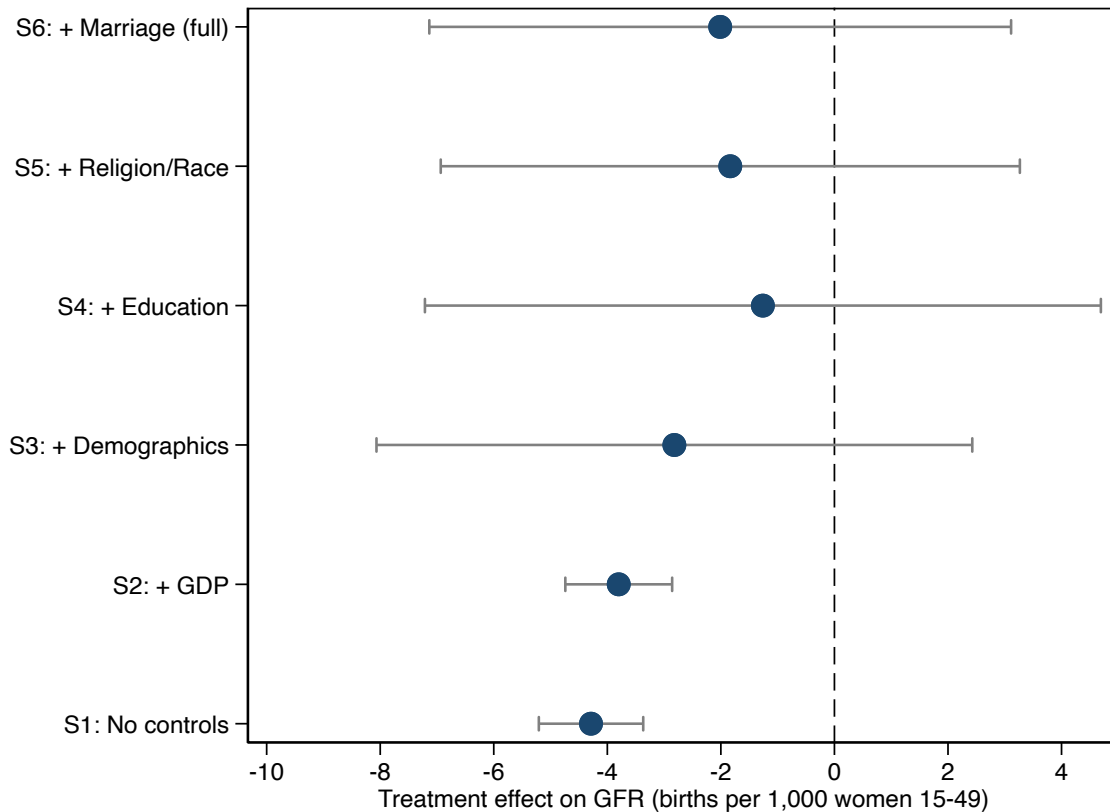


Figure 5: DiD Estimates by Specification 2010–2024

Point estimates with 95 percent confidence intervals. Outcome in annual GFR with municipal and time fixed effects. Using all 5565 municipalities from 2010–2024.

Source: Ministério da Saúde, IBGE and authors' calculations.

For every DiD test the economic control variable show a significant, positive coefficient. Meaning that a higher GDP per capita results between +1.8 to +1.6 more GFR depending on which variables are controlled for. Controlling for different age cohorts show the same pattern: a higher share of women aged 35-39 results in a significant, negative but very small effect on GFR. For the DiD tests (3-5) women aged 20-24 also show a significant but negligible effect on GFR.

Regarding the education, religion, race and union share controls, each of these are variables given in shares (0-100). This means that their coefficient should be interpreted as going from 0 to 100 percent. At first glance this is not intuitive to interpret. However, by dividing by 10 we get the interpretive effect of going from 0 to 10 percent for each of these control variables. Therefore, for each control being described below it should be interpreted as a 10 percent increase in X results in a +/- coefficient, divided by ten, GFR effect.

The education coefficients are compared to the high school share, which we omit to avoid perfect multicollinearity. Each of these are significant and high, with no primary and university

education and above showing a positive effect (ranging between +1.3 to 0.8, and +8.8 to +7.6 respectively), while finished primary show a negative effect (ranging between -12.5 and -9.3). Religion controls are compared relative to Catholics, and we can see that evangelicals have significant and negative GFR, ranging between -2.7 and -2.4. No religion also has significant, but less negative coefficients ranging between -1.8 and -1.4. This is in some ways a surprising result that will be discussed in more detail below.

Moving on to our race controls we can note some disparities between the racial profile of women aged 15-49, the baseline comparison is to white Brazilians. Mixed race Brazilian women see a significant positive effect, ranging between +2.5 and +2.4 GFR. Black women have a negative, but statistically insignificant effect, ranging between -0.6 and -0.4 GFR. Indigenous women see a positive but statistically insignificant effects ranging between +1.7 and +1.5. Asian women, however, do see a significant, positive coefficient ranging between +7.5 to +7.3 GFR effect. The large effect of Asian women aged 15-49 could be a spurious result, as Asian women are highly clustered in specific municipalities with low total shares of the female population, resulting in large effects in the DiD analysis (see Figure 23 in Appendix B). Finally, the union share control, which is a continuous variable between 0-100, show a significant and positive effect of +6.8 GFR.

5.4 Event Study Results

The DiD analysis is complemented by an event study, which allows us to investigate how the treatment effect evolves over time. The results are presented in Table 5 below, showing the estimated treatment coefficients for each year in the analysed time frame. The year being referenced is 2018, which is the year that the fertility awareness campaign was conducted. We also present the coefficients of the control variables which are estimated to the period 2010–2025. Accordingly, t-9 is the year 2010, and t+5 is 2024.

Table 5: Event Study Results – Dependent Variable: GFR

<i>Event-Time Indicators</i>	<i>Coefficient</i>	<i>Controls</i>	<i>Coefficient</i>
2010: Pre-Treatment t-9	-2.753 (3.835)	ln(GDP Per Capita)	1.542*** (0.208)
2011: Pre-Treatment t-8	-1.807 (3.364)	Women 15–19	0.001* (0.001)
2012: Pre-Treatment t-7	-0.231 (2.868)	Women 20–24	-0.001 (0.001)
2013: Pre-Treatment t-6	1.544 (2.336)	Women 30–34	0.000 (0.001)
2014: Pre-Treatment t-5	1.641 (1.771)	Women 35–39	-0.003*** (0.001)
2015: Pre-Treatment t-4	2.311* (1.283)	Women 40–44	0.001 (0.001)
2016: Pre-Treatment t-3	1.937** (0.972)	Women 45–49	0.000 (0.000)
2017: Pre-Treatment t-2	1.397** (0.551)	Edu: No Primary	11.535*** (2.861)
2018: Reference Year t-1	0.00 -	Edu: Primary	-10.442*** (3.701)
2019: Post-Treatment t=0	0.045 (0.482)	Edu: Degree	76.339 *** (3.955)
2020: Post-Treatment t+1	-1.149 (0.916)	Religion: Evangelical	-24.812*** (4.141)
2021: Post-Treatment t+2	-3.026** (1.522)	Religion: None	-14.307** (3.358)
2022: Post-Treatment t+3	-1.981 (1.974)	Race: Mixed	24.452*** (2.700)
2023: Post-Treatment t+4	-2.403 (2.494)	Race: Black	-4.003 (4.921)
2024: Post-Treatment t+5	-1.521 (2.977)	Race: Indigenous	16.823 (12.636)
		Race: Asian	72.823***

		Union Rate	(14.072) 68.602*** (5.787)
Constant	-11.763*** (4.479)		
R ²	0,7415		
Within R ²	0,0736		
Observations	83,446		
Clusters (Codmun)	5,565		

Reference category: pre_1 (one period before treatment). Specification includes municipality and year fixed effects and full controls. Standard errors (clustered at municipality level) in parentheses.

** $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Source: Ministério da Saúde, IBGE and authors' calculations.

Table 5 shows that in the pre-event period, there are three significant coefficients for the years 2015 (t-4), 2016 (t-3), and 2017 (t-2) with positive values of 2.311 (significant at a 10 percent level), 1.937 (significant at a 5 percent level), and 1.397 (significant at a 5 percent level), respectively. In the post-event period, the only significant coefficient of -3.026 at a 5 percent significance level corresponds to the year 2021 (t+2). The coefficients, the event-time indicators, should be interpreted as, how much does the GFR differ between our ten treated municipalities and the control municipalities relative to the reference year 2018, while taking time and municipal fixed effects into consideration.

Overall, the findings for the pre-treatment coefficients raise some concerns regarding the validity of the parallel trends assumption in the time period immediately preceding the campaign. The three significant pre-period coefficients suggest that GFR in the treated municipalities may have started to diverge from the treated municipalities in the years before the campaign started. This means that the previous reading in Section 5.2, in which no evidence for rejecting the identifying assumption could be found, should be treated with caution. It suggests that the parallel trends assumption may not hold perfectly in the immediate pre-treatment period, despite the presence of the control variables.

In the post-treatment period, the coefficients are predominantly just above zero or negative, and statistically insignificant, except for the years 2019 and 2021. In 2019, the analysis reports a statistically insignificant coefficient of 0.045. A positive coefficient would indicate that GFR in the treated municipalities was marginally higher relative to the control municipalities relative to the reference year. This, in turn, could point in the direction of the hypothesised positive treatment effect, indicating that the campaign indeed increased GFR in the treated municipalities. However, the near-zero magnitude of the 2019 coefficient suggests the

campaign did not generate a meaningful positive GFR effect, independent of the statistical insignificance of the estimate.

Furthermore, the coefficients of the remaining post-treatment years are negative, indicating that the treated municipalities had a smaller GFR compared to the control municipalities in the years following the 2018 fertility awareness campaign, contrary to the hypothesised positive effect on GFR. This difference seems to grow in magnitude up until 2021, after which it seems to decrease. Nevertheless, this development should be interpreted with caution since the estimates remain imprecise, given their insignificance. Thus, this pattern does not provide any evidence for that the campaign resulted in a positive effect on GFR in the treated municipalities. Notably, the only statistically significant post-event coefficient (-3.026), observed in 2021, is difficult to interpret as evidence of the campaign, since this year was marked with various disruptions related to the COVID-19 pandemic, which is further discussed in the following section 6. The dynamic pattern of the treatment effect across the full analysed period is presented in.

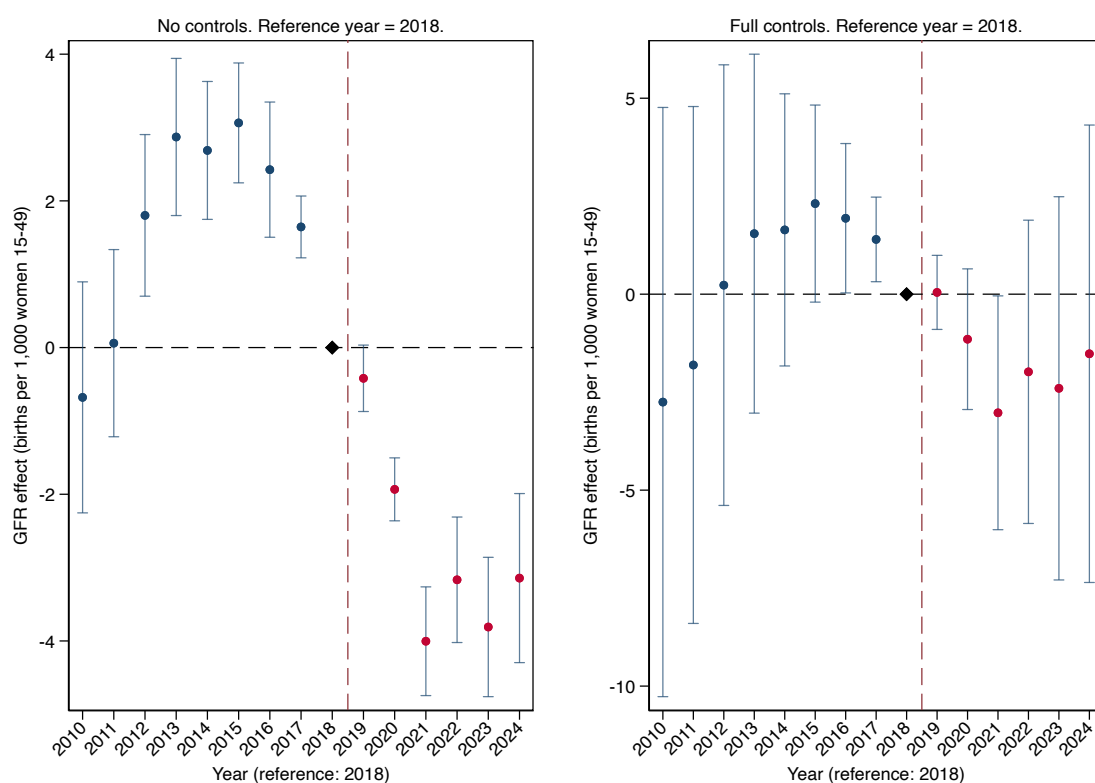


Figure 6: Event Study With and Without Controls

The blue dots show the pre-2018 coefficients, and the red the post-2018 coefficients. The black square show 2018 reference year. Using municipal and time fixed effects and standard errors clustered by municipality. To the left, we can see that the effect on annual GFR without controls has less variance and is further away from the 2018 reference. While the right shows the effect on annual GFR with controls, which illustrates greater variance but closer coefficients to the 2018 reference.

Source: Ministério da Saúde, IBGE and authors' calculations.

Regarding our control variable coefficients, we can note that these are almost identical to our full panel DiD result (Table 4, Column 6). This is reassuring, as it means that the relationship between our controls and the outcome variable, in this case GFR, seem to hold even when taking time lags into consideration. Hence, the DiD treatment outcome results can be viewed with more confidence, since the treatment estimates are not driven by the control variable composition differences between our ten treated municipalities and our controls.

5.5 Robustness Checks Results

This section reports the results of the robustness checks, which aim to assess the validity of the empirical strategy and the sensitivity of the main findings. The estimated treatment coefficients for robustness check one, three, four and five are presented in Table 6 below, followed by a discussion of the results for each respective robustness check.

Table 6: Robustness Checks Results — Dependent Variable: GFR

	(1) <i>RC1: Placebo Date (full controls)</i>	(2) <i>RC3: Restricted Control Group</i>	(3) <i>RC4: Placebo Treatment Group</i>	(4) <i>RC5: Population Weighted</i>
Treatment	-2.080** (1.050)	-1.455** (0.662)	6.810*** (2.001)	-2.016*** (0.498)
GDP Per Capita	0.014 (0.323)	2.020 (2.565)	1.484 *** (0.207)	1.740*** (0.498)
Women 15–19	0.000 (0.001)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Women 20–24	0.000 (0.001)	0.000 (0.000)	0.001 (0.001)	0.000 (0.000)
Women 30–34	0.000 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)
Women 35–39	-0.003** (0.001)	0.000 (0.000)	-0.002* (0.001)	-0.001* (0.000)
Women 40–44	0.001 (0.001)	0.000 (0.000)	-0.001 (0.001)	0.000 (0.000)
Women 45–49	0.001 (0.000)	0.000 (0.000)	0.000 (0.001)	0.000 (0.000)
Edu: No Primary	40.164*** (5.103)	-10.662 (19.043)	12.696*** (2.906)	3.266 (3.948)
Edu: Primary	-18.192*** (6.678)	118.597*** (24.116)	-10.354*** (3.694)	3.266 (5.624)
Edu: Degree	102.878***	68.725*	76.740***	54.531***

	(7.427)	(36.392)	(3.953)	(6.249)
Religion: Evangelical	-9.072	-87.397**	-24.787***	-18.756***
	(8.534)	(17.779)	(4.200)	(4.790)
Religion: None	16.865***	-55.434***	-13.226***	-21.823***
	(6.030)	(20.087)	(3.417)	(3.633)
Race: Mixed	26.892***	81.457*	23.961***	42.068***
	(5.091)	(41.692)	(2.696)	(4.117)
Race: Black	-10.372	224.101***	-3.487	20.672**
	(9.148)	(68.346)	(4.924)	(7.312)
Race: Indigenous	-10.355	-549.137	16.619	34.037**
	(21.862)	(449.363)	(12.653)	(14.625)
Race: Asian	56.441**	-36.871	70.314***	43.803**
	(23.297)	(105.909)	(14.098)	(20.063)
Union Rate	64.032***	141.859*	68.420***	64.792***
	(10.630)	(78.300)	(5.791)	(8.542)
Constant	-12.829	-73.972	-12.031***	19.140**
	(8.136)	(71.787)	(4.521)	(8.565)
Observations	44,505	300	83,296	83,446
Clusters	5,565	20	5,555	5,565
Within R ²	0.0469	0.5980	0.0747	0.1073

RC1: Placebo treatment date (fake post = year $\geq$ 2016); sample restricted to 2010–2017. RC3: Control group restricted to 10 large municipalities. SEs via wild cluster bootstrap result is in a p-value of 0.028 for the treatment coefficient. RC4: 10 large comparable cities used as fake treated group against full control group (real treated capitals excluded). RC5: Municipalities weighted by women 15–49 (analytical weights). Baselines: Religion = Catholic; Race = White/Branca; Education = High school; Age = 25–29. All specifications include municipality and year fixed effects. Standard errors (clustered at municipality level) in parentheses.

** $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.*

Source: Ministério da Saúde, IBGE and authors' calculations.

RC 1: Placebo Treatment Date

The first robustness check uses a placebo treatment date in 2015. The test simulates the intervention of the campaign in an earlier period in which it did not take place. The resulting placebo coefficient is statistically significant (Table 6, Column 1), which indicates that there were pre-existing differences in trends between the control and treated municipalities prior to the actual intervention through the campaign. Hence, it suggests that the groups' GFR trajectories started diverging a few years before the campaign was conducted. Although the formal parallel trends tests in Section 5.2 do not reject the assumption of conditional parallel trends over the analysed period of time, the finding of this robustness check raise some concerns. Specifically, regarding the identifying assumption, and therefore, complicates the interpretations of the main findings. Overall, this result suggests that the causal interpretation of the main findings should be treated with caution.

RC 2: Leave One-Treated Out

The second robustness check excludes each of the ten treated municipalities one-by-one and re-estimates the main specification. The estimated coefficients for each re-estimation show that when dropping most of the treated municipalities, the results do not change significantly (Figure 7 and Table 8 in Appendix A). The estimated treatment coefficients remain mostly negative and insignificant.

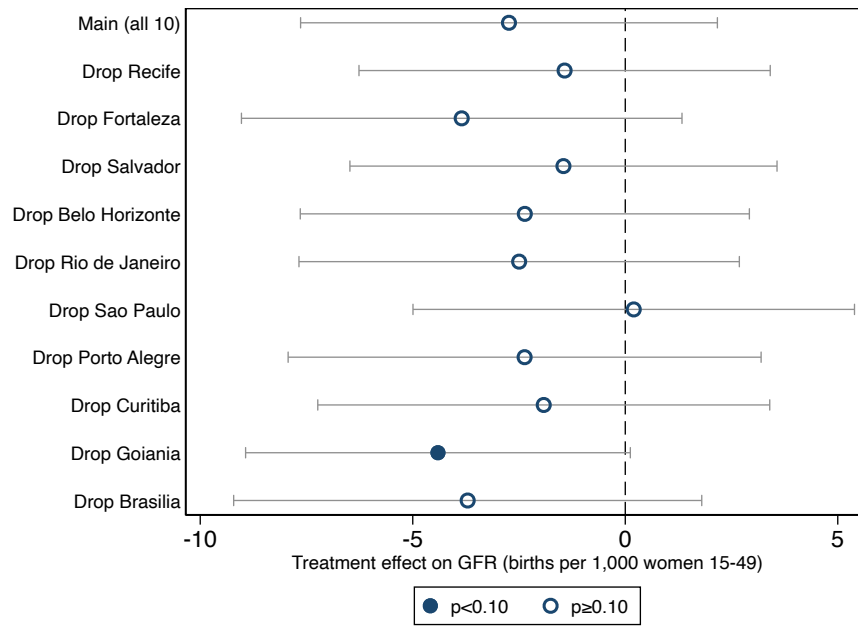


Figure 7: Robustness Check 2 – DiD Estimates

Point estimates with 95 percent confidence intervals where the outcome is GFR. Full controls. Municipality fixed effects and year fixed effects. Filled = significant at 10 percent. Hollow = not significant. Source: Ministério da Saúde, IBGE and authors' calculations.

Two results are striking: First, when excluding Goiânia from the treatment group the treatment coefficient becomes the most negative (-4.4) and marginally significant at a 10 percent significance level. This indicates that Goiânia pulls the main specification result toward zero, moderating rather than driving the overall result. Goiânia, located in Brazil's Centre-West region, is the second smallest treated municipality by population (see Figure 2; IBGE, n.d.d). Given regional structural differences in Brazil, it is possible to argue that Goiânia might have followed a slightly different trajectory in GFR more in line with the broader control group compared to other treated municipalities (Silva & Bezerra, 2023). In fact, its average GFR over the observed period was slightly higher than that of most other treated municipalities in the sample (see Table 11 in Appendix A). However, these differences are small, meaning this interpretation should be treated with caution. Second, when excluding São Paulo from the treatment group, the coefficient becomes slightly positive (0.2). São Paulo is Brazil's biggest

municipality in terms of both population and economic activity (IBGE, n.d.c; IBGE, n.d.d). Thus, the shift of the treatment coefficient suggests that the main specification may be largely driven by São Paulo, rather than reflecting a consistent pattern across the whole treatment group. However, this should be interpreted with caution. As the coefficient remains statistically insignificant, and the confidence interval includes both negative and positive values for both the main specification and this robustness check, no clear conclusion about the direction of the effect can be drawn. The overall evidence remains inconclusive.

RC 3: Restricted Control Group of Comparable Large Municipalities

The third robustness test restricts the control group to a smaller sample of a set of ten large municipalities that are comparable to the treated municipalities. Figure 10 in Appendix B shows the annual GFR trajectories for these two groups over the 2010–2024 period. Visually, the two groups follow broadly similar pre-and post-2018 trends. The formal analysis, however, yields an estimated treatment coefficient of -1.45 (Table 6, Column 2), which stays small and consistent in sign, compared to the DiD with full controls (Table 4, Column 6). The bootstrap p-value of 0.028 indicates that the result is significant at the 5 percent significance level (see the Note Section beneath Table 6). It suggests that when restricting the control to structurally more similar municipalities, the GFR declined more relative to the control municipalities, in the years after the campaign has been conducted. However, this result should be interpreted with caution due to the limited sample size (300), and small number of clusters (20). Overall, the finding is consistent with the direction of the main baseline result, which may suggest that the main result is not drastically driven by the inclusion of smaller and structurally different municipalities.

RC 4: Placebo Sample of Comparable Large Municipalities

The fourth robustness check uses a placebo sample group consisting of ten comparable large municipalities that were not exposed to the campaign. Figure 11 in Appendix B shows the annual GFR trajectories for both groups over the 2010–2024 period. Visually, the two groups follow broadly similar pre-trends, while the placebo treatment group appears to follow a slightly steeper post-2018 decline. When re-estimating the model using this placebo treatment group, however, the resulting coefficient (6.810) is positive and statistically significant at a 1 percent significance level (Table 6, Column 3). This result does not align with the pattern observed in the visual representation and our initial expectations. Firstly, the raw GFR trajectories in Figure 11 should be interpreted with caution, due to the heterogeneous control group. Secondly, since

these cities were not directly exposed to the campaign, they were expected to yield a zero result. The positive and significant result, therefore, indicates that the selected placebo group, initially included in the control group, followed a different post-2018 GFR trajectory compared to the broader group of control municipalities dominated by smaller municipalities, independent of any campaign exposure.

This finding could indicate that, despite addressing structural differences between large municipalities in the treatment group and smaller municipalities in the control group in the baseline specification by including various control variables and establishing conditional parallel trends, there may still be remaining structural differences between the municipalities. This could indicate that there are differences between the ten treated municipalities and the comparable ones that our controls do not account for. An example could be the possibility that our comparable municipalities might experience a smaller degree of domestic migration in and out of the city compared to the potentially more dynamic ten treated municipalities. However, we can only speculate around this, as the finding is in many ways puzzling. It raises the concern that larger municipalities may have followed different fertility trajectories compared to smaller municipalities, potentially due to unobserved urban-specific events in the post-period, unrelated to the campaign. This represents a potential limitation of this study. However, at the same time, the preceding robustness check suggests that the heterogeneous composition of the control group is not solely driven by the main finding. Even when restricting the control group to structurally more comparable control municipalities, the estimated treatment effect remains negative, pointing in the same direction as the baseline result.

RC 5: Population-Weighted Estimation

A re-estimation of the baseline model using population weights was conducted in the fifth robustness check. It assigns greater weight to municipalities with larger female populations for statistical precision. The resulting estimate (-2.016) remains negative but becomes statistically significant at a 1 percent significance level (Table 6, Column 4). The findings indicate that when greater weight is placed on larger municipalities, the estimate becomes statistically significant. However, this result should be interpreted with caution. By assigning more weight to larger municipalities, the estimation also places greater emphasis on São Paulo, which appears to drive the negative signal in the main specification, as shown in RC 2. Therefore, the results, once again, should not be interpreted as an effect on all treated municipalities, but rather as São Paulo's influence on the estimate.

RC 6: Conley-Taber Randomization Inference

The final robustness check addresses the concern that standard clustered standard errors may overstate the precision of the estimates, when the number of treated units is small, by implementing Conley and Taber's (2011) randomization inference approach.

The first version of the test includes all control municipalities and yields a p-value of 0.587. The Conley-Taber p-value is on placebo effects generated by repeatedly assigning treatment status to control municipalities (Conley & Taber, 2011). It measures the share of placebo coefficients whose absolute value is at least as large as the actual estimated treatment coefficient. Thus, it suggests that 58.7 percent of randomly chosen untreated control municipalities produce an effect equal to or larger than the real estimated treatment coefficient (-2.736). Meaning that the observed treatment effect is the result of random noise rather than a true impact of the event. Figure 8 below shows the empirical distribution of placebo coefficients. The real coefficient is visually close to the centre of this distribution, indicating there is no evidence that the estimated treatment effect in the main specification is an outlier driven by the campaign. That essentially underlines that there is no significant treatment effect driven by the campaign.

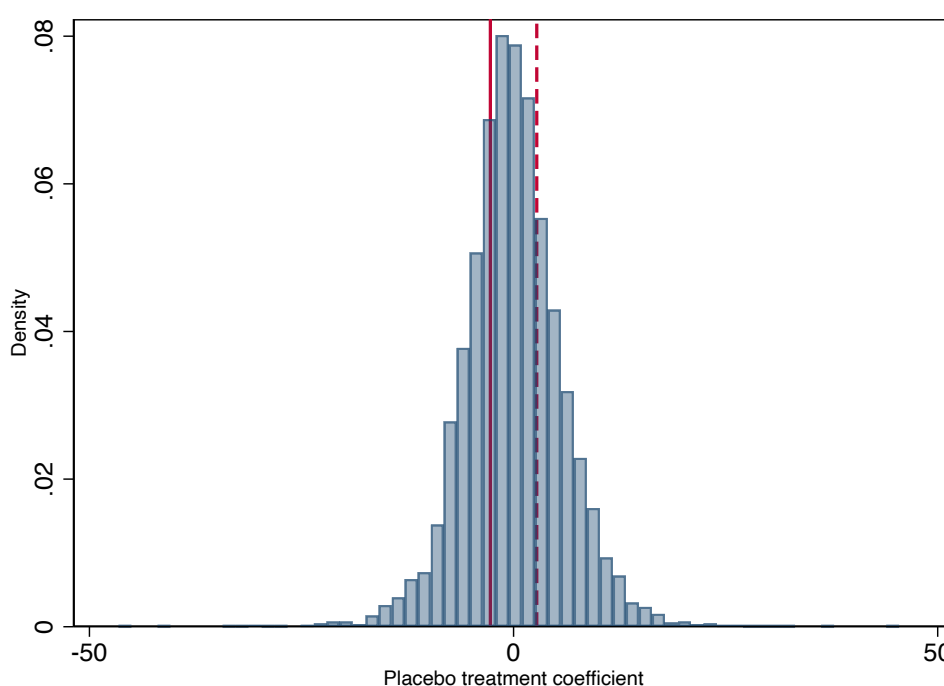


Figure 8: RC6 – Conley-Taber Placebo Distribution – Full Control Pool

Each bar represents the frequency of placebo treatment coefficients estimated by temporarily assigning each of the control municipalities a fake treatment status one-by-one, and re-estimating the main specification, excluding the real treated municipalities. The solid red line indicates the real treatment coefficient estimated in the main specification. The dashed red line is mirroring this effect. The Conley-Taber p-value of 0.587 represents the share of placebo coefficients whose absolute value equals or exceeds that of the real treatment estimate.

Source: Ministério da Saúde, IBGE and authors' calculations.

The second version of the test restricts the control group to the ten structurally more comparable control municipalities (Table 10, Appendix A). It yields a p-value of 0.8, indicating that the treatment coefficient falls within the range of effects one would expect to find by chance. The individual placebo coefficients for each control municipality are shown in Figure 9. As previously indicated, the small size of this placebo group limits the precision of the version of the robustness check.

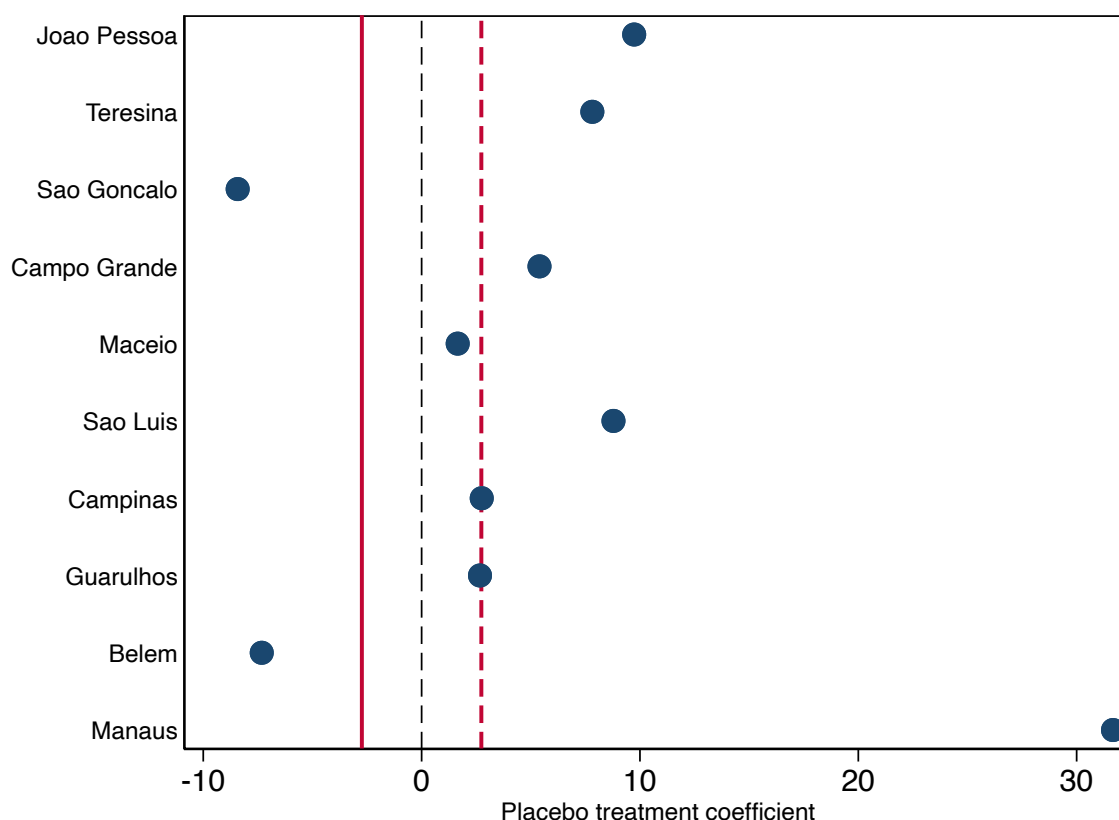


Figure 9: RC 6 – Conley-Taber Placebo Distribution – Restricted Control Pool

Each dot represents the placebo treatment coefficient estimated by temporarily assigning each of the ten chosen more comparable control municipalities a fake treatment status one-by-one and re-estimating the main specification, excluding the real treated municipalities. The solid red line indicates the real treatment coefficient estimated in the main specification. The dashed red line is mirroring this effect. The Conley-Taber p-value of 0.8 represents the share of placebo coefficients whose absolute value equals or exceeds that of the real treatment estimate.

Source: Ministério da Saúde, IBGE and authors' calculations.

Overall, both tests are consistent in their findings, meaning this robustness check provides no evidence that the 2018 fertility awareness campaign produced a significant effect on GFR in the ten treated municipalities. This finding aligns with the results in the main DiD analysis. Furthermore, Figure 12 in Appendix B provides visual overview of the treatment coefficients and their 95 percent confidence intervals for robustness checks 1, 4, and 5.

6. Analysis and Discussion

6.1 Difference-in-Differences Analysis

The most important result from our DiD tests is that our treatment variable – the difference between our ten treated municipalities and the control municipalities regarding their GFR in the period after the 2018 fertility awareness campaign – was negative for each DiD test. This means that the GFR did not trend in a positive direction in the aftermath of the campaign, as hypothesised. However, controlling for socioeconomic and demographic characteristics of the municipalities, the differences between the ten treated and the controls narrows. The estimated treatment coefficient ranges between -4.3 with no controls to -2.7 for full controls. The decrease in the treatment coefficient as controls are added indicates that a considerable part of the gap in GFR between treated and control municipalities reflects structural differences between the municipalities. Notably, the level difference in GFR between treated municipalities, which are large, urban centres in Brazil, and control municipalities, mostly consisting of smaller towns and cities, is not the primary area of focus. Instead, what matters is whether the trajectory of GFR in treated municipalities changed relative to control municipalities after the campaign was conducted. We interpret the results as indicating that, if the 2018 fertility awareness campaign had any effect, it did not lead to a statistically significant increase in births. The fact that the campaign lasted only one calendar year suggests that even if it changed some people's risk perceptions, information campaigns in large urban centres may need to be sustained for longer periods of time to produce measurable effects. With these factors in mind, there is a possibility that the GFR in the treated municipalities could have been even lower in the absence of the campaign, something we will explore in the robustness checks discussion below.

The economic controls show a positive coefficient throughout DiD (2-6). This is in some ways surprising, as we would expect more wealthy municipalities to have fewer children, but our results point to the opposite conclusion. There is a possibility that wealthier, rural municipalities have higher GFR than poorer, rural municipalities, and that wealthier, urban municipalities have higher GFR than poorer, urban ones. An even more interesting case could be the possibility of rich, urban municipalities having a higher GFR compared to poor, rural municipalities. However, this is speculation and could be addressed in future research. This points to an interesting dynamic in which the fertility drop in Brazil might be more pronounced among the

poorer part of the socioeconomic spectrum, something we can observe in Figures 3, 4, 26 and 27. The female age cohort control results confirm part of our VESPER model prediction, that a higher share of women aged 35-39 (older section of the 15-49 age spectrum) results in a lower GFR effect. However, this negative effect was just above zero, meaning that we cannot deduce a meaningful GFR effect of having more older women in our municipal comparisons. An important note is the effect on the standard errors by including the female age cohort controls. The fact that standard errors increase so dramatically from DiD (3) onwards indicates that the treated cities have a fundamentally different age cohort makeup, which we can see in the age distribution Figure 18 in Appendix B, with treated cities having more women in the upper half of the age distribution than the controls. This means that the age cohort controls have a high correlation with our outcome variable, which is reasonable given that a higher share of older women results in fewer births due to biological factors, as we explored in the literature review. Even if our DiD coefficients are around zero, the significance of the age range 35-39 and the large increase in standard errors point to age composition being an important factor explaining differences in GFR. This finding is consistent with our VESPER model prediction that a higher share of women in the upper half of the 15–49 age distribution, who attempt to have children at relatively older ages, will result in fewer births.

Regarding education, we can observe an interesting dynamic. Both incomplete primary education and university degree and above point to positive GFR outcomes compared to women who finished high school. However, completed primary education show a negative GFR effect as compared to high school educated women. This points to an interesting dynamic in which women with very little education and women with higher education potentially have more births than women with completed primary education. This might be indicative of an education polarization dynamic within the female population in Brazil, where the greatest fertility drop is among women in the middle of the education spectrum. This could also be connected to the income effects noted above, since educational outcomes are related to people's income levels. There is also the possibility that there exist differences between the share of women who are childless, and the family size of those who have children, between high, medium and low educated women. Perhaps a higher share of women who are highly educated are childless, but those who do have children have a larger number compared to medium educated women. In turn, medium educated women might have a smaller share who are childless, but fewer children per mother, conditional on having children. This could explain some of the coefficient differences within the education control variable and would be an interesting area for future research.

The religion control results also point in a very interesting direction. Both evangelical and non-religious women aged 15-49 seem to have fewer births compared to catholic women, once you control for certain factors. What is more surprising is that, controlling for different factors, evangelical women seem to have fewer births than non-religious women. It is possible that this can again be connected to the outcomes noted above. Namely, that women who are evangelical Christians might belong more to the urban, middle educated group of women who seem to experience fewer children per mother, compared both to their richer and poorer equivalents, and potentially urban rural equivalents as well. Inversely, this could mean that non-religious women belong to the higher educated group of women, who seem to have more births than their poorer, less educated peers. This could be an interesting area for future research to investigate.

Regarding race, although the coefficient values for black women were statistically insignificant, the results indicate that black women aged 15-49 seem to be associated with a lower GFR compared to white women in Brazil. The other racial categories show positive, but different, GFR estimated values. As noted previously, this may be related to broader socioeconomic differences across racial groups in Brazil, whereby women with lower levels of education and income are more likely to belong to certain racial categories. The high estimated value among Asian women could be spurious, as Asian women seem to be clustered in a small number of municipalities in comparison to other racial categories (see Figure 23 in Appendix B). Finally, the in-union control result is expected, namely that a higher share of women aged 15-49 in a union with a partner result in a higher GFR, seemingly confirming the relevance of the partner category in the VESPER model.

In summary, the results point to an interesting dynamic. GFR outcomes appear to be more strongly associated with levels of urbanisation and affluence, although the urban–rural divide may be less pronounced than initially expected. Additionally, there are substantial differences in GFR outcomes among Brazilian women aged 15-49 across age, race, education, religion, and union status, underscoring the importance of accounting for these socioeconomic factors in any analysis.

6.2 Event Study Analysis

The main thing to note about the event study results is that our ten treated municipalities seem to have had a lower GFR, compared to our control municipalities, in the period after the 2018 fertility awareness campaign. However, most of these yearly effects are insignificant, with two exceptions: the preceding years 2015-2017, and the COVID-19 pandemic year 2021. The years 2015-2017 being positive and significant is interesting, as it could point to the fact that the treated municipalities experienced some positive GFR policies or circumstances even before the fertility awareness campaign. It raises the question whether the treated municipalities were selected because they had more births leading up to the 2018 fertility awareness campaign. However, given that the treated municipalities are all large state capital, their selection was probably driven by other factors such as population size, for instance. Moreover, it suggests that the parallel trend assumption might not hold in the years preceding the treatment year 2018, as previously outlined in Section 5.2. This would complicate our analysis. Furthermore, the shift from positive to negative coefficients is noteworthy. In the years preceding the campaign, the treated municipalities exhibit a higher GFR to control municipalities, whereas in the post-treatment period the relationship reverses and treated municipalities show a lower GFR. This pattern could point to a downward shift in fertility in treated municipalities following the campaign, though the insignificance of most post-treatment coefficients limits this interpretation.

A likely contributor to the negative post-treatment pattern is the COVID-19 pandemic. The pandemic's negative effect seems to have been more pronounced in our ten treated municipalities compared to our controls. This is reasonable because our ten treated municipalities are larger than most Brazilian municipalities, meaning they might have been comparatively more affected by the pandemic. The COVID-19 pandemic's effect on births has been shown to be negative in most countries, and Brazil seems to be no exception to this (Winkler-Dworak et al. 2024). This complicates our analysis, as the negative drop after 2018, especially in 2021, can, to a large extent, be explained by the COVID-19 pandemic. We can also note that the standard errors jump from 2020 onwards. This indicates that the GFR differences might, during this period, have been the result of people's reactions to COVID-19 in the ten treated cities, rather than their updated risk perceptions as a consequence of the fertility awareness campaign.

Overall, the significant pre-treatment coefficients, raising concerns regarding the parallel trends assumption, and the COVID-19 pandemic, as a major confounder in the post-treatment period, make it difficult to isolate any potential campaign effect on GFR and emphasise that our results need to be treated with caution. These identification challenges emphasise the need for future research to use more granular data rather than aggregated, municipal-level datasets, with the aim of better controlling for confounding factors and achieving a cleaner identification of the causal effect of the fertility awareness campaign.

6.3 Robustness Checks Analysis

The robustness check results imply some key takeaways. They broadly support the main finding that the campaign did not result in a measurable, positive effect on GFR in the treated municipalities. Importantly, the robustness check findings align with the concerns already raised in the event study discussion regarding the parallel trends assumption. The significant RC 1 placebo coefficient combined with the significant pre-treatment coefficients, observed for the years 2015-2017, suggest that the parallel trends assumption may not hold. Therefore, this limits the causal interpretation of the findings. As previously concluded, the main treatment results need to be treated cautiously. Furthermore, two of the robustness checks, RC 2 and RC 5, indicate that São Paulo has a disproportionate influence on the estimated treatment effect. It raises the question of whether the main result reflects a consistent pattern for all treated municipalities or is mainly driven by Brazil's largest municipality.

Restricting the control group to more structurally comparable municipalities of comparable population size yield similar results to our main DiD findings. Meaning that our results are not swayed by the inclusion of a large number of small municipalities in the control panel. However, the placebo sample of comparable, large, non-treated municipalities produces a positive coefficient and a significant result. This may reflect that these municipalities followed different post-2018 GFR dynamics compared to the other control municipalities, reinforcing the interpretation that there exist structural differences between treatment and control municipalities. As previously noted, the most plausible explanation for this divergence is that large urban municipalities were relatively more harshly affected by the COVID-19 pandemic than other Brazilian municipalities. However, it can also be speculated whether other factors such as differences in migration in these cities, particularly of women aged 15-49 years of age, might have contributed to the positive coefficient. Finally, the Conley-Taber tests further

confirm that the estimated treatment effect cannot be distinguished from chance, strengthening the conclusion that the fertility awareness campaign did not significantly affect fertility in the treated municipalities. In summary, the robustness checks emphasize the identification challenges when evaluating the effect of the campaign and reinforce the need to interpret the main findings with caution.

6.4 Discussion

Taken together, the DiD, event study, and robustness check results indicate that the 2018 fertility awareness campaign “Fertility in Motion,” conducted in ten Brazilian municipalities, did not lead to any discernible effect on GFR in the treated municipalities—neither increasing, stabilizing, nor slowing the rate of decline relative to untreated municipalities. This reading is potentially complicated due to issues of identification. One is that we cannot track individuals who were exposed to the campaign, and thus create a better control group, leaving us to analyse large, aggregated datasets on a municipal level. Another complicating factor is that the treatment arguably had spillover effects on municipalities not primarily targeted in the fertility awareness campaign, making the treated and control groups not cleanly divisible. Finally, the fact that the ten treated municipalities were selected by the campaign organisers, and therefore are non-random, introduces a selection bias. This makes the identification of the campaign’s effect imperfect from a study design perspective. With these limitations in mind, we believe that a reasonable, combined reading of the results is as stated above.

This raises some interesting and important questions about what influences the effectiveness of fertility awareness campaigns in general. First, it could be the case that the Brazilian campaign was not extensive enough in time, lasting for just one year, and scope, more intensive information spreading during the course of the campaign, to change the risk perception of postponing childbirth among enough inhabitants of the treated municipalities to have an aggregate effect on the GFR. As highlighted in the literature review, the effectiveness of information campaigns depends on repeated exposure, and tailored communication to specific target groups (García et al. 2015; Maeda et al. 2018). Evidence from other health campaigns suggests that continuous, long-term interventions can induce behavioural change (Breitbart et al. 2006). Taken together, it seems likely that in the Brazilian case study we have investigated, the relatively short campaign duration of one calendar year may not have been sufficient to significantly influence fertility-related behaviour.

However, our results also indicate that our ten treated cities experienced an event in the years following the 2018 fertility awareness campaign that changed people's fertility choices when compared to non-treated municipalities. The most obvious candidate is the COVID-19 pandemic, which struck Brazil hard, and could have had an impact on fertility outcomes, namely births (Sott et al. 2022). Previous research has concluded that densely populated, urban municipalities with overcrowded housing in Brazil were more impacted by the negative effects of COVID-19, a profile that fits all ten treated municipalities (Razafindrakoto et al. 2021). It is therefore possible that, relative to the control municipalities, the ten treated municipalities suffered a greater negative impact on their GFR due to the COVID-19 pandemic.

This leaves open the possibility that the campaign might have had some effect on the GFR in the ten treated municipalities in the absence of the COVID-19 pandemic. It could be argued that the GFR in the ten treated municipalities would have been even lower in the absence of the campaign during the COVID-19 pandemic. For example, some people exposed to the campaign might have decided to have children despite the COVID-19 pandemic, but this was crowded out by the larger effect of people deciding to postpone childbirth due to COVID-19. However, these are counterfactuals that we can only speculate based on the limitations previously outlined in this study.

Another finding relevant to fertility awareness campaign effectiveness is the heterogeneous variation in GFR across education, race, religion, and income groups. This means that fertility awareness messaging should arguably be tailored to different segments of both the female and male population. Our study has focused on women aged 15-49, but the finding of different GFR outcomes for different socio-economic groups arguably applies to men based on previous research (Henkel et al. 2025). We are not in a position to advise on how exactly fertility awareness information should be tailored to specific groups. However, we believe that future fertility awareness campaigns should adapt their messaging to different population segments, rather than relying on a one-size-fits-all approach, in order to be more effective. This is potentially a key takeaway as more countries consider fertility awareness campaigns and interventions going forward, as our previous mention of France in the background section illustrates. A uniform campaign format might target some groups better than others, with potential implications for informational equality within a given society. In other words, future fertility awareness campaigns that do not consider variations in fertility behaviour and socioeconomic factors might provide a greater degree of informed fertility decision-making among some members of society but not others.

One aspect of the issue of fertility is a seeming asymmetry that is becoming more manifest across the world. It seems easier to make people not have children through greater access to contraception and abortion, incentives not to give birth to a certain number of children, postponing marriage etc. than it is to induce people to have children in the modern world. Put another way, there are fewer prerequisites for people not to have children than to have children, which makes the issue much more vexing than previous fertility outcomes, such as eliminating teenage pregnancy, allowing people to use contraceptives to avoid pregnancy during higher education, even sterilization in some cases to name just a few (UNFPA, 2025). The VESPER model that we have presented in this paper can be used to illustrate this. As was mentioned above, the fertility awareness campaign in Brazil does not seem to have induced a greater number of births in the ten treated municipalities. That is, updating people's risk perceptions might not be enough to make them have children earlier in life. Even if people who are aware of the risks of postponing childbirth would like to have children earlier, other factors, such as their values, economic situation, social constraints, lack of a partner or their environment might still hinder their realization of having children. To connect this back to the asymmetry observation raised above, to enable more people to have the children they want – whether that be to go from zero to one, or from three to four – several factors must be in place for this to occur. Put another way, the VESPER model setup can also explain why simply updating people's risk perceptions about the risk of postponing childbirth will arguably not be enough to induce more births.

However, this is not to argue that there is no need for public awareness campaigns about fertility to update people's beliefs. Our literature review shows a substantial and well-documented gap in people's perceptions about fertility and the facts, likelihoods and risks of postponing childbirth among both men and women (García et al. 2015; Hammarberg et al. 2017; UNFPA, 2025). There is an argument to be made that part of the fertility drop is driven by people revealing their true preferences. Namely, that they prioritize other things above having children at a certain point in their life, or to even have children at all. In some ways this is good news, as it shows that we humans have agency over our lives, and that we are not only beings focused on reproduction and survival. However, there is a difference between people making decisions about their lives and making informed decisions. In this case, decisions about when to have children if one seeks to become a parent at some point in life.

We therefore argue that the results of our study do not invalidate the need for future fertility awareness campaigns. Rather that their scope, scale and form might have to be reviewed to be

more effective than seems to have been the case with the 2018 Brazilian fertility awareness campaign “Fertility in Motion”. Providing fertility-related information over longer periods of time, particularly to younger adults, may give people more opportunity to plan and organise their lives with greater awareness of the risks associated with postponing childbirth. A larger-scale campaign using multiple forms of outreach, such as public events, media engagement, and activities in frequently visited public spaces, may also be better suited to reaching a broader share of the population. Finally, as we have shown through our results, the fact that socioeconomics seems to be a key factor for fertility outcomes arguably means that any future fertility awareness campaign should tailor its messaging to different groups of people, and not pursue uniform campaign messaging on the issue of fertility awareness.

The issue of below-replacement fertility rates is complicated for a whole range of different reasons. To many people the idea that global population decline and ageing is an issue, and not a global population explosion going forward, is arguably still quite common (Van Bavel, 2013). That is, transitioning from a conceptual understanding of a key global, demographic development being the exact opposite of what many thought was the case might take some time. There is also the view that fewer people in the world could result in less resource use, with potential environmental benefits down the line, which could be a positive development (Bloom et al. 2025). However, the fact that below-replacement fertility rates not only implies population decline but also that future humans will be considerably older than many might suspect, is arguably a conceptual lag that many people still have around the issue of below-replacement fertility rates. Even with fewer people in the future, environmental impacts and resource use could remain higher than many would assume (Budolfson et al. 2025).

Below-replacement fertility rates also raise potential issues and tensions across a wide range of areas. One is the fear that low number of births might induce an erosion of women’s rights, which has arguably been one of the most important developments of the modern world (UNFPA, 2025). This is an important issue to raise, as it would be unfortunate for more births to come at the expense of the rights of women. Another aspect is that some people simply do not want to become parents, and the issue of below-replacement fertility rates might result in pressures toward people to have children they do not wish to have (UNFPA, 2025). Population decline and ageing due to below-replacement fertility rates also raises issues around migration, with trade-offs between the demand for labour in countries with decreasing workforces, and social tensions around changes in the population makeup caused by migration that has been an issue in many countries in recent years (Peri, 2020). There is also a risk that the global issue of

below-replacement fertility might increasingly induce a “too few of us, too many of you” mindset in a world of relative differences in fertility rates between groups, which historically has been a source of much strife (Goldstone, 2002). In a world of decreasing and ageing populations, the risk of shrinking economies could also induce a greater sense of zero-sum thinking, as lower, and potentially even negative economic growth, could induce a sense of existential scarcity of resources.

In economic discussions, concerns about declining fertility are often linked to the prospect of a shrinking labour force (Coelli & Guzmán, 2026). However, a more optimistic perspective on this issue arises from rapid technological advancement, such as artificial intelligence and robotics, which can partially substitute for certain human tasks and labour (ELA, 2024). Only time will tell whether we do experience technologically induced productivity gains that offset the effects of a smaller workforce and consumer base. However, even if we do experience productivity gains that address issues around the future labour force, this does not diminish the relevance of this study’s area of inquiry. Namely, to allow people who wish to have children to have the children they want. Promoting fertility awareness and informed reproductive decision-making remains important to ensure that individuals are not involuntarily childless. The examples above are not exhaustive. However, they illustrate that the way we approach the issue of below-replacement fertility is necessarily complex and contested.

At the same time, given the wide-ranging economic, welfare and social consequences of below-replacement fertility, there is a need to address the issue (Hansson & Lundberg, 2026). We propose that the VESPER framework could be used to understand the factors shaping fertility decisions, primarily as a question of informed fertility decision-making for those who wish to become parents. By adopting such an approach, which respects the decision of those who do not wish to become parents, we do not necessarily eliminate the complexity and contentiousness of the issue. However, we may make the issue of below-replacement fertility less polarizing for people with different views and perspectives. If it turns out that, on aggregate, when people get to have the children they want, this results in a TFR that is below the replacement rate, then maybe this is not so much a societal “problem” as something that we simply need to handle and adapt to. However, if people become involuntarily childless, or they do not have the number of children they want despite already being parents, using the VESPER framework to try to identify what factor or series of factors are hindering this, does arguably warrant the label of a societal problem. For policymakers, researchers and laypeople, this may have implications not just for how we view the issue of below-replacement fertility, but how we view people in general, and children in particular. Addressing below-replacement fertility

may require a shift in perspective, whereby resources devoted to children's and families's needs and welfare are seen not only as costs, but also as long-term social investments.

In conclusion, the issue of fertility decision-making under risk, where there exists uncertainty in the outcome of becoming a parent, involves trade-offs within material and immaterial constraints for individuals and societies at large. The VESPER model illustrates that people are making decisions under the identified constraints of values, economics, social aspects, partnership, environment and risk, with accompanying tensions and trade-offs for individuals, groups of people and entire societies. The complicated issue of below-replacement fertility rates will necessitate solutions and approaches that do not fully resolve the tension between different aspects and considerations. However, part of the human condition is the ability to handle complicated issues by making trade-offs. Not by finding clean and uncomplicated answers, but by accepting solutions that exist in the tension of things. To paraphrase the political economist Nicholas Eberstadt, whoever solves the puzzle of below-replacement fertility rates deserves a Nobel prize, not in economics but in literature (Hoover Institution, 2025).

7. Conclusion

7.1 Research Aims and Findings

This paper aims to make two main contributions to the literature on below-replacement fertility rates. First, it introduces the VESPER model, a new multicausal framework that synthesises key factors and mechanisms underlying fertility decline into six broad categories grounded in the existing literature: Values, Economics, Social, Partner, Environment, and Risk. Second, it empirically tests the risk perception component of VESPER by analysing whether the 2018 Brazilian fertility awareness campaign "Fertility in Motion", which aimed to correct misperceptions about age-related fertility decline and the risk of postponing childbirth, had a measurable effect on fertility outcomes in the ten municipalities where it was conducted.

The research question and hypothesis we sought to answer were whether the 2018 "Fertility in Motion" campaign, through updating risk perceptions about postponing childbirth, produced a meaningful increase in the GFR among women aged 15–49 in treated Brazilian municipalities relative to untreated ones. Our results do not support this hypothesis. Instead, the ten treated municipalities seem to have experienced a greater drop in their GFR compared to the non-treated municipalities in Brazil. The most likely reason for this was the COVID-19 pandemic, which occurred in close conjunction with the fertility awareness campaign, and which seemingly affected the treated municipalities to a greater degree when measured by the outcome of GFR. We therefore conclude that the campaign did not result in an increase, stabilisation, or slower rate of decline of the GFR in the ten treated municipalities relative to the control municipalities.

More broadly, the results are consistent with the VESPER model's proposition that changes in risk perception alone, in the absence of shifts in other factors, such as values, economic conditions, social context, partner dynamics, and the environment, may be insufficient to generate measurable changes in aggregate fertility outcomes.

7.2 Practical Implications

The findings of this study do not invalidate the need for future fertility awareness campaigns. A substantial gap exists between people's perceptions of fertility and the biological reality of age-related decline among both men and women. However, for such interventions to be effective, several design considerations of future fertility awareness campaigns emerge from the findings of this study. Future campaigns should be conducted at greater scale, and over a longer duration, allowing for repeated exposure to information. They should also employ more diverse forms of messaging to reach different socioeconomic groups, a consideration that is especially important given the heterogeneity in fertility outcomes across education, income, religion, and racial composition documented in this study.

7.3 Limitations

Internal Limitations

The Difference-in-Differences framework relies on the parallel trends assumption in the pre-treatment period. Although the pre-treatment tests conducted in this paper do not reject the assumption, it cannot be directly verified. Moreover, the significant coefficient in the 2015 pre-period introduces some additional uncertainty. Further limitations arise from the nature of the data. Several control variables are constructed through interpolation and extrapolation based on census data, which smooths year-to-year variation and may obscure short-term dynamics. In addition, the analysis is conducted at an aggregate, municipal level rather than at the individual level, which limits the ability to track people exposed to the campaign and to account for the characteristics of those giving or not giving birth. The study period also includes the peak COVID-19 years 2020–2021, which may confound the post-treatment estimates. This concern is particularly relevant if treated and control municipalities were affected differently, for instance due to differences between large urban areas and smaller municipalities. Finally, potential spillover effects cannot be ruled out. Although the campaign was implemented in specific municipalities, some communication channels, particularly social media, may have reached individuals outside the treated areas, thereby attenuating the estimated treatment effects and leading to less clear identification.

External Limitations

The findings of this study are potentially context-specific to Brazil and may not be broadly generalisable to other countries or settings. The results primarily apply to large Brazilian municipalities, and may not translate to smaller municipalities, which differ substantially in economic development, education levels, and degree of urbanisation. Moreover, the institutional, cultural, and economic context of Brazil could mean that the socioeconomic aspects of fertility observed in this study might not be generalized to other countries.

7.4 Future Research

We suggest that future research examine the effectiveness of fertility awareness campaigns using individual level data, with a clearly identifiable treatment group and a comparable control group, to better identify the causal effect of updating risk perceptions about postponing childbirth. Ideally, such studies would also account for contemporaneous shocks, such as the COVID-19 pandemic. Future research could investigate the relationship between wealth, urban and rural status, and GFR in Brazil and other countries. We also suggest further research into whether Brazil and other countries have an education-polarization dynamic in fertility outcomes, and whether childlessness and children-per-mother differs across educational attainment groups. Future research could also investigate why evangelical women appear to have fewer births than non-religious women after controlling for socioeconomic factors, and whether this reflects urban status, income, education, or other compositional effects. Investigating whether the presence of a social media or smart phone control affects the results of a similarly designed study could also be a relevant aspect for future research. Finally, we suggest future testing of the VESPER model in different cross-country settings, to verify whether it brings analytical value in understanding and addressing the issue of below-replacement fertility rates.

References

- Adeste, A. (2026). Inflation and fertility in the United States: Insights from new research, *Institute for Family Studies*, <https://ifstudies.org/blog/inflation-and-fertility-in-the-united-states-insights-from-new-research> [Accessed 26 April 2026]
- Angrist, J. D., & Pischke, J.-S. (2009). *Mostly Harmless Econometrics: An Empiricist's Companion*, Princeton: Princeton University Press
- Begall, K. & Hiekel, N. (2025). Examining the gender equality–fertility paradox in three Nordic countries, *Population and Development Review*, vol. 51, no. 2, pp.858–888, <https://doi.org/10.1111/padr.12721>
- Bellido, H. & Marcén, M. (2016). Fertility and the business cycle: The European case, *MPRA Paper*, no. 69368, <https://ideas.repec.org/p/pra/mprapa/69368.html> [Accessed 26 April 2026]
- Bernardi, L. & Klärner, A. (2014). Social networks and fertility, *Demographic Research*, vol. 30, pp.641–670, <https://doi.org/10.4054/demres.2014.30.22>
- Bloom, D., Kuhn, M. & Prettnner, K. (2025). The debate over falling fertility, *IMF Finance & Development*, <https://www.imf.org/en/publications/fandd/issues/2025/06/the-debate-over-falling-fertility-david-bloom> [Accessed 10 May 2026]
- Bodin, M., Plantin, L., Schmidt, L., Ziebe, S. & Elmerstig, E. (2021). The pros and cons of fertility awareness and information: A generational, Swedish perspective, *Human Fertility*, vol. 26, no. 2, pp.216–225, <https://doi.org/10.1080/14647273.2021.1968045>
- Boxem, A. J., Blaauwendraad, S. M., Mulders, A. G. M. G. J., Bekkers, E. L., Gaillard, R. & Jaddoe, V. W. V. (2025). Age among women and men, time to pregnancy and risk of miscarriage, *BMC Medicine*, vol. 23, p.639, <https://doi.org/10.1186/s12916-025-04462-8>
- Brand, J. E. & Davis, D. (2011). The impact of college education on fertility: Evidence for heterogeneous effects, *Demography*, vol. 48, no. 3, pp.863–887, <https://doi.org/10.1007/s13524-011-0034-3>
- Breitbart, E. W., Greinert, R. & Volkmer, B. (2006). Effectiveness of information campaigns, *Progress in Biophysics and Molecular Biology*, vol. 92, no. 1, pp.167–172, <https://doi.org/10.1016/j.pbiomolbio.2006.02.023>
- Britannica. (2026). Brazil | history, map, culture, population, & facts, <https://www.britannica.com/place/Brazil> [Accessed 26 April 2026]
- Buber-Ennsner, I., Panova, R. & Dorbritz, J. (2013). Fertility intentions of university graduates, *Demográfia*, vol. 56, no. 5, pp.27–55, <https://demografia.hu/demografia/index.php/demografia/article/view/2904> [Accessed 26 April 2026]
- Budolfson, M., Geruso, M., Kuruc, K. J., Spears, D. & Vyas, S. (2025). Is less really more? Comparing the climate and productivity impacts of a shrinking population, working paper, no. 33932, National Bureau of Economic Research, <https://www.nber.org/papers/w33932> [Accessed 20 May 2026]

- Burn-Murdoch, J. (2026). Why birth rates are falling everywhere all at once, *Financial Times*, 16 May, <https://www.ft.com/content/fba35eca-df3a-4ad6-b42d-eb08eb7c9ad3> [Accessed 19 May 2026]
- Bursztyn, L. & Yang, D. Y. (2022). Misperceptions about others, *Annual Review of Economics*, vol. 14, no. 1, pp.425–452, <https://doi.org/10.1146/annurev-economics-051520-023322>
- Chvaja, R., Shaver, J. H. & Bulbulia, J. A. (2026). Investigating the causal effects of religiosity on childbearing among U.S. adolescents using a three-wave longitudinal design, *Scientific Reports*, vol. 16, no. 1, pp.4255, <https://doi.org/10.1038/s41598-025-34358-9>
- Coelli, P. & Guzmán, P-G. (2026). How could falling birth rates reshape the global economy? *Economics Observatory*, <https://www.economicsobservatory.com/how-could-falling-birth-rates-reshape-the-global-economy> [Accessed 28 April 2026]
- Comolli, C. L. & Vignoli, D. (2021). Spreading uncertainty, shrinking birth rates: A natural experiment for Italy, *European Sociological Review*, vol. 37, no. 4, pp.555–570, <https://doi.org/10.1093/esr/jcab001>
- Conley, T. G. & Taber, C. R. (2011). Inference with “difference in differences” with a small number of policy changes, *The Review of Economics and Statistics*, vol. 93, no. 1, pp.113–125, https://doi.org/10.1162/rest_a_00049
- Cukrowska-Torzewska, E. & Matysiak, A. (2020). The motherhood wage penalty: A meta-analysis, *Social Science Research*, vol. 88–89, 102416, <https://doi.org/10.1016/j.ssresearch.2020.102416>
- Cunningham, S. (2021). *Causal Inference: The Mixtape*, New Haven: Yale University Press
- da Silva Frost, A., Wang, Y. A., Eastwick, P. W. & Ledgerwood, A. (2024). Summarized attribute preferences have unique antecedents and consequences, *Journal of Experimental Psychology: General*, vol. 153, no. 4, pp.913–938, <https://doi.org/10.1037/xge0001242>
- Dattani, S., Rodés-Guirao, L. & Roser, M. (2025). Fertility rate, *Our World in Data*, [e-journal], <https://ourworldindata.org/fertility-rate> [Accessed 10 May 2026]
- Estévez, J. L. & Rotkirch, A. (2026). Fertility trends across migrant generations reexamined: Insights from Finnish register data, *European Sociological Review*, p.jcag009, <https://doi.org/10.1093/esr/jcag009>
- European Labour Authority (ELA). (2024). Employment and work aspects of technological advancements: Strategic foresight [pdf], <https://www.ela.europa.eu/sites/default/files/2024-12/driver-1-employment-work-aspects.pdf> [Accessed 26 April 2026]
- Fiori, F., Graham, E. & Feng, Z. (2014). Geographical variations in fertility and transition to second and third birth in Britain, *Advances in Life Course Research*, vol. 21, pp.149–167, <https://doi.org/10.1016/j.alcr.2013.10.002>
- García, D., Vassena, R., Prat, A. & Vernaev, V. (2015). Increasing fertility knowledge and awareness by tailored education: A randomized controlled trial, *Reproductive*

- BioMedicine Online*, vol. 32, no. 1, pp.113–120,
<https://doi.org/10.1016/j.rbmo.2015.10.008>
- Giwerzman, A., Elmerstig, E., Rylander, L., Kitlinski, M. & Koppelhus, O. K. (2026). Ofrivillig barnlöshet – förekomst, orsaker, behandling och konsekvenser [In Swedish] [pdf], https://framtidmedbarn.se/wp-content/uploads/2026/03/Skrift-4-Ofrivillig-barnlosket_web.pdf [Accessed 26 April 2026]
- Goldin, C. (2014). A grand gender convergence: Its last chapter, *American Economic Review*, vol. 104, no. 4, pp.1091–1119, <https://doi.org/10.1257/aer.104.4.1091>
- Goldin, C. (2025). The downside of fertility, working paper, no. 34268, *National Bureau of Economic Research*, <https://doi.org/10.3386/w34268>
- Goldstone, J. A. (2002). Population and security: How demographic change can lead to violent conflict, *Journal of International Affairs*, vol. 56, no. 1, pp.3–21, <https://www.jstor.org/stable/24357881> [Accessed 26 April 2026]
- Guirola, L. & Hospido, L. (2024). Family and career: An analysis across Europe and North America, *Banco de España*, <https://www.bde.es/wbe/en/publicaciones/analisis-economico-investigacion/documentos-trabajo/family-and-career--an-analysis-across-europe-and-north-america.html> [Accessed 26 April 2026]
- Hammarberg, K., Collins, V., Holden, C., Young, K. & McLachlan, R. (2017). Men's knowledge, attitudes and behaviours relating to fertility, *Human Reproduction Update*, vol. 23, no. 4, pp.458–480, <https://doi.org/10.1093/humupd/dmx005>
- Hansson, Å. & Lundberg, K. (2026). The silent crisis: The impact of declining birth rates on Sweden's economy and welfare [pdf], <https://framtidmedbarn.se/wp-content/uploads/2026/04/No-1-The-silent-crisis-002.pdf> [Accessed 26 April 2026]
- Henkel, R., Elbardisi, H., Majzoub, A. & Arafa, M. (2025). Racial differences in male fertility parameters in 2,996 men examined for infertility in a single center, *Arab Journal of Urology: An International Journal*, vol. 23, no. 4, pp.255–265, <https://pubmed.ncbi.nlm.nih.gov/41050388/> [Accessed 26 April 2026]
- Hoover Institution. (2025). The age of depopulation, with Nicholas Eberstadt, <https://www.hoover.org/research/age-depopulation-nicholas-eberstadt> [Accessed 27 April 2026]
- Hornik, R. & McAnany, E. (2001). Mass media and fertility change, in J. B. Casterline (ed.), *Diffusion Processes and Fertility Transition: Selected perspectives*, Washington, DC: National Academies Press, <https://www.ncbi.nlm.nih.gov/books/NBK223858/> [Accessed 19 May 2026]
- Hudson, N. & Moscoso Boedo, H. J. (2026). The collapse of teen fertility in the digital era, Department of Economics, Carl H. Lindner College of Business, working paper, University of Cincinnati, <https://ssrn.com/abstract=6676839> [Accessed 19 May 2026]
- IBGE. (2025). 2022 census: Catholics remain in decline; Protestants and persons with no religion increase in the country, *Agência de Notícias – IBGE*, <https://agenciadenoticias.ibge.gov.br/en/agencia-news/2184-news-agency/news/43602-2022-census-catholics-remain-in-decline-protestants-and-persons-with-no-religion-increase-in-the-country> [Accessed 28 April 2026]

- IBGE. (2026). Brazil's population will stop growing in 2041, *Agência de Notícias – IBGE*, <https://agenciadenoticias.ibge.gov.br/en/agencia-news/2184-news-agency/news/41065-populacao-do-pais-vai-parar-de-crescer-em-2042> [Accessed 26 April 2026]
- IBIS. (n.d.). Health indicator report important facts – General fertility rate, https://ibis.utah.gov/ibisph-view/indicator/important_facts/FertRat.html [Accessed 26 April 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.a). Tabela 1552: População residente, por situação do domicílio e sexo, segundo a forma de declaração da idade e a idade (SIDRA), <https://sidra.ibge.gov.br/tabela/1552> [Accessed 25 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.b). Tabela 9514: População residente, por sexo, idade e forma de declaração da idade (SIDRA), <https://sidra.ibge.gov.br/tabela/9514> [Accessed 25 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.c). Tabela 5938: Produto interno bruto a preços correntes, impostos, líquidos de subsídios, sobre produtos a preços correntes e valor adicionado bruto a preços correntes total e por atividade econômica, e respectivas participações – Referência 2010 (SIDRA), <https://sidra.ibge.gov.br/tabela/5938> [Accessed 25 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.d). Tabela 6579: População residente estimada (SIDRA), <https://sidra.ibge.gov.br/tabela/6579> [Accessed 25 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.e). Tabela 2472: Pessoas de 10 anos ou mais de idade por estado civil, condição de convivência, grupos de anos de estudo e grupos de idade (SIDRA), <https://sidra.ibge.gov.br/tabela/2472> [Accessed 28 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.f). Tabela 3105: Pessoas de 10 anos ou mais de idade, por estado conjugal e estado civil, segundo o nível de instrução, a condição de atividade na semana de referência e os grupos de idade (SIDRA), <https://sidra.ibge.gov.br/tabela/3105> [Accessed 27 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.g). Tabela 10184: Pessoas de 10 anos ou mais de idade, por estado conjugal, segundo os grupos de idade e o nível de instrução (SIDRA), <https://sidra.ibge.gov.br/tabela/10184> [Accessed 27 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.h). Tabela 2466: Pessoas de 10 anos ou mais de idade por estado civil, situação do domicílio, sexo, condição de convivência e grupos de idade (SIDRA), <https://sidra.ibge.gov.br/tabela/2466> [Accessed 28 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.i). Tabela 1539: Pessoas de 10 anos ou mais de idade, por estado conjugal (SIDRA), <https://sidra.ibge.gov.br/tabela/1539> [Accessed 2 April 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.j). Tabela 2470: Pessoas de 10 anos ou mais de idade por estado civil, condição de convivência, sexo e religião (SIDRA), <https://sidra.ibge.gov.br/tabela/2470> [Accessed 28 March 2026]

- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.k). Tabela 1206: Pessoas de 10 anos ou mais de idade, por estado conjugal e estado civil, segundo o sexo, a religião (SIDRA), <https://sidra.ibge.gov.br/tabela/1206> [Accessed 27 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.l). Tabela 10183: Pessoas de 10 anos ou mais de idade, por estado conjugal, segundo o sexo, os grupos de idade e a religião (SIDRA), <https://sidra.ibge.gov.br/tabela/10183> [Accessed 27 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.m). Tabela 2468: Pessoas de 10 anos ou mais de idade por estado civil, condição de convivência, cor ou raça e grupos de idade (SIDRA), <https://sidra.ibge.gov.br/tabela/2468> [Accessed 28 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.n). Tabela 3193: Pessoas de 10 anos ou mais de idade, por estado civil, segundo o estado conjugal, a situação do domicílio, o sexo, a cor ou raça e os grupos de idade (SIDRA), <https://sidra.ibge.gov.br/tabela/3193> [Accessed 31 March 2026]
- Instituto Brasileiro de Geografia e Estatística (IBGE). (n.d.o). Tabela 10185: Pessoas de 10 anos ou mais de idade, por estado conjugal, segundo o sexo, os grupos de idade e a cor ou raça (SIDRA), <https://sidra.ibge.gov.br/tabela/10185> [Accessed 27 March 2026]
- Johnson, S. L., Dunleavy, J., Gemmell, N. J. & Nakagawa, S. (2015). Consistent age-dependent declines in human semen quality: A systematic review and meta-analysis, *Ageing Research Reviews*, vol. 19, pp.22–33, <https://doi.org/10.1016/j.arr.2014.10.007>
- Khatsenkova, S. (2026). Measures to boost France’s falling birth rate spark debate, *Euronews*, <https://www.euronews.com/2026/02/12/interest-free-home-loans-and-250-per-child-can-france-boost-its-falling-birth-rate> [Accessed 10 May 2026]
- Kleven, H., Landais, C. & Søgaaard, J. E. (2019). Children and gender inequality: Evidence from Denmark, *American Economic Journal: Applied Economics*, vol. 11, no. 4, pp.181–209, <https://doi.org/10.1257/app.20180010>
- Kuang, B., Berrington, A., Vasireddy, S. & Kulu, H. (2025). The changing inter-relationship between partnership dynamics and fertility trends in Europe and the United States: A review, *Demographic Research*, vol. 52, pp.179–228, <https://doi.org/10.4054/demres.2025.52.7>
- La Ferrara, E., Chong, A. & Duryea, S. (2012). Soap operas and fertility: Evidence from Brazil, *American Economic Journal: Applied Economics*, vol. 4, no. 4, pp.1–31, <https://doi.org/10.1257/app.4.4.1>
- Lee, R. & Mason, A. (2014). Is low fertility really a problem? Population aging, dependency, and consumption, *Science*, vol. 346, no. 6206, pp.229–234, <https://doi.org/10.1126/science.1250542>
- Lois, D. & Becker, O. A. (2013). Is fertility contagious? Using panel data to disentangle mechanisms of social network influences on fertility decisions, *Advances in Life Course Research*, vol. 21, pp.123–134, <https://doi.org/10.1016/j.alcr.2013.10.001>
- Ma, B., Wu, J. & Yu, Y. (2025). Inequality of opportunity and fertility intentions, *China Economic Quarterly International*, vol. 5, no. 2, pp.102–119, <https://doi.org/10.1016/j.ceqi.2025.05.003>

- Maeda, E., Boivin, J., Toyokawa, S., Murata, K. & Saito, H. (2018). Two-year follow-up of a randomized controlled trial: Knowledge and reproductive outcome after online fertility education, *Human Reproduction*, vol. 33, no. 11, pp.2035–2042, <https://doi.org/10.1093/humrep/dey293>
- Mercatus Center. (2026). Jesús Fernández-Villaverde on the quandary of global demographic decline, <https://www.mercatus.org/macro-musings/jesus-fernandez-villaverde-quandary-global-demographic-decline> [Accessed 26 April 2026]
- Ministério da Saúde. (2026). Sistema de informação sobre nascidos vivos – Sinasc, <https://dadosabertos.saude.gov.br/dataset/sistema-de-informacao-sobre-nascidos-vivos-sinasc> [Accessed 25 March 2026]
- Mu, Q., Hanson, L., Hoelzle, J. & Fehring, R. J. (2019). Young women’s knowledge about fertility and their fertility health risk factors, *Journal of Obstetric, Gynecologic & Neonatal Nursing*, vol. 48, no. 2, pp.153–162, <https://doi.org/10.1016/j.jogn.2018.12.009>
- Nakagawa, H. M. (2018). Fertility awareness campaign, *JBRA Assisted Reproduction*, vol. 22, no. 4, pp.284–285, 10.5935/1518-0557.20180074
- Parham, B. (2025). Government launches inquiry to tackle Sweden’s record-low birth rate, Sveriges Radio, 1 July, <https://www.sverigesradio.se/artikel/government-launches-inquiry-to-tackle-swedens-record-low-birth-rate> [Accessed 27 April 2026]
- Penzias, A., Azziz, R., Bendikson, K., Falcone, T., Hansen, K., Hill, M., Jindal, S., Kalra, S., Mersereau, J., Reindollar, R., Shannon, C. N., Steiner, A., Tanrikut, C., Taylor, H. & Yauger, B. (2022). Optimizing natural fertility: A committee opinion, *Fertility and Sterility*, vol. 117, no. 1, pp.53–63, <https://doi.org/10.1016/j.fertnstert.2021.10.007>
- Peri, G. (2020). Immigrant Swan Song, *IMF Finance & Development*, <https://www.imf.org/en/publications/fandd/issues/2020/03/can-immigration-solve-the-demographic-dilemma-peri> [Accessed 28 April 2026]
- Razafindrakoto, M., Roubaud, F., Saboia, J., Castilho, M. R. & Pero, V. (2021). Municípios in the time of Covid-19 in Brazil: Socioeconomic vulnerabilities, transmission factors and public policies, *European Journal of Development Research*, vol. 34, no. 6, pp.2730–2758, <https://doi.org/10.1057/s41287-021-00487-w>
- Ritchie, H. & Arriagada, P. (2026). Which countries have fertility rates above or below the “replacement level”? *Our World in Data*, <https://ourworldindata.org/data-insights/which-countries-have-fertility-rates-above-or-below-the-replacement-level> [Accessed 26 April 2026]
- Roser, M. (2014). The global decline of the fertility rate, *Our World in Data*, [e-journal], <https://ourworldindata.org/global-decline-fertility-rate> [Accessed 26 April 2026]
- Roser, M. (2023). Demographic transition: Why is rapid population growth a temporary phenomenon? *Our World in Data*, [e-journal], <https://ourworldindata.org/demographic-transition> [Accessed 26 April 2026]
- Rothman, K. J., Wise, L. A., Sørensen, H. T., Riis, A. H., Mikkelsen, E. M. & Hatch, E. E. (2013). Volitional determinants and age-related decline in fecundability: A general

- population prospective cohort study in Denmark, *Fertility and Sterility*, vol. 99, no. 7, pp.1958–1964, <https://doi.org/10.1016/j.fertnstert.2013.02.040>
- SBRA. (n.d.). Movimento da fertilidade, *Associação Brasileira de Reprodução Assistida* [In Portuguese], <https://sbra.com.br/fertilidade-o-tempo-nao-para/> [Accessed 26 April 2026]
- Schmidt, L. (2008). Risk preferences and the timing of marriage and childbearing, *Demography*, vol. 45, no. 2, pp.439–460, <https://doi.org/10.1353/dem.0.0005>
- Shaw, S. J. (2025). On a microdemographic framework for decomposing contemporary fertility dynamics, *Scientific Reports*, vol. 15, no. 1, p.30726, <https://doi.org/10.1038/s41598-025-11522-9>
- Silva, A. C. da & Bezerra, F. D. da S. (2023). The ‘thinking territorially’ regional differences in Brazil, *Seven Editora*, [e-journal], <https://sevenpubl.com.br/index.php/editora/article/view/2642> [Accessed 12 May 2026]
- Sott, M. K., Bender, M. S. & da Silva Baum, K. (2022). Covid-19 outbreak in Brazil: Health, social, political, and economic implications, *International Journal of Health Services*, vol. 52, no. 4, <https://doi.org/10.1177/00207314221122658>
- Svanberg, A. S., Lampic, C., Karlström, P. & Tydén, T. (2006). Attitudes toward parenthood and awareness of fertility among postgraduate students in Sweden, *Gender Medicine*, vol. 3, no. 3, pp.187–195, [https://doi.org/10.1016/s1550-8579\(06\)80207-x](https://doi.org/10.1016/s1550-8579(06)80207-x)
- Tartakovsky, E. & Mizrahi, M. (2025). The motivational foundations of childbearing: Investigating relationships between childbearing attitudes, value preferences, and parental bonding, *PLOS One*, vol. 20, no. 5, <https://doi.org/10.1371/journal.pone.0322802>
- Thaler, R. H. (2016). Behavioral economics: Past, present, and future, *American Economic Review*, vol. 106, no. 7, pp.1577–1600, <https://doi.org/10.1257/aer.106.7.1577>
- The Demographic Future of Humanity (23 October 2025.). YouTube video, added by Stanford Classical Liberalism Initiative, <https://www.youtube.com/watch?v=QziqIoKS-uA> [Accessed 26 April 2026]
- Treas, J. (2008). The dilemma of gender specialization, *Rationality and Society*, vol. 20, no. 3, pp.259–282, <https://doi.org/10.1177/1043463108092529>
- UNESCO. (2025). Record number of higher education students highlights global need for recognition of qualifications, <https://www.unesco.org/en/articles/record-number-higher-education-students-highlights-global-need-recognition-qualifications> [Accessed 5 May 2026]
- UNFPA. (n.d.). PAPP101 – S04: Measuring fertility, http://papp.iussp.org/sessions/papp101_s04/PAPP101_s04_060_010.html [Accessed 26 April 2026]
- UNFPA. (2025). The real fertility crisis, *State of World Population 2025*, <https://www.unfpa.org/swp2025> [Accessed 29 April 2026]

- Van Bavel, J. (2013). The world population explosion: Causes, backgrounds and projections for the future, *Facts, Views & Vision in ObGyn*, vol. 5, no. 4, pp.281–291, <https://pmc.ncbi.nlm.nih.gov/articles/PMC3987379/> [Accessed 26 April 2026]
- Wainwright, E., Ali, Z., Lawrie, L., Getreu, N. & O'Neill, H. C. (2025). Fertility awareness in 97,414 women trying to conceive: Gaps, misconceptions, and implications for reproductive education, *Reproductive Health*, vol. 22, no. 1, 152, <https://doi.org/10.1186/s12978-025-02079-x>
- Wesselink, A. K., Rothman, K. J., Hatch, E. E., Mikkelsen, E. M., Sørensen, H. T. & Wise, L. A. (2017). Age and fecundability in a North American preconception cohort study, *American Journal of Obstetrics and Gynecology*, vol. 217, no. 6, pp.667.e1–667.e8, <https://doi.org/10.1016/j.ajog.2017.09.002>
- WHO. (n.d.). Total fertility rate (per woman), <https://www.who.int/data/gho/indicator-metadata-registry/imr-details/123> [Accessed 26 April 2026]
- WHO. (2025). Infertility, <https://www.who.int/news-room/fact-sheets/detail/infertility> [Accessed 27 April 2026]
- Winkler-Dworak, M., Zeman, K. & Sobotka, T. (2024). Birth rate decline in the later phase of the COVID-19 pandemic: The role of policy interventions, vaccination programmes, and economic uncertainty, *Human Reproduction Open*, vol. 2024, no. 3, p.hoae052
- World Population Review. (2026). Average age of having first child by country 2026, <https://worldpopulationreview.com/country-rankings/average-age-of-having-first-child-by-country> [Accessed 26 April 2026]
- WPP. (n.d.). TFR 2024, <https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Most%20used> [Accessed 7 May 2026]
- Yanatma, S. (2026). Europe's fertility keeps falling: Which country has the highest rate? 3 March, *Euronews*, <https://www.euronews.com/health/2026/03/14/europes-fertility-rates-keep-falling-which-countries-have-the-highest-rates-and-biggest-dr> [Accessed 27 April 2026]
- Zhang, T.-T., Cai, X.-Y., Shi, X.-H., Zhu, W. & Shan, S.-N. (2023). The effect of family fertility support policies on fertility, their contribution, and policy pathways to fertility improvement in OECD countries, *International Journal of Environmental Research and Public Health*, vol. 20, no. 6, pp.4790, <https://doi.org/10.3390/ijerph20064790>
- Zhang, Y., Zhang, H., Zhao, J., Zhao, Y., Zhang, J., Jiang, L., Wang, Y., Peng, Z., Zhang, Y., Jiao, K., He, T., Wang, Q., Shen, H., Zhang, Y., Yan, D. & Ma, X. (2024). Gravidity modifies the associations of age and spousal age difference with couple's fecundability: A large cohort study from China, *Human Reproduction*, vol. 39, no. 1, pp.201–208, <https://doi.org/10.1093/humrep/dead209>

Appendix A – Tables

Table 7: Treated Municipalities in Brazil

<i>State</i>	<i>Municipality</i>
Pernambuco	Recife
Ceará	Fortaleza
Bahia	Salvador
Minas Gerais	Belo Horizonte
Rio de Janeiro	Rio de Janeiro
São Paulo	São Paulo
Rio Grande do Sul	Porto Alegre
Paraná	Curitiba
Goiás	Goiânia
Distrito Federal	Brasília

Source: (SBRA, n.d.).

Table 8: Robustness Check 2 – Results: DiD Estimates. Dependent Variable: GFR

<i>City Dropped</i>	<i>Treatment Coefficient</i>	<i>S.E</i>	<i>P-Value</i>	<i>Number of Observations</i>
Main specification (all municipalities)	-2.736	(2.502)	0.274	83,446
Drop Recife	-1.427	(2.468)	0.563	83,431
Drop Fortaleza	-3.848	(2.644)	0.146	83,431
Drop Salvador	-1.454	(2.564)	0.571	83,431
Drop Belo Horizonte	-2.363	(2.696)	0.381	83,431
Drop Rio de Janeiro	-2.497	(2.643)	0.345	83,431
Drop São Paulo	0.200	(2.650)	0.940	83,431
Drop Porto Alegre	-2.368	(2.839)	0.404	83,431
Drop Curitiba	-1.918	(2.713)	0.480	83,431
Drop Goiânia	-4.407*	(2.309)	0.056	83,431
Drop Brasília	-3.707	(2.809)	0.187	83,431

RC2: All treated municipalities are dropped one by one. Outcome: annual GFR. All specifications include municipality and year fixed effects.

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

Table 9: Variable Overview

<i>Variable</i>	<i>Coverage</i>	<i>Definition</i>	<i>Data Source</i>	<i>Notes</i>
<i>Outcome Variable</i>				
General Fertility Rate (GFR)	2002–2024 per municipality	Births per 1,000 women aged 15-49; Self-constructed	SINASC 2002-2024: Raw monthly births per municipality (DTNASC, CODMUNNASC) IBGE Tabela 1552: Resident population per municipality – Census 2000 and 2010 (IBGE, n.d.a) IBGE Tabela 9514: Resident population per municipality – Census 2022 (IBGE, n.d.b)	Variable indicating population of women aged 15-49 per municipality has been linearly interpolated between censuses, and linearly extrapolated to the year 2024.
<i>Control Variables</i>				
Log GDP per Capita	2002–2024, per municipality	Log-transformed GDP per capita	IBGE Tabela 5938: GDP at current prices (thousands BRL) 2002-2023 municipalities (IBGE, n.d.c) IBGE Tabela 6579: Estimated resident population 2001-2025 per municipality (IBGE, n.d.d)	GDP data for the years 2007, 2010, and 2022-2023 was missing, thus linear interpolation was conducted between the years 2006-2008, 2009-2011, and 2021-2024.
Age Structure	Census 2000, 2010 and 2022 per municipality	Share of women aged between 15 and 49 in each age bin: • 15–19 • 20–24 • 25–29 • 30–34 • 35–39 • 40–44 • 45–49	IBGE Tabela 1552: Resident population by age groups based on birth date / presumed age – Census 2000 and 2010 (IBGE, n.d.a) IBGE Tabela 9514: Resident population by age groups based on birth date / presumed age – Census 2022 (IBGE, n.d.b)	Linear interpolation between censuses, and linear extrapolation to 2024
Education	Census 2000, 2010 and 2022 per municipality	Harmonized categories: No education / Incomplete (0, 1-3 and 4-7 years of schooling) Completed primary / Incomplete secondary education (8-10 years of schooling)	IBGE Tabela 2472: Population aged 10+, education – Census 2000 (IBGE, n.d.e) IBGE Tabela 3105: Population aged 10+, education – Census 2010 (IBGE, n.d.f)	Categories in Census 2000 were partially merged to align with Census 2010 and 2022 categories Linear interpolation between censuses, and linear extrapolation to 2024

		High school diploma / Incomplete college (11-14 years of schooling) Bachelor's degree or higher (+15 years of schooling)	IBGE Tabela 10184: Population aged 10+, education – Census 2022 (IBGE, n.d.g)	The education variable is harmonized using the 2000 Census to align with the categories used in the 2010 and 2022 censuses. For 2000, six education categories are aggregated into four groups: no education/incomplete primary (no instruction through 7 years of schooling), completed primary (8-10 years), high school (11-14 years), and bachelor's degree or higher (15 or more years).
Union Status	Census 2000, 2010 and 2022 per municipality	Share of total resident population: Living with a spouse or partner Not living with a spouse or partner	IBGE Tabela 2466: Population aged 10+, cohabitation – Census 2000 (IBGE, n.d.h) IBGE Tabela 1539: Population aged 10+, cohabitation – Census 2010 and 2022 (IBGE, n.d.i)	Linear interpolation between censuses, and linear extrapolation to 2024
Religion	Census 2000, 2010 and 2022 per municipality	Share of women in each group Roman Catholic Evangelical No Religion	IBGE Tabela 2470: Population aged 10+, religion – Census 2000 (IBGE, n.d.j) IBGE Tabela 1206: Population aged 10+, religion – Census 2010 (IBGE, n.d.k) IBGE Tabela 10183: Population aged 10+, religion – Census 2022 (IBGE, n.d.l)	Linear interpolation between censuses, and linear extrapolation to 2024 Religion data for women aged 15-49 is unavailable, therefore, we hypothesize that the population data is also representative for the group of interest
Racial Composition	Census 2000, 2010 and 2022 per municipality	Share of women aged between 15 and 49 by self-identified race: Branco – White Parda – Mixed Amarela – Asian Indígena – Indigenous	IBGE Tabela 2468: resident population aged 10+, race – Census 2000 (IBGE, n.d.m) IBGE Tabela 3193: resident population aged 10+, race – Census 2010 (IBGE, n.d.n) IBGE Tabela 10185: resident population aged 10+, race – Census 2022 (IBGE, n.d.o)	Linear interpolation between censuses, and linear extrapolation to 2024

Table 10: Placebo-Treated Municipalities

<i>State</i>	<i>Municipality</i>
Amazonas	Manaus
Pará	Belém
São Paulo	Guarulhos
São Paulo	Campinas
Maranhão	São Luís
Alagoas	Maceió
Mato Grosso do Sul	Campo Grande
Rio de Janeiro	São Gonçalo
Piauí	Teresina
Paraíba	João Pessoa

Table 11: Summary Statistics – Treated & Placebo Municipalities – Pre-Treatment Period

Municipality	GFR	In GDP per Capita	Women 15-49	Edu: No Prim.	Edu: Prim.	Edu: High Sch.	Edu: Degree	Rel.: Cath.	Rel.: Evang.	Rel.: None	Race: White	Race: Mixed	Race: Black	Race: Indig.	Race: Asian	Union Share
Panel A: Treated State Capitals																
Recife	50.9	10.30	445,372	0.25	0.19	0.38	0.18	0.53	0.29	0.14	0.40	0.49	0.10	0.002	0.01	0.45
Fortaleza	50.6	9.96	743,153	0.25	0.22	0.39	0.13	0.67	0.25	0.07	0.34	0.59	0.05	0.001	0.01	0.46
Salvador	45.1	9.88	808,358	0.24	0.20	0.42	0.14	0.52	0.25	0.19	0.17	0.51	0.30	0.003	0.01	0.44
Belo Horizonte	45.6	10.43	684,826	0.19	0.19	0.38	0.23	0.58	0.29	0.09	0.45	0.42	0.12	0.002	0.01	0.44
Rio de Janeiro	50.3	10.75	1,721,123	0.20	0.21	0.39	0.20	0.51	0.27	0.15	0.48	0.38	0.13	0.001	0.01	0.47
Sao Paulo	53.5	10.88	3,246,726	0.21	0.20	0.36	0.22	0.57	0.25	0.12	0.58	0.32	0.08	0.001	0.02	0.48
Porto Alegre	50.2	10.69	380,236	0.19	0.19	0.37	0.25	0.63	0.14	0.15	0.78	0.10	0.12	0.002	0.00	0.48
Curitiba	48.1	10.67	508,634	0.16	0.19	0.38	0.27	0.61	0.27	0.09	0.78	0.18	0.03	0.002	0.01	0.51
Goiania	53.1	10.35	406,167	0.19	0.20	0.39	0.21	0.50	0.36	0.09	0.46	0.46	0.06	0.002	0.02	0.49
Brasilia	54.6	11.19	812,195	0.20	0.19	0.38	0.24	0.55	0.31	0.10	0.41	0.49	0.09	0.003	0.02	0.47
Panel B: Comparable Large Municipalities																
Manaus	72.6	10.42	561,242	0.25	0.21	0.42	0.12	0.52	0.40	0.08	0.26	0.69	0.04	0.004	0.01	0.47
Belem	51.4	9.88	410,498	0.23	0.23	0.40	0.14	0.60	0.33	0.05	0.26	0.64	0.08	0.002	0.01	0.45
Guarulhos	59.2	10.56	359,642	0.23	0.23	0.40	0.14	0.51	0.33	0.13	0.52	0.40	0.07	0.001	0.01	0.50
Campinas	49.4	10.78	311,584	0.20	0.20	0.38	0.22	0.57	0.29	0.10	0.64	0.28	0.08	0.001	0.01	0.52
Sao Luis	52.2	10.12	325,058	0.19	0.21	0.47	0.14	0.63	0.28	0.08	0.28	0.56	0.14	0.002	0.01	0.43
Maceio	52.7	9.84	284,136	0.33	0.19	0.34	0.14	0.59	0.28	0.11	0.34	0.56	0.09	0.002	0.01	0.48
Campo Grande	58.2	10.23	235,462	0.23	0.21	0.38	0.18	0.50	0.35	0.10	0.49	0.43	0.06	0.008	0.01	0.50
Sao Goncalo	42.8	9.60	274,043	0.24	0.24	0.44	0.09	0.41	0.38	0.19	0.41	0.45	0.14	0.001	0.00	0.49
Teresina	53.6	9.90	256,568	0.25	0.22	0.38	0.15	0.77	0.17	0.05	0.26	0.60	0.12	0.002	0.02	0.45
Joao Pessoa	51.8	9.98	226,648	0.25	0.19	0.38	0.18	0.61	0.29	0.08	0.42	0.49	0.07	0.003	0.01	0.48

All variables are municipality mean values per variable over the time period 2010–2017.
Source: Ministério da Saúde, IGBE and authors' calculations.

Appendix B – Figures

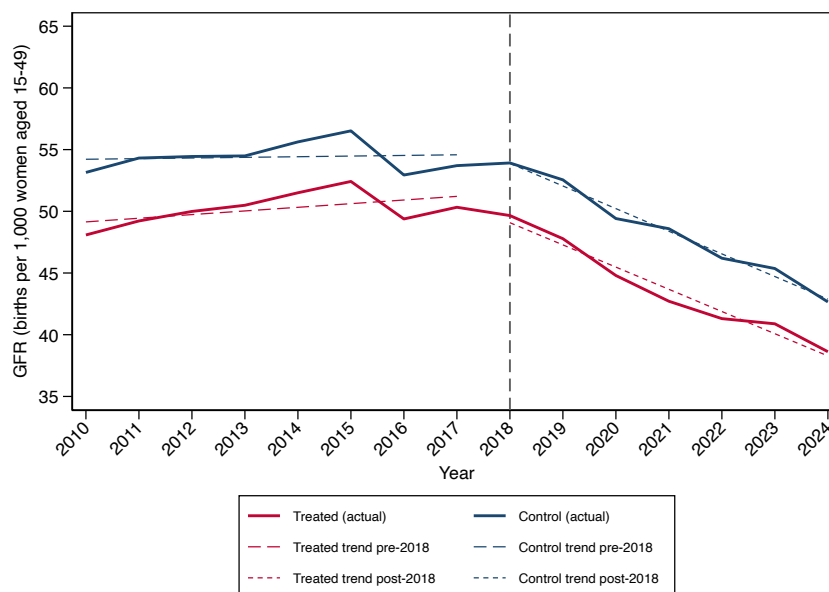


Figure 10: Treated- & Comparable Large Municipalities, Annual GFR 2010–2024

RC3: Ten treated municipalities and ten more comparable large non-treated municipalities. The dashed, vertical black line represents the treatment year 2018, while the red and blue dashed lines show fitted lines for the pre- and post-2018 periods, respectively. We can note a downward sloping trend for both treated and ten comparable control municipalities.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

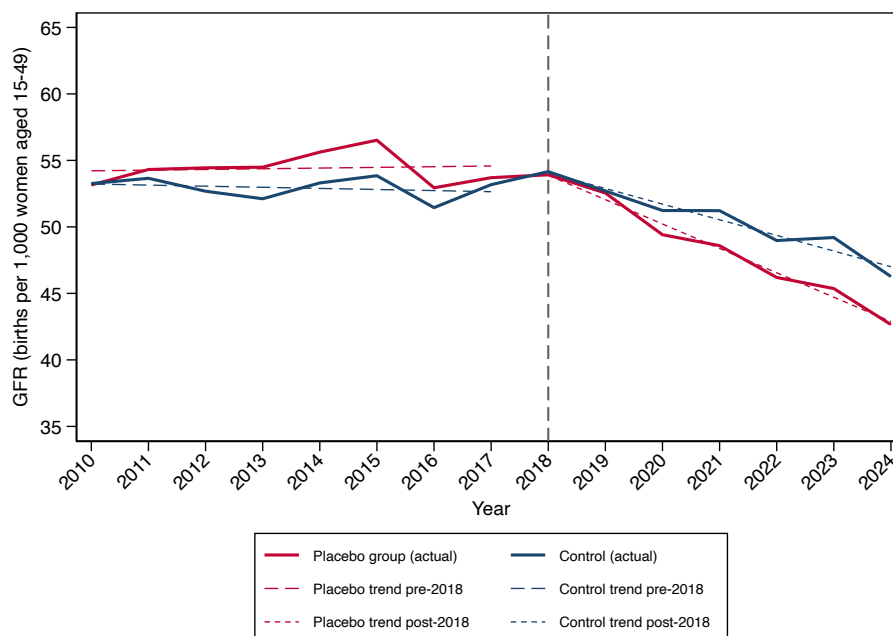


Figure 11: Placebo Sample & Remaining Control Municipalities, Annual GFR 2010–2024

RC4: Ten more comparable large non-capital municipalities and all remaining control municipalities. Real treated capitals excluded. The dashed, vertical black line represents the treatment year 2018, while the red and blue dashed lines show fitted lines for the pre- and post-2018 periods, respectively. We can note a downward sloping trend for both placebo treated and control municipalities. However, the slopes seem to differ.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

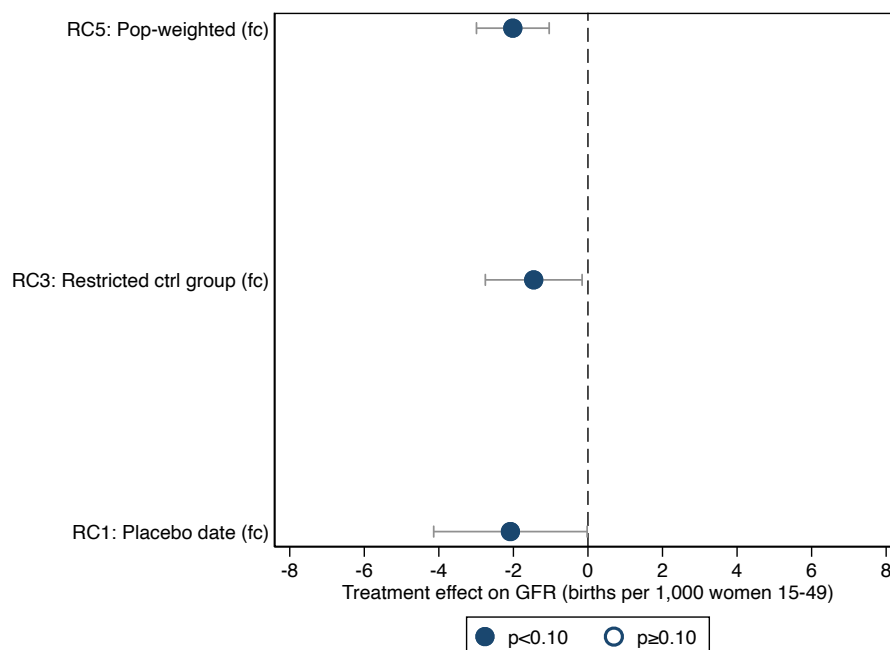


Figure 12: Robustness Checks – DiD Estimates

Point estimates with 95 percent confidence intervals where the outcome variable is GFR. Full controls. Municipality fixed effects and year fixed effects. Red circles illustrate a negative estimate.

Source: Ministério da Saúde, IBGE and authors' calculations.

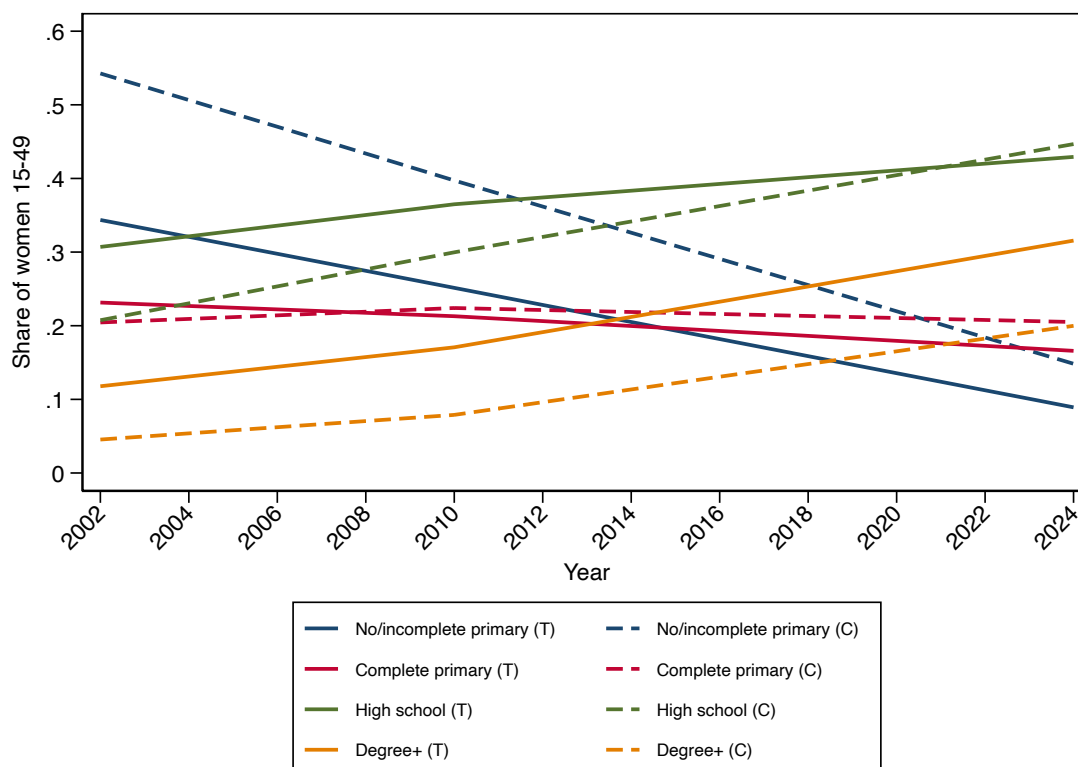


Figure 13: Education Shares 2002–2024

Solid lines show treated municipalities, dashed lines show control municipalities. Linear interpolation has been conducted between census anchor years, with linear extrapolation for the years 2023 and 2024.

Source: IBGE (n.d.e, n.d.f, n.d.g).

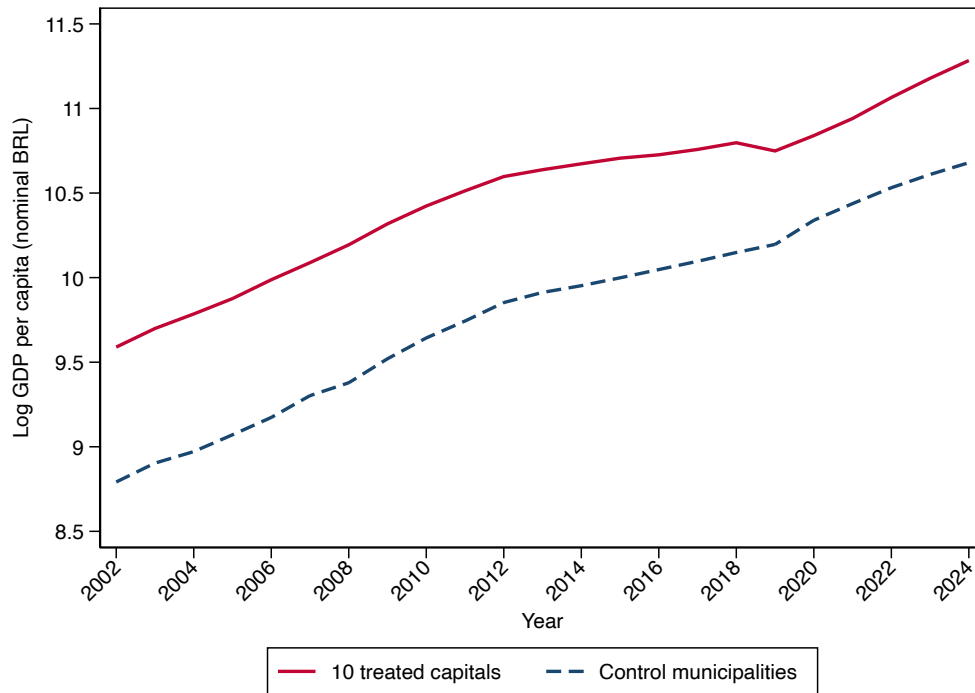


Figure 14: Log GDP per Capita 2002–2024

The data show population weighted means, where solid lines show the ten treated municipalities and the dashed line is the control municipalities. We can observe that the ten treated municipalities have had a higher GDP per capita throughout the entire time frame and that each of them seems to have developed positively in a similar trajectory. The values for the years 2023–2024 have been extrapolated from the 2021–2022 trend.
Source: IBGE (n.d.c, n.d.d).

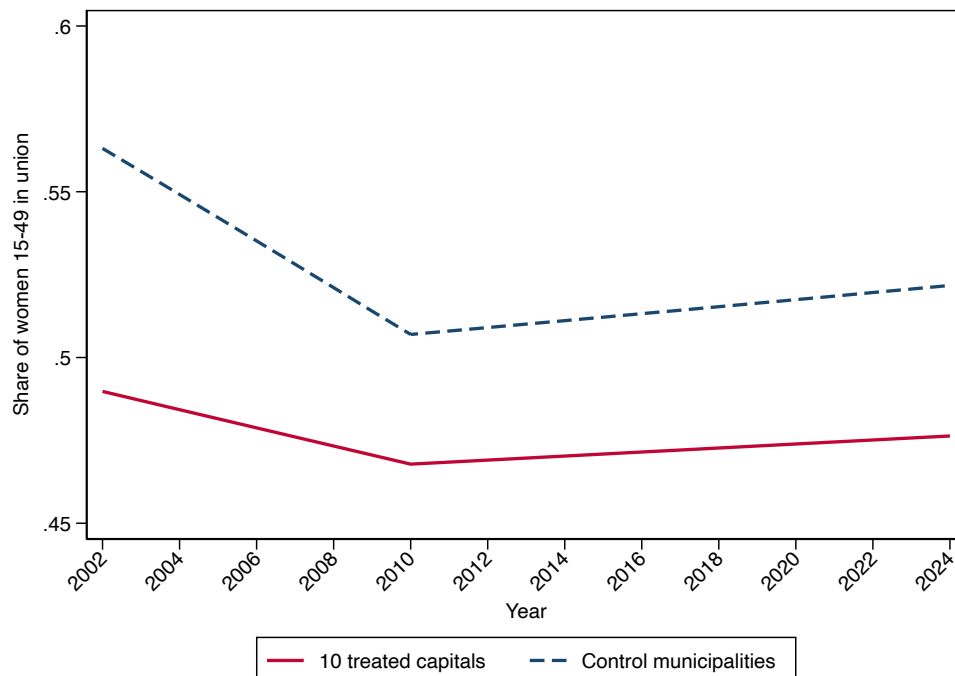


Figure 15: Union Rate 2002–2024

Share of women aged 15–49 living with a partner. The solid line shows the ten treated municipalities, and the dashed line shows the control municipalities. Linear interpolation has been conducted between census anchor years.
Source: IBGE (n.d.h, n.d.i).

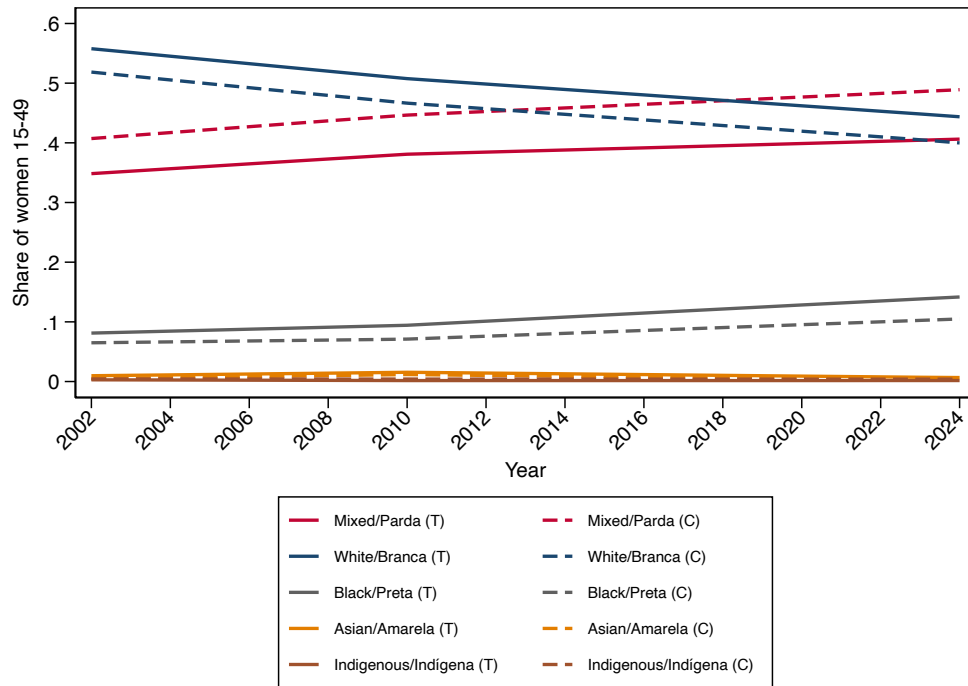


Figure 16: Racial Composition of Women aged 15–49 2002–2024

Share of women aged 15-49 who identify with an official racial category according to Brazilian statistical authorities. The solid line shows the ten treated municipalities, and the dashed line shows the control municipalities. Linear interpolation has been conducted between census anchor years. Extrapolation has been done for 2023-2024 from the 2022 census.

Source: IBGE (n.d.m, n.d.n, n.d.o).

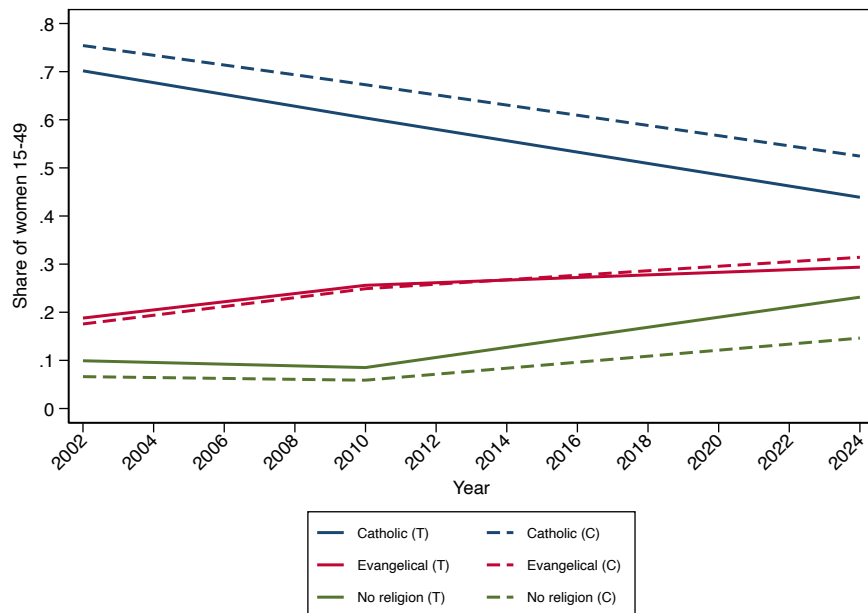


Figure 17: Religious Composition 2002–2024

Share of the population who identify with a religious creed. The solid line shows the ten treated municipalities, and the dashed line shows the control municipalities. Linear interpolation has been conducted between census anchor years. Extrapolation has been done for 2023-2024 from the 2022 census. We can note a significant change in the shares of the three most common religious identifiers in Brazil, with Catholicism losing shares to both Evangelicals and non-religious self-identification.

Source: IBGE (n.d.j, n.d.k, n.d.l).

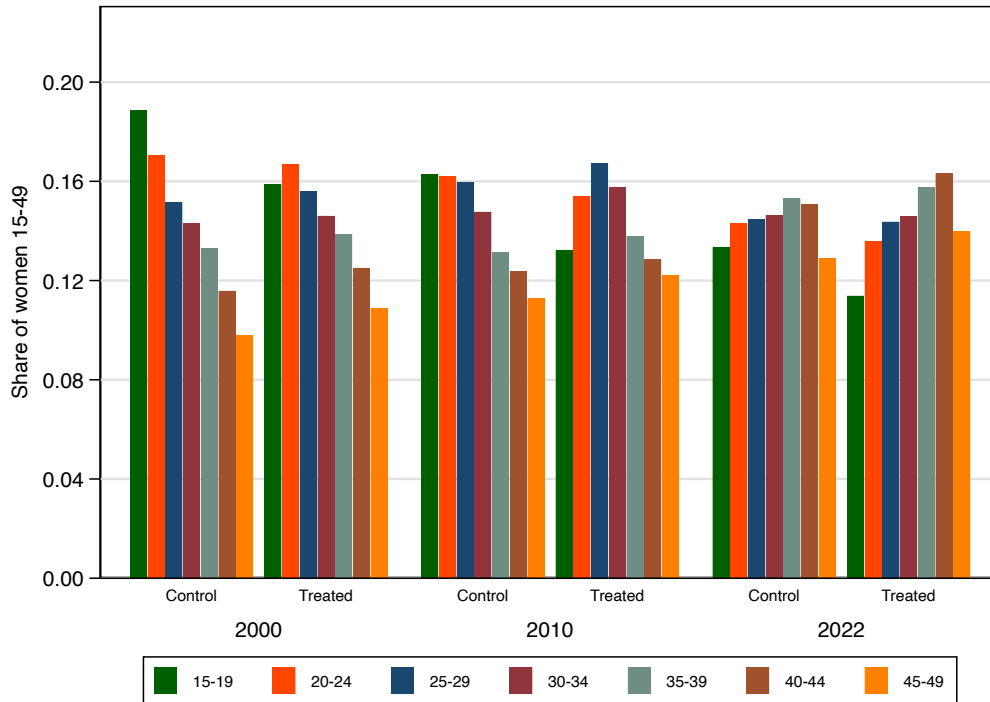


Figure 18: Age Distribution of Women aged 15-49

Each bar shows the percentage of women 15-49 belonging to that age group according to the 2002, 2010 and 2022 Brazilian censuses. We can note that with the passage of time between the 2000 and 2022 censuses more women belong to older age ranges, mirroring the ageing phenomenon of Brazil as a whole.

Source: IBGE (n.d.a, n.d.b).

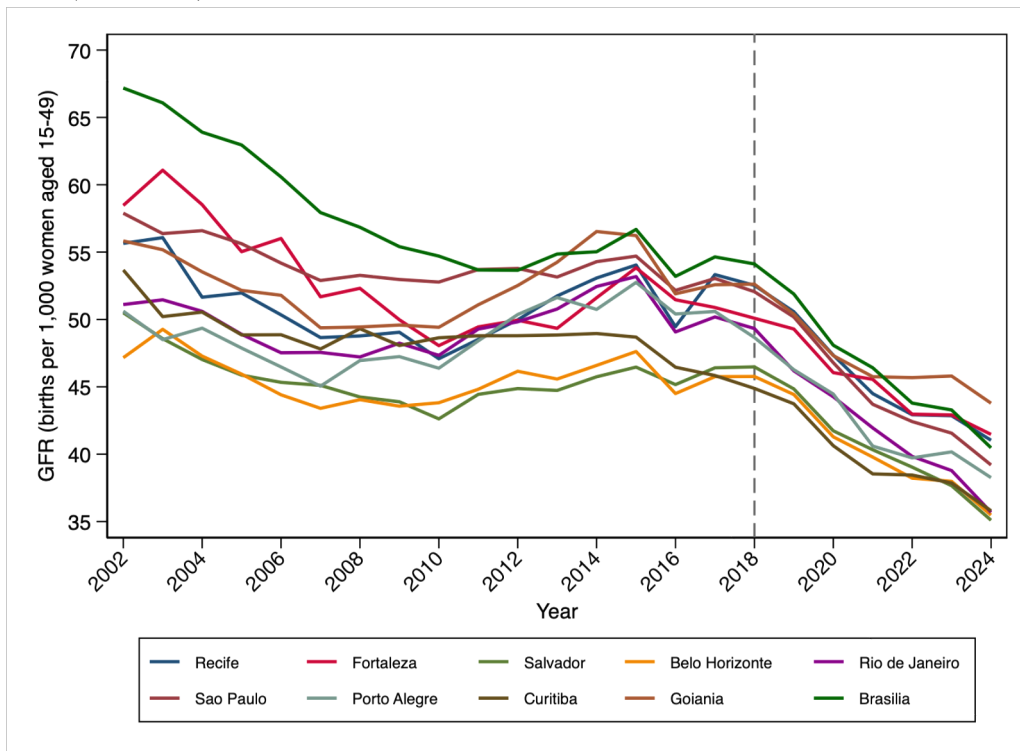


Figure 19: Annual GFR Treated Capitals 2002–2024

Monthly GFR average times 12. The dashed vertical line shows the 2018 treatment year. We can note a convergence in GFR with time, and that the GFR was decreasing both before and after the treatment year.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

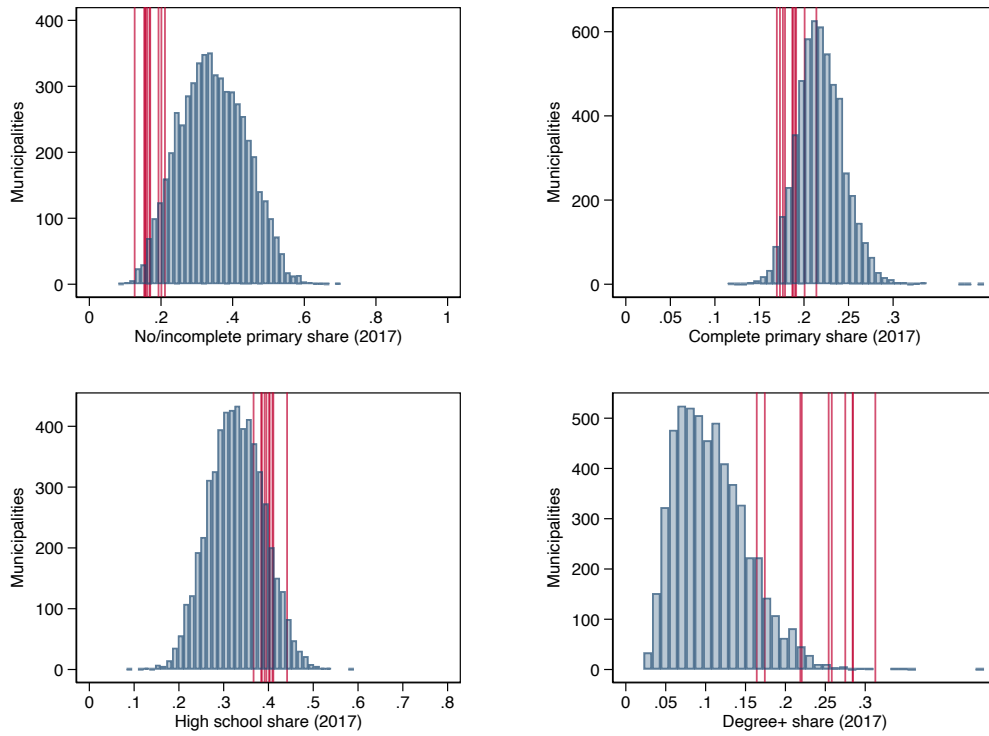


Figure 20: Education Share Distribution in 2017

The blue boxes show the control municipalities, red lines show the ten treated municipalities with their respective actual values. We can see that in 2017, the year before the treatment in 2018, the treated municipalities had a higher share of women with a higher level of education compared to the control municipalities. Source: IBGE (n.d.e, n.d.f, n.d.g).

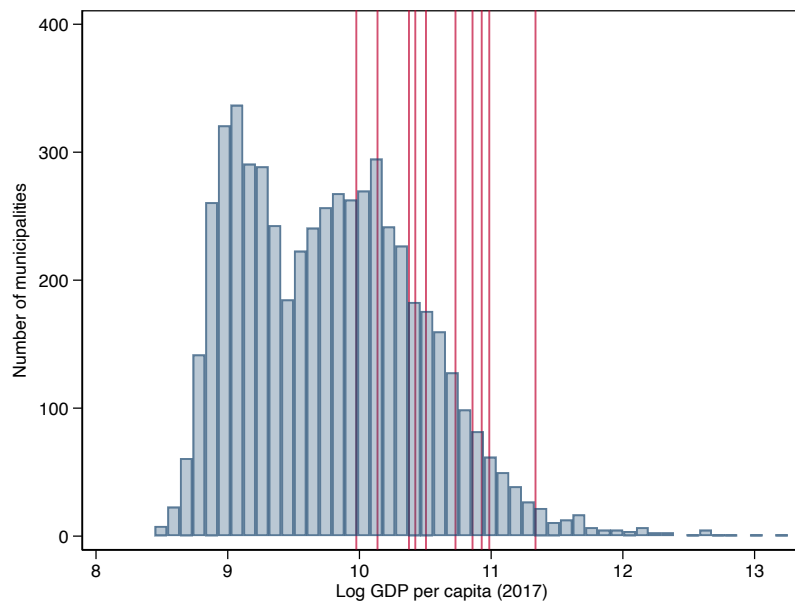


Figure 21: Log GDP per Capita in 2017

The blue boxes show the control municipalities, red lines show the ten treated municipalities with their respective actual values. We can see that in 2017, the year before the treatment in 2018, the treated municipalities overall had a higher GDP per capita compared to most control municipalities, but there are quite a few control municipalities that are wealthier than the ten treated ones. We can also note two humps for most of the control municipalities, where many are clustered around either a lower- or middle GDP per capita level. Source: IBGE (n.d.c, n.d.d).

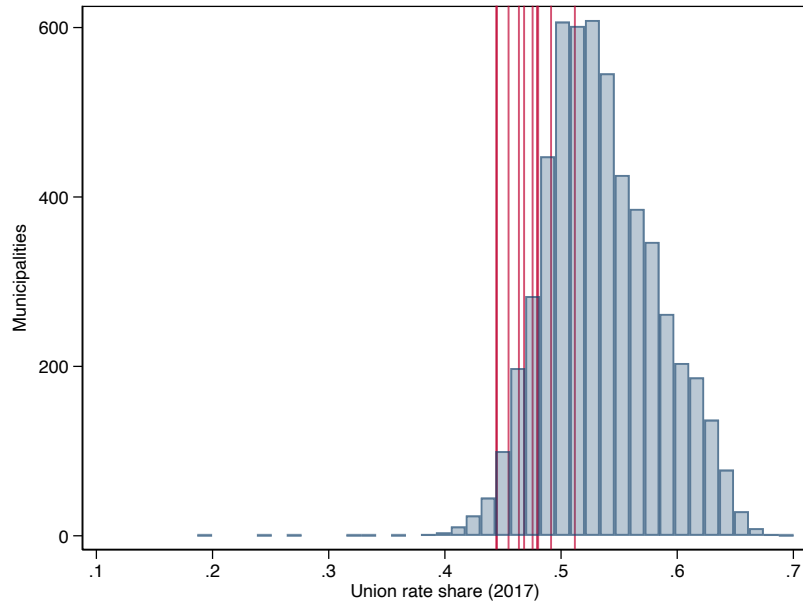


Figure 22: Union Rate Distribution in 2017

The blue boxes show the control municipalities, red lines show the ten treated municipalities with their respective actual values. We can see that in 2017, the year before the treatment in 2018, the treated municipalities overall had a lower union rate than most control municipalities, indicating a higher share of single people.

Source: IBGE (n.d.h, n.d.i).

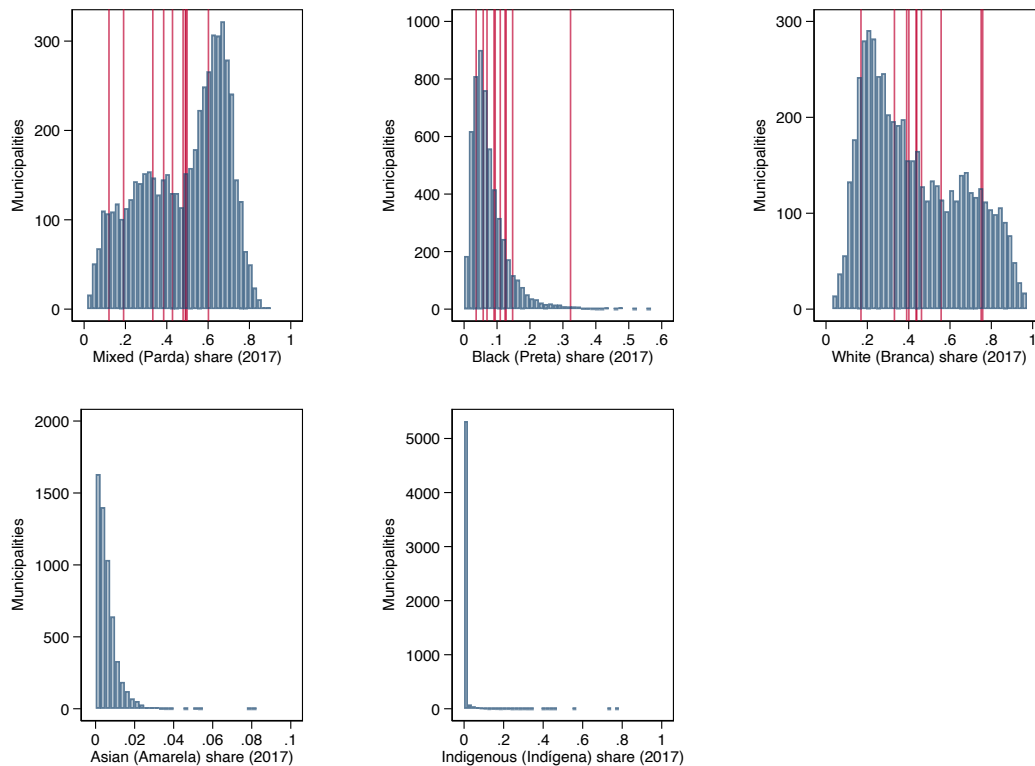


Figure 23: Racial Composition Distribution in 2017

The blue boxes show the control municipalities, red lines show the ten treated municipalities with their respective actual values. We can see that in 2017, the year before the treatment in 2018, the racial makeup of the treated and control municipalities are quite varied. We can also note that certain racial categories are more or less clustered in specific municipalities around Brazil.

Source: IBGE (n.d.m, n.d.n, n.d.o).

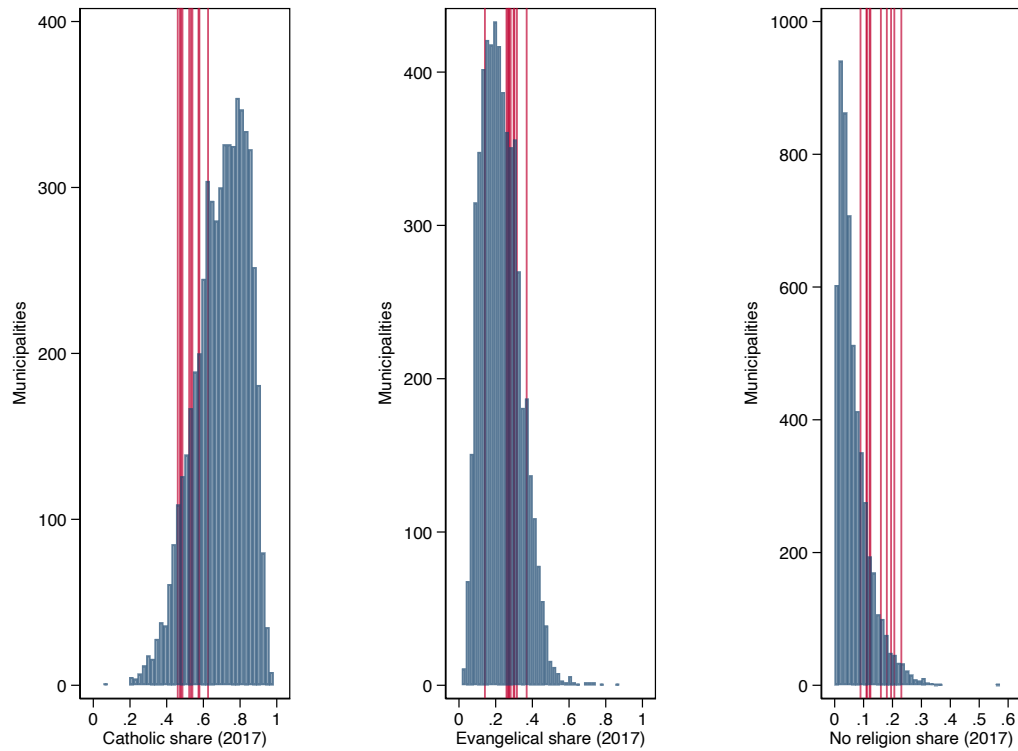


Figure 24: Religion Share Distribution in 2017

The blue boxes show the control municipalities, red lines show the ten treated municipalities with their respective, actual values. We can see that in 2017, the year before the treatment in 2018, the ten treated municipalities had a higher share of Evangelicals and non-religious, but a lower share of Catholics compared to the control municipalities.

Source: IBGE (n.d.j, n.d.k, n.d.l).

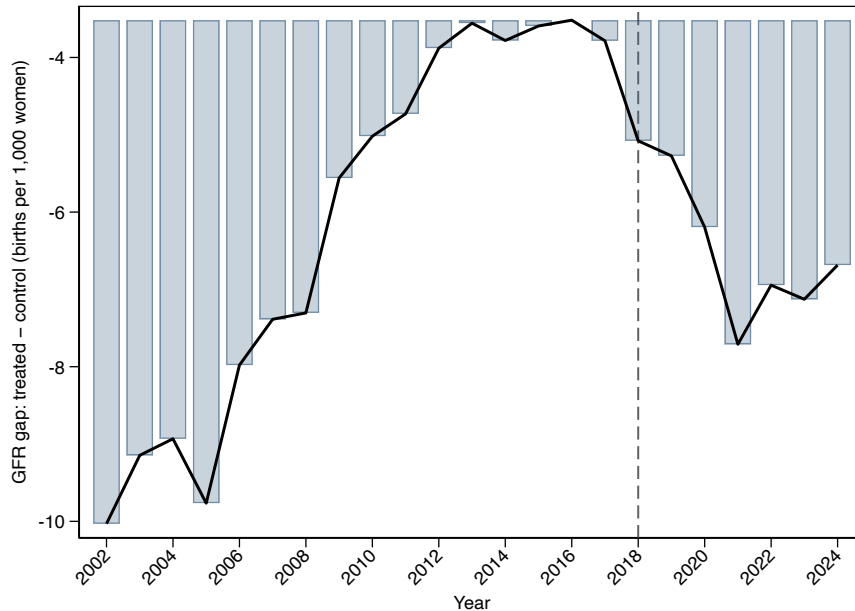


Figure 25: Difference in GFR between Treated and Control Municipalities 2002–2024

Population weighted mean differences. Using the control mean GFR, we can see that the treated municipalities consistently had a lower GFR between 2002–2024. However, the gap narrowed up until around 2016, then a greater divergence occurred in the years after.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

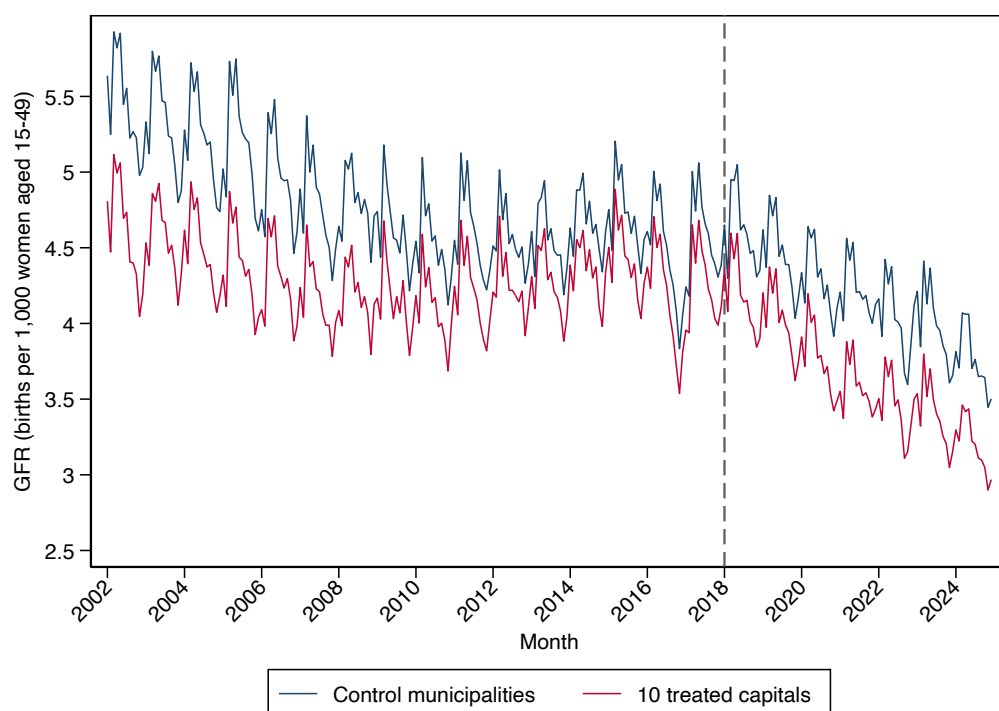


Figure 26: Monthly GFR Treated and Control Municipalities 2002–2024

Monthly GFR. Dashed vertical line show the 2018 treatment year. We can note a convergence in GFR with time between the ten treated and control municipalities.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

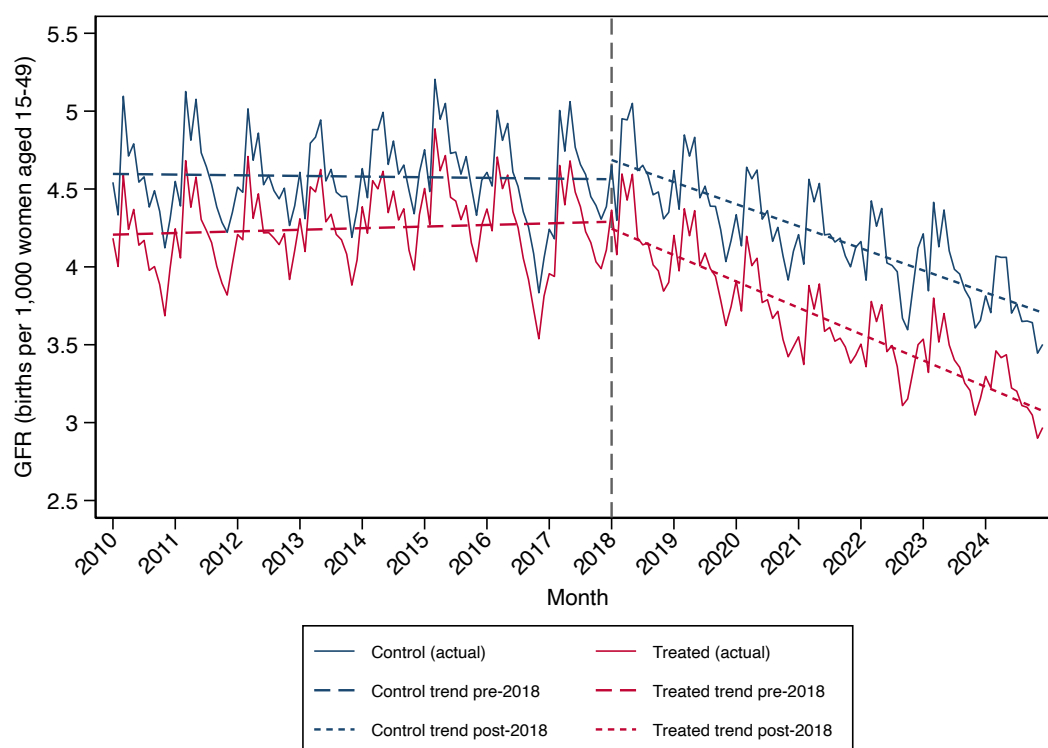


Figure 27: Monthly GFR Treated and Control Municipalities 2010–2024

Monthly GFR. Dashed vertical line show the 2018 treatment year. We can see a parallel trend before the 2018 treatment between treated and control municipalities.

Source: Ministério da Saúde (2026) and IBGE (n.d.a, n.d.b).

Appendix C – STATA, Data & Contact

In the link below, you can access two Kaggle webpages. There you will find the seven STATA Do-files we used for our work, and the data from IBGE and SINASC that we compiled using the Brazilian CSV format.

Dataset

<https://www.kaggle.com/datasets/sethengellau/fertility-decision-making-under-risk-brazil-data>

STATA Do-Files

<https://www.kaggle.com/code/sethengellau/stata-do-files>

Email

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Appendix D – AI Statement

During the course of our work, we have utilized the AI tools listed in Table 12 below. All outputs of the AI were critically reviewed and fact-checked to ensure accuracy and alignment with our own understanding. The use of generative AI was limited to supporting role and did not replace our own analysis. Lund University’s guidelines and this course’s guidelines on the use of generative AI were checked beforehand, and the tools were used accordingly.

Table 12: AI Tool and Usage Description

<i>AI Tool (Company)</i>	<i>Description of Usage</i>
ChatGPT (OpenAI)	• Used for grammar correction and language review to improve clarity and readability of our text • Used for providing alternative phrasing of our text • Used for searching for relevant articles
Claude (Anthropic)	• Used for grammar correction and language review to improve clarity and readability of our text • Used for providing alternative phrasing of our text • Used for coding assistance, particularly in data cleaning and formulating commands for data analysis • Format the reference list using the LUSEM citation guide and list in alphabetical order • Generate Figure 1 based on TFR data from WPP. As the map is generated using AI, the authors of this paper do not take any stance as regards to potential territorial disputes that is reflected on the mapping • Generate Figure 2 based on treated municipalities identification from SBRA
Google Translate (Google)	• Used for translating Brazilian statistical websites from Portuguese to English
Grammarly (Grammarly)	• Used for generating alternative phrasing suggestions to enhance language, grammar, and style of our writing
NotebookLM (Google)	• Used to summarize articles to gain an initial overview of the literature, group sources into thematic areas, and to search for keywords to trace specific ideas or arguments
Speechify (Speechify)	• Used to have our text read out loud by an AI voice agent, to check the flow of our text and the comprehension of our sentence structure