With a Little Help from my Friends: Unlocking Better Outcomes through Coordination in Public Health

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Abstract

This paper assesses the importance of coordination and integration among local agents and governments in the health sector by investigating the case of the Rede Cegonha (RC) Program, a Brazilian public health initiative focused on enhancing maternal and child health. Based on a difference-in-differences (DiD) design, the paper exploits the staggered implementation of the program and its two forms of adhesion: Regional Adhesion, targeting municipalities according to epidemiological and demographics criteria and requiring greater coordination among health agents; and Isolated Adhesion, allowing municipalities to participate individually via simple enrollment and without multi-agent coordination. The analysis covers various dimensions of the health sector, including human and physical resources, prenatal care, maternal displacement for childbirth, distances traveled, health procedures during pregnancy and birth, and postnatal health outcomes for infants. The findings indicate that the RC Program, by fostering better coordination among health agents, led to adequate resource allocation, improved prenatal care, and enhanced newborn and mother health outcomes.

1 Introduction

Coordination across sectors and levels of government is critical to optimizing public investment and ensuring high-quality delivery and services(OECD, 2023), a principle highly relevant in the context of maternal-child health care networks. In Brazil, changes in the maternal-child healthcare network over the last decades highlight the importance of coordination, involving collaboration across different health departments and agents (horizontal coordination) and interactions between national and sub-national governments (vertical coordination). Drawing on this idea, the Ministry of Health of Brazil launched the *Rede Cegonha* Program[1] in March 2011, as part of a strategic plan developed in 2010, which aimed to establish care networks to reduce the high level of fragmentation in the Brazilian health system and increase management efficiency and health production effectiveness for maternal-child health. As governments' challenges evolve, policy coordination persists as a longstanding matter that has grown increasingly crucial Peters (2018). This involves addressing the root causes of coordination challenges, exploring potential mechanisms to improve coordination among local governments, and recognizing the limits of governance coordination in addressing local and national challenges.

Analyzing changes in Brazilian administrative boundaries, Dahis and Szerman (2024) suggests that creating smaller government units, such as municipalities, through reforms aimed at devolving power to local governments has resulted in significant long-term benefits. Their study highlights that voluntary redistricting increases the size of the public sector, enhances public service delivery, and stimulates economic activity in newly formed local governments. The findings show that the decentralization of decision-making promotes local development, particularly in disadvantaged areas. However, Brazil is characterized by numerous small municipalities spread across its vast territory, which often lack the scale to justify substantial healthcare infrastructure in most areas. This fragmentation poses a

[1]Established by Ordinance MS/GM No. 1.459/2011 and implemented by Ordinance No. 4.279 of 12/30/2010.

challenge for providing consistent and high-quality maternal-child healthcare services and well-equipped healthcare facilities. Exploring the impacts of changes in the organization of maternal-child healthcare networks in Brazil offers unique insights into effectively managing and delivering healthcare in regions with limited infrastructure and resources, where the benefits from coordination could be substantial. Additionally, as explored by Cejudo and Michel (2017), achieving a full theoretical and empirical understanding of policy coordination and integration remains a challenge in the literature, highlighting its importance for policy design and the strategic and administrative decisions aimed at solving complex problems.

Addressing health coordination in a population-fragmented country divided into numerous small municipalities presents challenges such as unequal access to resources, varied healthcare infrastructure, and inconsistent policy implementation across local governments. In this context, Brazil offers a unique setting for studying the impacts of changes in the organization of maternal-child healthcare networks. First, Brazil's municipalities possess substantial administrative and political decision-making power. Second, the country's Unified Health System (SUS), one of the largest public health systems globally, provides a unique opportunity to analyze responses to organizational changes within a publicly funded healthcare model. Third, the vast size of Brazil's territory adds another layer of complexity, necessitating effective coordination and management of healthcare services across diverse and geographically dispersed regions, making it an ideal setting to study the logistics and scalability of healthcare interventions. Fourth, Brazil's diverse population and significant socioeconomic disparities allow for an examination of how healthcare changes impact different segments of society, providing insights into addressing health inequities. Finally, recent healthcare reforms, such as the Rede Cegonha Program, aimed at improving efficiency, accessibility, and quality, offer valuable data on their effectiveness and challenges.

The RC Program emphasizes comprehensive maternal and child care, providing coordinated health services from prenatal stages through postnatal care. This initiative involves a

range of health professionals working together over an extended period to ensure the well-being of both mother and child. Its services range from sexual and reproductive planning to postpartum care and early childhood development. The primary objective of this program is to combat infant, fetal, and maternal mortality while improving the quality of care to ensure access, reception, and effectiveness. Brazil has shown significant improvement over the past decades regarding maternal and infant health indicators. Despite this progress, there is still much to be done. The infant mortality rate dropped from 47 deaths per 1,000 live births in 1990 to 11.9 deaths per 1,000 live births in 2019. However, there are substantial regional and socioeconomic disparities in infant mortality. Additionally, the country continues to struggle with issues related to child malnutrition, low birth weight, and lack of access to adequate healthcare. Thus, Brazil's high rates of maternal and infant mortality make it a crucial case study for developing strategies to reduce these rates and improve health outcomes, with lessons that can be applied globally to enhance health systems.

The unequal distribution of health resources across the country contributes to disparities in maternal and child health. Brazil is marked by significant economic and social inequality, and the distribution of health resources reflects this disparity. Some regions and municipalities have access to more resources and healthcare services than others, resulting in inequalities in the quality of services and the ability to meet the health needs of women and children. To address the pervasive inequalities in the country's public health system, the RC Program has devised a nuanced approach to its accession process, tailored to the diverse needs of municipalities and regions. The program offers two modalities of accession: Isolated adhesion and Regional adhesion, each designed to match the varying levels of priority and resources in different regions.

Facilitated Adhesion is intended for municipalities outside priority health regions (based on epidemiological, demographics, and socioeconomic factors), enabling them to implement only specific components of the Rede Cegonha Program, particularly prenatal and compre-

hensive child healthcare. In contrast, Regional adhesion is aimed at municipalities within prioritized health regions, ensuring the full implementation of all four components of the RC Program and requiring more coordination. These components include prenatal and comprehensive child healthcare, full care during delivery, birth, and puerperium, as well as logistical support, transportation, and an expanded network. This last one carries the network aspect of the program that comes in its name. The logistics system for sanitary transport and regulation is designed to ensure that services are accessible in a timely and high-quality manner. Pregnant women will be assessed for risk classification during care and may receive treatment at the same facility or be referred to another through the regulation center. The initial reception staff is responsible for ensuring that the pregnant woman receives proper care, either on-site or at another facility. It is this aspect of RC and the municipalities' ability to coordinate with each other to provide it that is what this paper is interested in.

This strategic approach acknowledges the unique challenges faced by different regions and strives to provide comprehensive healthcare nationwide. Moreover, the intention behind the differentiation in treatment is to prioritize areas with the worst socioeconomic and health indicators to achieve a more immediate impact in the regions that need it most. This reflects the principle of equity the Ministry of Health aimed for.

In this paper, we use data from several administrative data from the Ministry of Health: (i) the Live Birth Information System (SINASC); (ii) the National Register of Health Facilities-CNES; (iii) the Ambulatory Information System (SIA); and (iv) the Mortality Information System (SIM). Based on Callaway and Sant'Anna (2021) method, we compare Regional adhesion with Isolated Adhesion to assess the effects of coordination in a differences-in-differences analysis. This strategy allows for a detailed examination of the program's effects and assessing the effects of coordination. We compare the outcomes of municipalities that adopted the program with those that had not yet been treated, exploring the staggered adhesion of the program from 2011 to 2013 and the different timing of the

public health intervention. The availability of detailed data allows for a comprehensive evaluation of how changes in the healthcare network and coordination influence health inputs and outcomes for mothers and children in Brazil. This study assesses the impact of these changes, focusing on how enhanced coordination can improve service delivery and outcomes in maternal-child healthcare. By doing so, we investigate how multi-agent coordination generates synergies and efficiencies in the healthcare sector.

The findings reveal that regional adhesion consistently yields more positive outcomes across a variety of health metrics compared to isolated adhesion.

The direct effect of this difference in adhesion of the program is directly seen in the difference between the effects of Rede Cegonha on health outcomes. In terms of mortality, we find that regional adhesion leads to a decrease in maternal deaths at all stages of the childbirth process, from pregnancy to puerperium, while there are no similar results for isolated adhesion. We find that the regional adhesion ones show a stronger decrease in the fraction a low weight births. One key finding here is that regional adhesion municipalities show a strong significant reduction in the fraction of low APGAR index births, while such an effect is not observed for isolated adhesion municipalities.

That is enough evidence to believe that, among the components of the RC program that were present for regional adhesion and not present for isolated adhesion, some must have had significant positive effects on maternal and newborn health. Still, it isn't straightforward that these effects necessarily came from better coordination and logistics.

To assess the mechanisms behind the improvements in maternal and neonatal health, we investigate the difference between the effects of Regional and Isolated RC adhesion on health services accessibility. We find that for both adhesion groups, there was an improvement in hospital accessibility and a reduction of deliveries at home. We find the regional municipalities improve their integrability with other municipalities, having more women leaving the municipality of residence for delivery, even though the distance traveled for such trips is not

affected. We find a consistent effect of improvement in accessibility of hospital beds related to obstetrics and neonatal care, as well as for ICU beds. As for prenatal appointments, although we find that isolated municipalities increased more than regional ones the fraction of women who had more than seven prenatal appointments during pregnancy, we find that regional municipalities reduced strongly the number of women who had no prenatal appointment, with more women doing 1 to 6 prenatal appointments in these municipalities. This underscores one key feature of regional adhesion of improving extremely poor healthcare conditions more than improving overall healthcare. We also find that regional municipalities reduced the fraction of women who did a cesarean delivery, with a stronger effect looking at low-risk pregnancies, highlighting that regional municipalities are better at risk classifying mothers, providing the option of natural delivery for those who can and want. Finally, we also find increasing effects of accessibility to maternal and neonatal procedures. The regional aspect of Rede cegonha seems to have been important in the accessibility to Complete Blood Count, Human Chorionic Gonadotropin Dosage (HCG, Beta HCG), and Consultation for Growth and Development Monitoring (Pediatrics).

The evidence strongly supports that regional adhesion of Rede Cegonha not only improves outcomes more consistently across various health indicators but also enhances the overall effectiveness of healthcare service provision. This suggests that healthcare initiatives benefit significantly from a coordinated regional approach, ensuring a broader impact and more efficient resource utilization within maternal and neonatal healthcare services.

We contribute to the literature first by highlighting the effects of coordination between small municipal units in the form of health regions on accessibility to public health and ultimately on health outcomes. It is not vast the literature covering the effect of regionalization/decentralization (Alves et al., 2013) ,(Cavalcante and Lotta, 2021), (Rashidian et al., 2014). (Zhong, 2011) analyze the effect of decentralization on equity of access to healthcare in Canada, finding a reduction in utilization inequality while (Costa-Font and Pons-Novell,

2007) find no effect on the difference of access between different regions but an increase in inequality inside the regions. Nonetheless, little is known about the role played by coordination in the effects of health policies and interventions. This highlights the need for further investigation into how better integration and collaboration can enhance public service provision and welfare, in this case maternal and child health provision and health outcomes.

We also contribute to the literature by providing an important policy valuation highlighting the relevance of coordination and logistics. The research conducted on the RC Program has so far been limited to analyzing its implementation (Gama et al. (2021a)) and the challenges of its application in the network of the Brazilian Unified Health System (SUS) (Santos Filho and Souza (2021)), with different focuses, such as the assessment of delivery and birth care practices in RC maternity hospitals (Vilela et al. (2021)) and the degree of implementation of its main actions (Bittencourt et al. (2021)). Also, there are papers evaluating the role of socioeconomic inequities in access to RC Program and technologies related to childbirth (Alves et al. (2021), Leal et al. (2021a), Thomaz et al. (2021), Leal et al. (2021b)), adequancy of practices for different types of risk during the pregnancy and delivery (Viellas et al. (2021), Gomes et al. (2021), Ayres et al. (2021)), improvement of the physical infrastructure and human resources of maternity hospitals (Miranda et al. (2021), Gama et al. (2021b), Silva et al. (2021)), among other topics directly connected with the implementation and monitoring of RC Program.

Finally, it is well-documented in the literature that prenatal health conditions and early life events significantly impact various cognitive and socioemotional outcomes throughout life Attanasio et al. (2022); Goodman-Bacon (2021), which are key dimensions of human capital. Consequently, these factors have garnered considerable attention in the economic literature on child development. Much of the focus is also concentrated on the effects of prenatal care on the future outcomes of children Almond and Currie (2011); Currie and Almond (2011), as well as on the importance of adequate care during the prenatal period and childbirth,

and the availability of hospital practices and infrastructure Avdic et al. (2024); Fischer et al. (2022); Card et al. (2023).

The paper is organized as follows. Section 2 describes the details of the Brazilian context in which RC Program was implemented. Section 3 provides detailed information about the Data used in the paper. Section 4 presents the empirical strategy. Section 5.1 presents our estimates of the effects of RC Program and Section 6 concludes.

2 Institutional Context

The Unified Healthcare System (SUS) in Brazil was established as part of an ambitious effort to address significant health disparities and improve access to comprehensive health services across the nation. The SUS emerged from a context marked by persistent and emerging infectious diseases, high maternal and child mortality, and new challenges driven by various transitions. These transitions included the migration from rural to urban areas, leading to the disorganized growth of municipalities with limited infrastructure (CANO, 1988), the opening of the Amazon frontier in the 1980s (De Castro et al., 2006), and the epidemiological transition characterized by increases in mortality and morbidity from non-communicable diseases (Barreto et al., 2011; Schmidt et al., 2011).

The SUS was instrumental in narrowing health inequalities by improving coverage and access to health care across Brazil. However, significant variations persisted between municipalities in terms of infrastructure, human resources, management capacity, and access to effective healthcare services (França et al., 2016; Facchini et al., 2008). The implementation of the SUS began after the enactment of Laws 8080 and 8142 in 1990, which incorporated the principles of universality, integrality, decentralization, and community participation. This shift transferred responsibility and funds for health care provision from the federal to state and municipal governments, reorienting political power and responsibility to local governments. Decentralization was accompanied by the creation of tripartite and bipartite inter-

managerial commissions, with federal, state, and municipal governments participating in shared decision-making on health policies, and health conferences and councils serving as mechanisms for social participation (Castro et al., 2019).

As part of the decentralization process, Brazilian municipalities were required to create health departments to administer healthcare facilities and assume responsibility for co-financing health programs and managing healthcare services. The 5570 municipalities in Brazil are responsible for providing primary health care (PHC) and health surveillance, ensuring patient access to general and specialized hospital care, including emergency and mental health services (Giovanella et al., 2012). Decentralization also involved the creation of health regions, the development of guidelines for integrated health planning, and the establishment of regional management boards coordinated by state health secretariats in partnership with municipal authorities (Viana et al., 2017).

The implementation of the SUS marked a shift towards a comprehensive model of health care, characterized by the rapid expansion of PHC centers and the development of health networks for mental health services, emergency care, and specialized outpatient services. The community health workers program was established in 1991 to serve the poorest areas in northeastern Brazil, followed by the family health program in 1994. This program set standards for family health teams, which include a general physician, a nurse, a nurse assistant, and community health agents who provide acute services, health promotion, disease prevention, chronic disease management, and maternal and child services. Family health teams became the core of PHC in the SUS, with significant expansion in subsequent years, despite challenges related to inadequate staffing, which hampered equitable expansion (Castro et al., 2019).

At the end of 2010, the Ministry of Health established the organization of Health Care Networks (RAS) within the SUS through Ordinance 4.279 on December 30, 2010. This policy aimed to ensure comprehensive care and led to the creation of five healthcare networks: Rede

Cegonha (RC), Urgent and Emergency Care Network (RUE), Psychosocial Care Network (Raps), Care Network for People with Disabilities (RCPD), and Health Care Network for People with Chronic Diseases (RPDC).

In this study, we focus on the impacts of Rede Cegonha (RC). The RC is a strategy designed to ensure the effectiveness of the maternal and child care network, aiming to guarantee women's rights to reproductive planning and humane care during pregnancy, childbirth, and the postpartum period. Additionally, it ensures children's rights to a safe birth and healthy growth and development. The focus of this initiative is to promote the implementation of a new model of care for women's and children's health, emphasizing childbirth, birth, growth, and child development. It aims to organize the Maternal and Child Health Care Network, ensuring access, welcoming, and problem-solving capabilities, and reducing maternal and child mortality with an emphasis on the neonatal component.

The RC comprises four components: prenatal care, childbirth and birth, postpartum and comprehensive child health care, and a logistics system that includes sanitary transportation and regulation. (Marques et al., 2015) outline the details of each of the components of the program:

I) **Prenatal Care:** Initially, prenatal care (PN) involves early identification of pregnant women, risk and vulnerability classification, integrated consultation, prenatal exams, educational programs, linking the pregnant woman to the place of birth, and the implementation of dental consultation.

II) **Delivery and Birth:** Actions related to delivery and birth include ensuring sufficient obstetric and neonatal beds (ICU, intermediate care unit, and Kangaroo care) according to regional needs; maternity environments guided by Resolution of the Collegiate Directorate (RDC) No. 36/2008 of the National Health Surveillance Agency (ANVISA); health care practices based on scientific evidence, as per the 1996 World Health Organization document "Care in Normal Birth: a practical guide"; guaranteeing a com-

panion during reception, labor, delivery, and immediate postpartum; performing risk classification in obstetric and neonatal care services; encouraging the implementation of horizontal care teams in obstetric and neonatal care services; and encouraging the implementation of Management Collegiate in maternities and other co-management devices addressed in the National Humanization Policy. Ordinance GM/MS No. 11/2015 redefines the guidelines for the implementation and accreditation of the Normal Delivery Center (CPN) within the Unified Health System (SUS) for attending women and newborns at the time of delivery and birth, in accordance with the DELIVERY AND BIRTH component of Rede Cegonha and provides for the respective financial investment, maintenance, and monthly maintenance incentives.

III) **Puerperium and Comprehensive Child Health Care:** Regarding the puerperium, home visits are conducted in the first week after delivery, promoting, protecting, and supporting breastfeeding, and conducting a postpartum consultation between the 30th and 42nd day postpartum. In the context of the Rede Cegonha organization, this component includes promoting breastfeeding and healthy complementary feeding; monitoring the puerperal woman and child in primary care with a home visit in the first week after delivery and birth; actively searching for vulnerable children; implementing social communication strategies and educational programs related to sexual and reproductive health; preventing and treating STDs/HIV/AIDS and hepatitis; and providing guidance and offering contraceptive methods.

IV) **Logistics System: Sanitary Transport and Regulation:** Sanitary transport and regulation aim to ensure timely and quality access to services. Pregnant women, during care, will undergo risk classification and may be attended at the same unit or referred to another unit through the regulation center. The welcoming staff will be responsible for the pregnant woman until her care is guaranteed at another unit. In urgent situations, promoting access to safe transport for high-risk pregnant women, puerperal

women, and newborns through the Mobile Emergency Care Service - SAMU Cegonha, whose advanced support ambulances must be properly equipped with incubators and neonatal ventilators. It is important to highlight that Rede Cegonha is implemented with differentiated characteristics, adapting to the needs of each region. Therefore, it is essential for the Management Committee to prepare a report to understand these factors, which include political issues, epidemiological situations, financial, material, and human resources, and trained professionals, according to Ordinance No. 1.473, of June 24, 2011.

Given its specific characteristics, a tailored adhesion model was developed for this policy. To respect the principle of equity, as outlined in Ordinance MS/GM No. 1,459/2011, the Ministry of Health committed to gradually implementing the RC, prioritizing municipalities with high infant and maternal mortality rates, among other epidemiological and demographic criteria. Thus, two methods of joining the program were established: Facilitated adhesion and Regional adhesion. The first group targets municipalities not located within a priority Health Region, allowing for the implementation of specific program components, namely Prenatal Care, postpartum care, and Comprehensive Child Health Care. Regional Adhesion, on the other hand, is for priority municipalities and involves the full implementation of the Rede Cegonha.

Regional Adhesion

This initiative targets municipalities within health regions prioritized by the State Conductor Group of Rede Cegonha (GCE/RC) based on epidemiological and population criteria. The agreed-upon actions encompass the four components of Rede Cegonha:

Municipalities wishing to implement Regional Adhesion should contact the GCE/RC of their state to participate in discussions about which regions will be prioritized by this group.

Isolated Adhesion

Municipalities that are not part of a priority region can join the program through Isolated Adhesion. This provides access to the following program components:

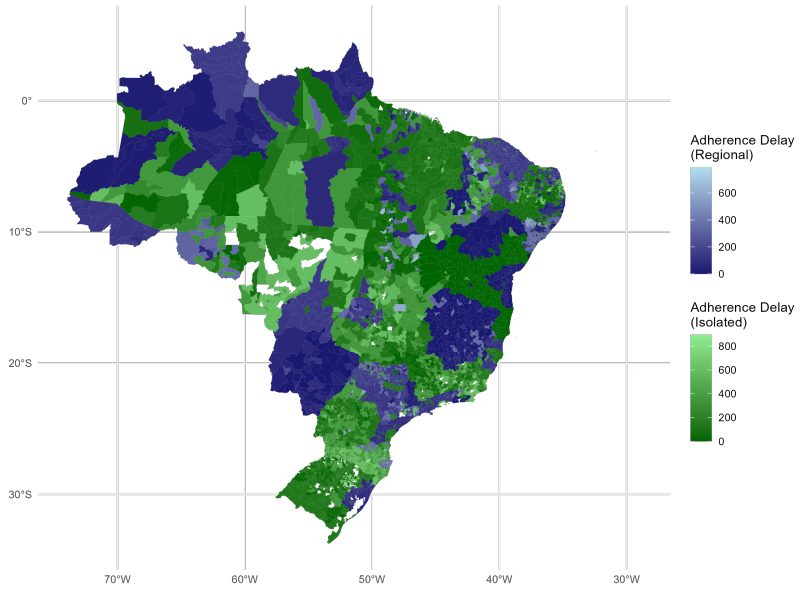
I) Prenatal care

II) Puerperium and comprehensive child health care

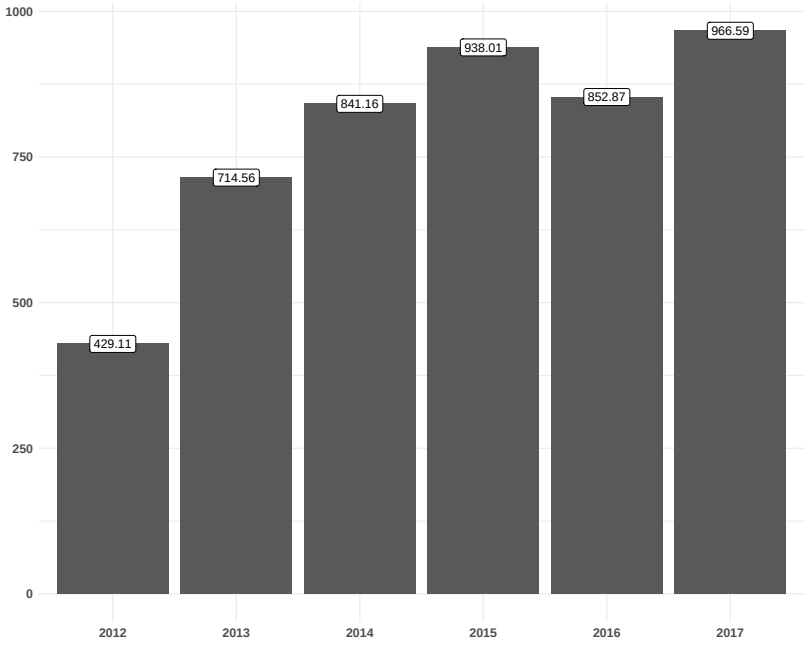
Figure 1 displays the adhesion of the municipalities over time.

Figure 1: Regional and Isolated Adhesion and Budget over time

(a) Regional and Isolated Adhesion



(b) Budget



Before this strategy of organizing Health Care Networks, the Brazilian health system was characterized by high levels of segmentation and fragmentation. This conclusion was reached through a study conducted by the Pan American Health Organization and the World

Health Organization in 2009, which was discussed at the 49th Directing Council during the 61st Session of the Regional Committee.

In Brazil, as in other American countries, segmentation is characterized by the co-existence of "subsystems with different forms of financing, affiliation, and provision, each specialized for different segments of the population based on their employment status, income level, ability to pay, and social position" (PAHO, CD49/16, 2009). This results in the reproduction of various inequalities within the health care system.

Fragmentation, in turn, consists ofThe (1) care that does not cover all stages, including prevention, diagnosis and treatment, rehabilitation, and palliative care; (2) lack of coordination between different levels of care; (3) discontinuity of services over time; and (4) provision of services that do not meet the needs of the population.

Both aspects contribute to the poor performance of health services and systems. Combined with these other factors, fragmentation can lead to "difficulties in accessing services, provision of low-quality technical services, irrational and inefficient use of available resources, unnecessary increases in production costs, and low user satisfaction with the services provided" (PAHO, CD49/16, 2009).

The Brazilian Ministry of Health itself has identified these problems and others. In an annex to the ordinance that establishes the organization of the Health Care Network within the SUS, there is a document outlining its guidelines. While advocating for the implementation of the policy and its value, the Brazilian health system is described as intensely fragmented. This can be observed through: "(1) significant care gaps; (2) insufficient, fragmented public financing and low efficiency in resource utilization, reducing the system's capacity to provide comprehensive health care; (3) inadequate configuration of care models, characterized by inconsistency between service provision and care needs (...); (4) weakness in workforce management with the serious problem of precariousness and shortage of professionals in number and alignment with public policy; (5) the dispersion of services across

municipalities; and (6) limited integration of Health Surveillance and Promotion into the daily routines of care services, especially in Primary Health Care (PHC)" (Ordinance 4,279 of December 30, 2010).

Given this context, representatives from Brazil and other member countries of the Ibero-American Community convened at the IX Ibero-American Conference of Health Ministers to discuss about how to make health systems more inclusive and efficient. During this meeting, the Iquique Consensus was signed, emphasizing the importance of developing "health networks based on primary care, public financing, and universal coverage."

Therefore, the Brazilian Ministry of Health developed in the following years the strategy of the Health Care Networks (RAS), as mentioned above. Respecting the consensus reached at the Ministerial Meeting of Health in Iquique (Chile) and taking into account the analyses conducted by PAHO and the Ministry of Health, a system was developed that aimed to "overcome the fragmentation of care and management in Health Regions and improve the political-institutional functioning of the SUS, in order to ensure users with the set of actions and services they need effectively and efficiently" (Ordinance 4,279 of December 30, 2010).

3 Data

SINASC

This data originates from the Live Birth Information System (SINASC) developed by the Department of Informatics of the Brazilian Unified Health System (DATASUS). SINASC is managed by the Department of Health Situation Analysis under the Ministry of Health's Health Surveillance Secretariat, in conjunction with State and Municipal Health Secretariats. Health Secretariats collect Declaration of Live Births (DN) from healthcare facilities and registry offices (for home births), and enter the information contained therein into SINASC. Generally, State Health Secretariats send their databases to the Ministry of Health when

they deem data collection complete. The Ministry of Health can only consider the National Database complete when all states have submitted their data. Consolidation is then carried out, including redistribution of data by place of residence, which is the traditional way of presenting Live Birth data. Occasionally, corrections are made to the information.

We explore SINASC's dataset at a municipality of residence, quarter (or year) level. We get data for the number of births; delivery facility type (whether births were given in hospitals, other health facilities, or at home); location (in the municipality of residence or not, in the health region of residence or not, and distance to the municipality of birth); newborn weight; whether it was a normal or cesarean delivery; classification of number of prenatal appointments (0, 1 to 3, 4 to 6 and 7 or more). We also get data on the characteristics of the pregnancy that allow us to construct a pregnancy risk index. We use the number of previous pregnancies (zero being risky); gestational age at the moment of birth (less than 37 weeks being risky); number of fetuses (more than one being considered risky); and mother's age (more than 35 years being considered risky).

SIM

The Brazil Mortality Information System (SIM) is a vital tool for comprehensively understanding mortality patterns and trends within the country. Managed by the Department of Health Informatics of the Brazilian Unified Health System (DATASUS), SIM collects, processes, and disseminates data related to deaths occurring within Brazil's territory. This system plays a critical role in public health surveillance, aiding in the identification of epidemiological trends, disease burden assessments, and the evaluation of health policies and interventions. Through the collaboration of various stakeholders, including health facilities, civil registry offices, and governmental health agencies at the federal, state, and municipal levels, SIM ensures the availability of reliable mortality statistics essential for informed decision-making and the formulation of effective public health strategies.

CNES

The Cadastro Nacional de Estabelecimentos de Saúde (CNES), or National Register of Health Facilities, serves as a fundamental database for the management and regulation of healthcare establishments across Brazil. Administered by the Department of Health Informatics of the Brazilian Unified Health System (DATASUS), CNES compiles comprehensive information about healthcare facilities, including hospitals, clinics, laboratories, and other healthcare services nationwide. This centralized repository facilitates the monitoring and planning of healthcare services, ensuring equitable distribution and access to healthcare resources across regions. By providing detailed data on the infrastructure, equipment, and services offered by each establishment, CNES supports policymakers, health administrators, and researchers in making informed decisions, optimizing resource allocation, and enhancing the quality and efficiency of healthcare delivery throughout Brazil.

We gather data on the number of hospital beds for each year, month, and health facility. We chose specific types of beds relevant to the health of the mother and the newborn: surgical obstetrics, neonatal unit, clinical obstetrics, intermediate care for neonatal, and ICU types I, II, and III.

SIA

The Ambulatory Information System (SIA) is part of DATASUS and was implemented nationally in the 1990s with the purpose of recording outpatient visits, procedures, and treatments performed at each healthcare facility through the Outpatient Production Bulletin (BPA). The Ambulatory Information System (SIA) refers to a health information system, within the Brazilian Unified Health System (SUS), which focuses specifically on collecting, processing, and analyzing data related to outpatient care services. This includes medical consultations, diagnostic tests, therapeutic procedures, and other healthcare services provided on an outpatient basis. The SIA aims to improve the efficiency and quality of ambulatory

healthcare delivery by providing reliable and comprehensive data to support decision-making, policy development, and resource allocation within the SUS.

We gather data for procedures related to maternal and newborn attention: Amniocentesis; Blood Collection for Neonatal Screening; Fetal Hemoglobin Dosage; Complete Blood Count; Alpha-Fetoprotein Dosage; Non-Treponemal Test for Syphilis Detection in Pregnant Women; Human Chorionic Gonadotropin Dosage (HCG, Beta HCG); Phenylalanine Dosage TSH or T4 and Hemoglobin Variant Detection (Component of the Heel Prick Test); Obstetric Ultrasonography With Colored and Pulsed Doppler; Rapid Test for HIV Detection in Pregnant Women or Partners; Consultation for Growth and Development Monitoring (Pediatrics).

4 Empirical Strategy

We use the Difference-in-Differences approach to estimate the effects of two modalities of adhesion to Rede Cegonha on several health-related outcomes. For regional adhesion, groups of municipalities adhered jointly to the program with a logistic plan integrating health services across health regions. For isolated adhesion, municipalities adhered individually. We compare the effects of the program in each of the modalities.

Thus, we estimate the following econometric model:

$$Y_{mt} = \alpha_m + \gamma_t + \beta D_{mt} + \epsilon_{mt}, \tag{1}$$

Y_{mt} represents the outcome of interest, which can be divided into maternal/newborn health outcomes and public health accessibility outcomes. The variable D_{mt} is an indicator variable for whether unit m has been treated by time t, i.e., indicates 1 (one) for the time after which we observe the first calamity in municipality m, and zero otherwise (i.e., whether the municipality never suffers any calamity or if the calamity is not the first occurrence in the

municipality). Thus, the parameter of interest, β, measures the effect of Rede Cegonha adhesion in municipalities. The coefficients α_m control for municipality-specific (time-invariant) heterogeneities at the municipality level while the γ_t controls for aggregate shocks that may have similarly affected Rede Cegonha adhesion across municipalities over time. Finally, the term ϵ_{mt} represents idiosyncratic error to which we assume the classical assumptions.

We adopt an event study framework that allows effects to vary over time and is commonly used to assess the assumption of standard parallel pre-treatment trends. The event study model is outlined by:

$$Y_{mt} = \alpha_m + \gamma_t + \sum_{j=-J}^{+J} \beta_j D_{mj} + \epsilon_{mt}. \tag{2}$$

In Equation (2), each β_j coefficient captures the average differences on Y_{mt} for municipalities j periods before/after the Rede Cegonha adhesion, relative to the baseline at one period before the adhesion $j = -1$, which is omitted from the model as the reference category. The event study specification allows us to not only test for the persistence of the Rede Cegonha adhesion by allowing its effects to vary by time but also determine whether pre-treatment trends were similar before the adhesions. In particular, we expect the estimated β_j's for the prior periods to be statistically indistinguishable from zero to validate our empirical strategy.

Considering our setting of staggered treatment adhesion and given that once a municipality participates in the treatment, it remains treated, we adopt the recently developed estimator of Callaway and Sant'Anna (2021), which accounts for variation in treatment timing and adequately assesses the impact of the staggered adhesion. To exploit only appropriate policy variation, the authors propose an approach to implement DiD methods in situations of differential treatment timing. We must point out that for the program being studied here all units were eventually treated. Thus, we use not yet treated units in a given period as the comparison group.

Let G be the period when unit becomes treated (often groups are defined by the period when a unit becomes treated; hence, the G notation). A natural way to estimate the parameter of interest is to define group-time average treatment effects:

$$ATT(g,t) = E[Y_t - Y_t(0)|G = g]. \tag{3}$$

This is the average effect of participating in the treatment for units in group g at period t. Now let D_t be an indicator variable for whether unit is not-yet-treated at period t. Thus, when we impose the parallel trends assumption, based on these "not-yet-treated units", we have that, for all $t \geq g$:

$$ATT(g,t) = E[Y_t - Y_{g-1}|G_g = 1] - E[Y_t - Y_{g-1}|D_t = 0]. \tag{4}$$

Following Callaway and Sant'Anna (2021), we aggregate the group-time average treatment effect to highlight treatment effect dynamics given by the estimator outlined as follows:

$$\theta_D(e) := \sum_{g \in \mathcal{G}} \mathbf{1}\{g + e \leq \mathcal{T}\} ATT(g, g+e) P(G = g|G + e \leq \mathcal{T}). \tag{5}$$

The parameter $\theta_D(e)$ measures the average effect of experiencing Rede Cegonha for the group of municipalities exposed to the treatment for exactly e periods.

In order to facilitate the interpretation of results we also aggregate the group-time treatment effect into the overall average treatment effect by computing:

$$ATT = \sum_{g \in \mathcal{G}} ATT(g) P(G = g|G \leq \mathcal{T}) \tag{6}$$

where $ATT(g)$ is computed by aggregating group and period specific average treatment

effects through periods into:

$$ATT(g) = \frac{1}{\mathcal{T} - g + 1} \sum_{t=g}^{\mathcal{T}} ATT(g,t) \tag{7}$$

We split our sample into municipalities that eventually adhered to each of the Rede Cegonha treatment groups (regional and isolated) and we compute Rede Cegonha ATTs for each of these samples and we compare these effects in order to have an estimate of the differential effect of regional and isolated adhesion to Rede Cegonha.

5 Results

We present the results of our empirical strategy here. Results are present in the form of event study plots, distinguishing for effects of Isolated and Regional Rede Cegonha adhesion by color (red for Isolated and blue for Regional). Overall ATTs are also presented, as well as standard errors and significance.

5.1 Effect on Health Outcomes

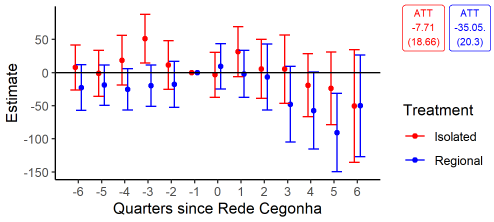
First, we investigate the effects of Rede Cegonha on health outcomes related to maternal and neonatal health in the form of infant and maternal mortality; newborn weight; and newborns' APGAR index. These results outline the effect of Rede Cegonha in addressing general public health standards as well as specific standards present in the program guidelines. One key detail is that they compute the effect of the policy on outcomes with a delay of 9 months, allowing for the policy to have full effect during pregnancy and birth.

In Figure 2, we present results for the effect of Rede Cegonha on Infant Mortality (9 months later). We find no effect of Rede Cegonha on Early Neonatal Death Preventable by Care During Pregnancy for Isolated adhesion and a marginally significant decrease of 35.05 deaths per 100000 births for Regional adhesion. We find a significant increase of 29.34 deaths

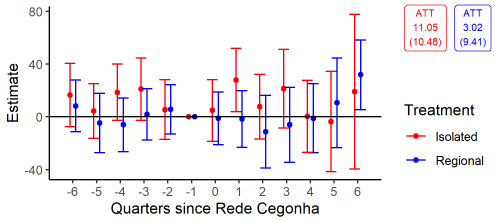
per 100000 births of Rede Cegonha on Late Neonatal Death Preventable by Care of the Fetus or Newborn for Isolated adhesion, and no effect for Regional adhesion. We find no effect of Rede Cegonha on Post-Neonatal Death Preventable by Care of the Fetus or Newborn for Isolated adhesion and a significant decrease of 11.35 deaths per 100000 births for Regional adhesion. Overall we can see that despite being a difficult outcome to be addressed, we find an effect of regional adhesion of Rede Cegonha on child mortality decrease during early neonatal and post neonatal stages. More specifically, the death reduction during the early neonatal stage comes from deaths that were preventable by care during pregnancy, while the death reduction during post neonatal stage comes from deaths that were preventable by care of the fetus and newborn. We do not find any other effects on infant mortality.

Figure 2: Effect of Rede Cegonha on Infant Mortality (9 months later)

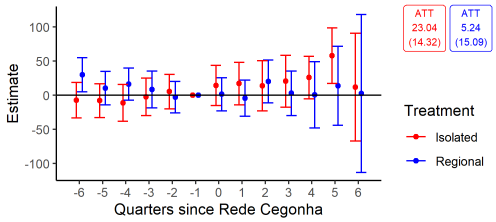
(a) Early Neonatal Death Preventable by Care During Pregnancy



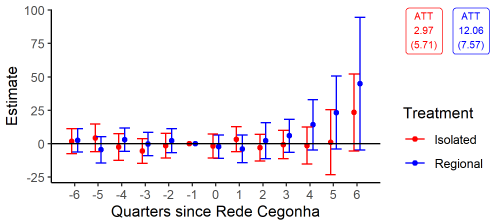
(b) Early Neonatal Death Preventable by Care During the Delivery



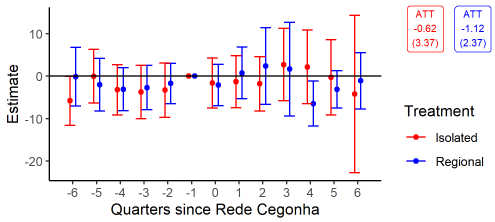
(c) Early Neonatal Death Preventable by Care of the Fetus or Newborn



(d) Post-Neonatal Death Preventable by Care During Pregnancy



(e) Post-Neonatal Death Preventable by Care During the Delivery



(f) Post-Neonatal Death Preventable by Care of the Fetus or Newborn

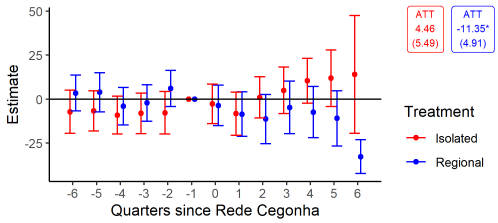


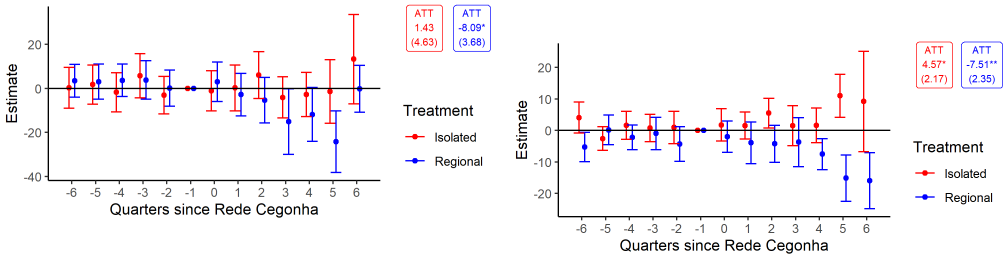
Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

In Figure 3, we present results for the effect of Rede Cegonha on Mother Mortality (9

months later). We find no effect of Rede Cegonha on Mother Mortality During Pregnancy for Isolated adhesion and a significant decrease of 8.09 deaths per 100000 births for Regional adhesion. For the effect on Mother Mortality During Puerperium we find a significant decrease of 7.51 deaths per 100000 births for Rede Cegonha Regional adhesion. We find no effect of Rede Cegonha on Mother Mortality Post Puerperium for Isolated adhesion and a significant decrease of 9.97 deaths per 100000 births for Regional adhesion. We find that regional adhesion of Rede Cegonha is consistent in reducing mother mortality across all stages analyzed: pregnancy, puerperium, and post-puerperium.

Figure 3: Effect of Rede Cegonha on Mother Mortality (9 months later)

(a) Mother Mortality During Pregnancy (b) Mother Mortality During Puerperium



(c) Mother Mortality Post Puerperium

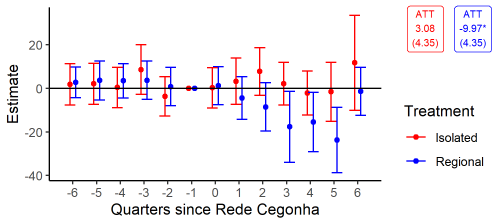


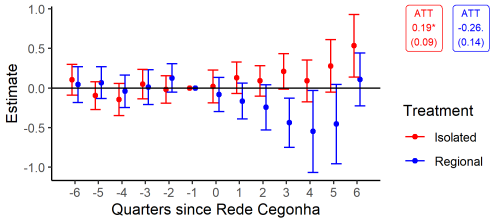
Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

In Figure 4, we present results for the effect of Rede Cegonha on Newborn Health Measures. We find a significant increase of 0.19 percentage points of Rede Cegonha on the Fraction of Underweight Newborns (Less than 2500g) for Isolated adhesion and a marginally significant decrease of 0.26 percentage points for Regional adhesion. We find no effect of

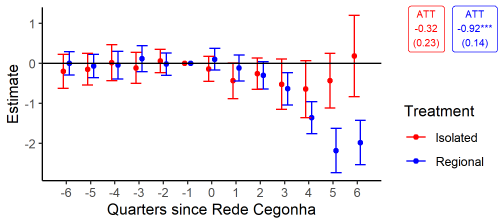
Rede Cegonha on the Fraction of Low APGAR Index Briths One Minute After Childbirth (Less than 8) for Isolated adhesion and a significant decrease of 0.92 percentage points for Regional adhesion. We find no effect of Rede Cegonha on the Fraction of Low APGAR Index Briths Five Minutes After Childbirth (Less than 8) for Isolated adhesion, and a significant decrease of 0.27 percentage points for Regional adhesion. We also find a marginally significant reduction in the fraction of low-weight births for regional adhesion municipalities. This highlights that regional adhesion led to healthier newborns compared to isolated adhesion.

Figure 4: Effect of Rede Cegonha on Living Newborn Health Measures (9 months later)

(a) Fraction of Underweight Newborns (Less than 2500g)



(b) Fraction of Low APGAR Index Briths One Minute After Childbirth (Less than 8)



(c) Fraction of Low APGAR Index Briths Five Minutes After Childbirth (Less than 8)

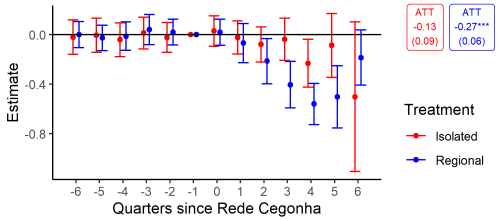


Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

5.2 Effect on Health Service Accessibility

One key component of Rede Cegonha present for municipalities that were treated through Regional Adhesion is the logistic component. Now we investigate whether logis-

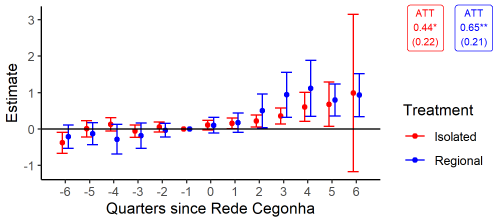
tics and regional integration were affected differently by regional/isolated adhesion. Such effects would give strength to the assumption that the effects of the program on health outcomes came from increase in accessibility to public health infrastructure.

We investigate the effects of Rede Cegonha on health service accessibility, in the form of access to hospitals and other healthcare facilities; delivering in other municipalities, as well as the distance traveled to do so; access to maternal and newborn health-specific hospital beds; the number of prenatal appointments that mothers attended during pregnancy; fraction of cesarean deliveries; and access to maternal and newborn health-specific procedures.

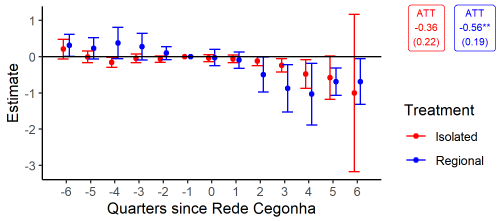
In Figure 5, we present results for the effect of Rede Cegonha on Delivery Facility Type Distribution. For the effect on the Fraction of Deliveries in Hospitals, we find a significant increase of 0.44 percentage points of Rede Cegonha for Isolated adhesion and a significant increase of 0.65 percentage points for Rede Cegonha Regional adhesion. For the effect on the Fraction of Deliveries at Home we find a significant decrease of 0.1 percentage points of Rede Cegonha for Isolated adhesion and a significant decrease of 0.13 percentage points for Rede Cegonha Regional adhesion. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adhesion on the Fraction of Deliveries at Home. We find that both regional and isolated adhesion of Rede Cegonha led to an improvement in access to health facilities, more specifically to hospitals, which have better infrastructure to assist the delivery.

Figure 5: Effect of Rede Cegonha on Delivery Facility Type Distribution

(a) Fraction of Deliveries in Hospitals



(b) Fraction of Deliveries in Others Health Facilities



(c) Fraction of Deliveries at Home

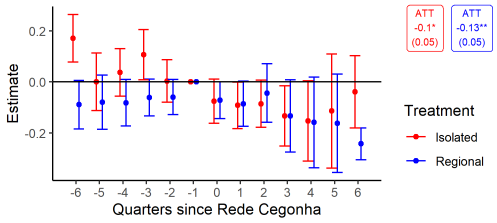


Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

In Figure 6, we present results for the effect of Rede Cegonha on variables related to the flow of pregnant women between municipalities for delivery. We find no effect of Rede Cegonha on the Fraction of Deliveries in Municipalities Outside Residence for Isolated adhesion and a significant increase of 1.05 percentage points for Regional adhesion. We find no effect of Rede Cegonha on the Average Distance Travelled for Delivery, either for Regional adhesion or Isolated adhesion. We find that mothers in regional municipalities left for other municipalities more often to deliver. This is consistent with the interpretation that these were municipalities with poor access to health services and were, with the regional adhesion of Rede Cegonha, better integrated with other municipalities.

Figure 6: Effect of Rede Cegonha on Delivery Location Distribution

(a) Fraction of Deliveries in Other Municipalities

(b) Average Distance Travelled for Delivery

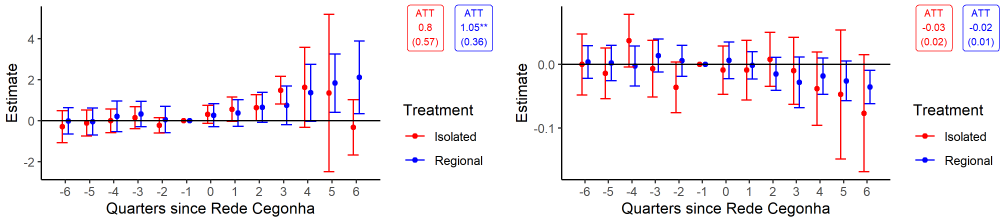


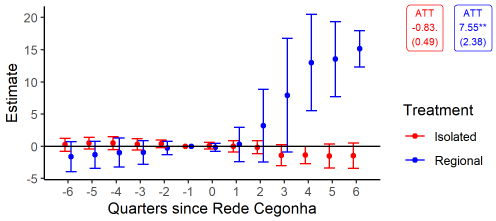
Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. For each dependent variable, we use the number of equipment divided by the number of births in the pre-treatment year 2010 and multiplied by 1000. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

In Figure 7, we present results for the effect of Rede Cegonha on Accessibility to Hospital Beds. We find a marginally significant decrease of 0.83 percentage points of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Have Surgical Obstetrics Beds for Isolated adhesion, and a significant increase of 7.55 percentage points for Rede Cegonha Regional adhesion. We find no effect of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Have Neonatal Unit Beds for Isolated adhesion and a significant increase of 5.32 percentage points for Regional adhesion. We find no effect of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Have Clinical Obstetrics Beds for Isolated adhesion, and a significant increase of 6.6 percentage points for Regional adhesion. We find no effect of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Have Intermediate Care Neonatal Beds for Isolated adhesion, and a significant increase of 8.79 percentage points for Regional adhesion. For the effect on the Fraction Of Deliveries In Health Facilities That Have ICU Beds - Type I we find a significant increase of 4.03 percentage points of Rede Cegonha for Isolated adhesion and a significant decrease of 1.01 percentage points for Rede Cegonha Regional adhesion. We find a marginally significant

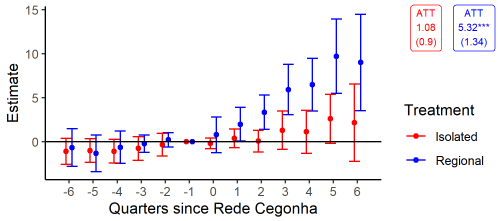
increase of 1.9 percentage points of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Have ICU Beds - Type II for Isolated adhesion, and a significant increase of 5.15 percentage points for Rede Cegonha Regional adhesion. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adhesion on the Fraction Of Deliveries In Health Facilities That Have ICU Beds - Type II. We find a marginally significant increase of 1.28 percentage points of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Have ICU Beds - Type III for Isolated adhesion, and a significant increase of 0.72 percentage points for Rede Cegonha Regional adhesion. We find a consistent effect of an increase in access to hospitals with maternal and newborn-specific hospital beds in regional adhesion municipalities, while no such effect is found for isolated adhesion municipalities. One detail is that ICU bed' types are increasing in infrastructure, hence a decrease in ICU bed type I is not necessarily negative since it might be the case that ICU beds may be upgraded from type I to type II for example.

Figure 7: Effect of Rede Cegonha on Accessibility to Hospital Beds

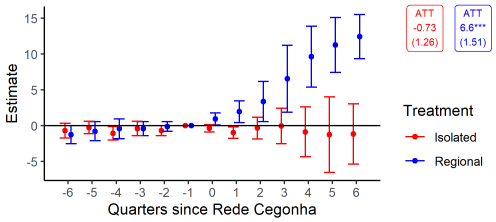
(a) Surgical Obstetrics Beds



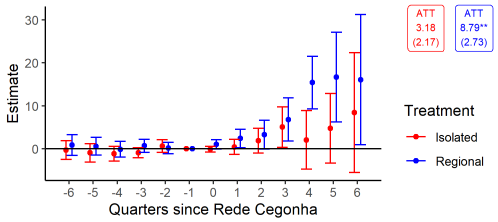
(b) Neonatal Unit Beds



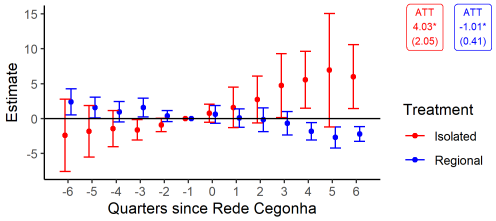
(c) Clinical Obstetrics Beds



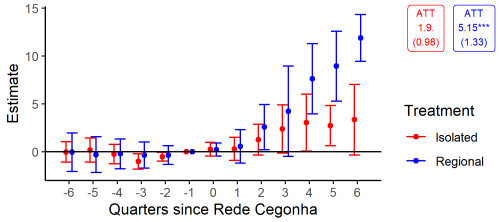
(d) Intermediate Care Neonatal Beds



(e) ICU Beds - Type I



(f) ICU Beds - Type II



(g) ICU Beds - Type III

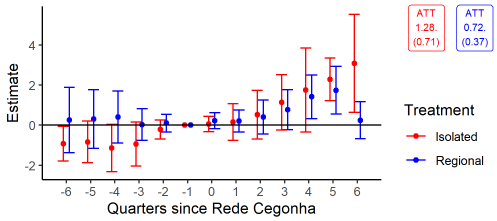


Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. For each dependent variable, we use the number of equipment divided by the number of births in the pre-treatment year 2010 and multiplied by 1000. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

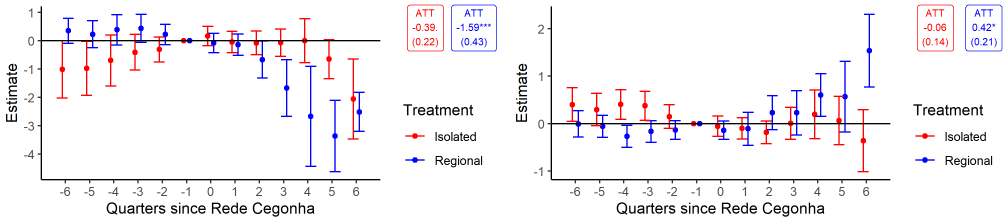
In Figure 8, we present results for the effect of Rede Cegonha on Number of Prenatal Appointments. We find a marginally significant decrease of 0.39 percentage points of Rede

Cegonha on the Fraction of Deliveries that Underwent No Prenatal Appointment for Isolated adhesion, and a significant decrease of 1.59 percentage points for Rede Cegonha Regional adhesion. We find no effect of Rede Cegonha on the Fraction of Deliveries that Underwent 1 to 3 Prenatal Appointments for Isolated adhesion and a significant increase of 0.42 percentage points for Regional adhesion. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adhesion on the Fraction of Deliveries that Underwent 1 to 3 Prenatal Appointments. For the effect on the Fraction of Deliveries that Underwent 4 to 6 Prenatal Appointments, we find a significant decrease of 0.89 percentage points of Rede Cegonha for Isolated adhesion and a significant increase of 1.15 percentage points for Rede Cegonha Regional adhesion. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adhesion on the Fraction of Deliveries that Underwent 4 to 6 Prenatal Appointments. We find a significant increase of 1.04 percentage points of Rede Cegonha on the Fraction of Deliveries that Underwent 7 or More Prenatal Appointments for Isolated adhesion, and no effect for Regional adhesion. Regional adhesion significantly reduced the percentage of deliveries without any prenatal appointments and increased the percentage of deliveries with 1 to 3 and 4 to 6 prenatal appointments. In contrast, isolated adhesion does increase the percentage of deliveries with seven or more prenatal appointments, an effect not observed in the regional adhesion. Overall, regional adhesion of Rede Cegonha appears more effective and consistent in enhancing prenatal care metrics for situations of most need (very few prenatal appointments).

Figure 8: Effect of Rede Cegonha on the Number of Prenatal Appointments

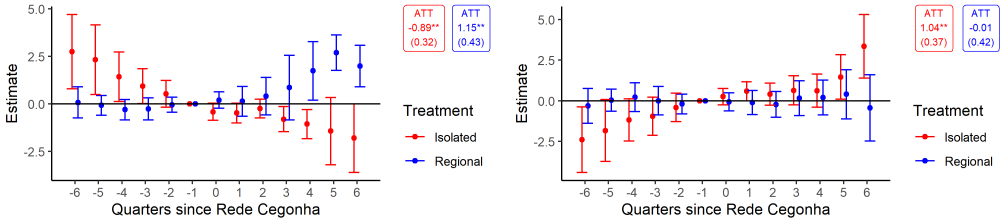
(a) Fraction of Deliveries that Underwent No Prenatal Appointment

(b) Fraction of Deliveries that Underwent 1 to 3 Prenatal Appointments



(c) Fraction of Deliveries that Underwent 4 to 6 Prenatal Appointments

(d) Fraction of Deliveries that Underwent 7 or More Prenatal Appointments



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In Figure 9, we present results for the effect of Rede Cegonha in the Fraction of Cesarean Deliveries. We find no effect of Rede Cegonha on Fraction of Cesarean Deliveries for Isolated adhesion, and a significant reduction of 1.21 percentage points for Regional adhesion. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adhesion on Fraction of Cesarean Deliveries. This outcome highlights the efficacy of regional adhesion in potentially influencing hospital practices and maternal health policies to reduce unnecessary cesarean sections, promoting safer and potentially more natural birthing practices across a wider network of healthcare facilities.

Figure 9: Effect of Rede Cegonha on Fraction of Cesarean Deliveries)

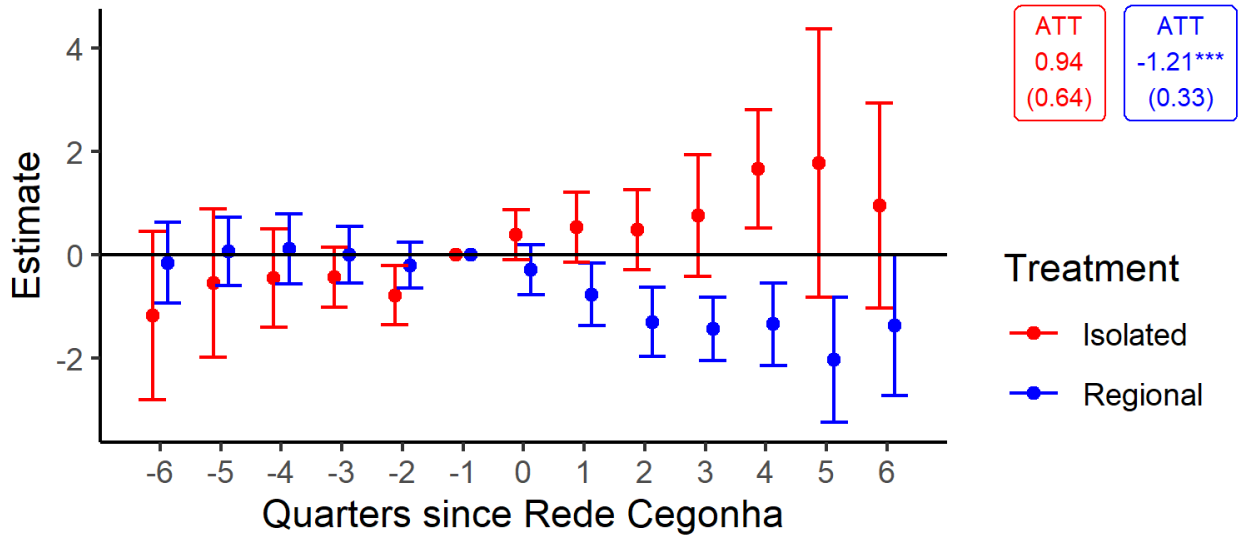


Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. For each dependent variable, we use the number of equipment divided by the number of births in the pre-treatment year 2010 and multiplied by 1000. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

Considering that Brazil is a country with a much-inflated number of cesarean deliveries, much higher than the standards established by the WHO, Table 9's result is seen as an improvement in public health conditions. On the other hand, it could still be the case that the reduction in cesarean deliveries is being driven by high-risk deliveries, which would be undesirable. In Table 10, we present results for the pregnancy risk heterogeneous effect of Rede Cegonha in the Fraction of Cesarean Deliveries. We find no effect of Rede Cegonha on the Fraction of Cesarean Deliveries for Isolated adhesion for high or low risk and a significant reduction of 1.51 percentage points for Regional adhesion conditional on low-risk pregnancies and a decrease of 1 percentage point conditional on high risk. This outcome highlights that the reduction found in the fraction of cesarean deliveries in regional adhesion municipalities was stronger for low-risk pregnancies. This is consistent with the idea that, even though

Brazil has a larger than optimal number of pregnancies being done, sometimes it is safer for high-risk pregnancies.

Figure 10: Effect of Rede Cegonha on Fraction of Cesarean Deliveries)

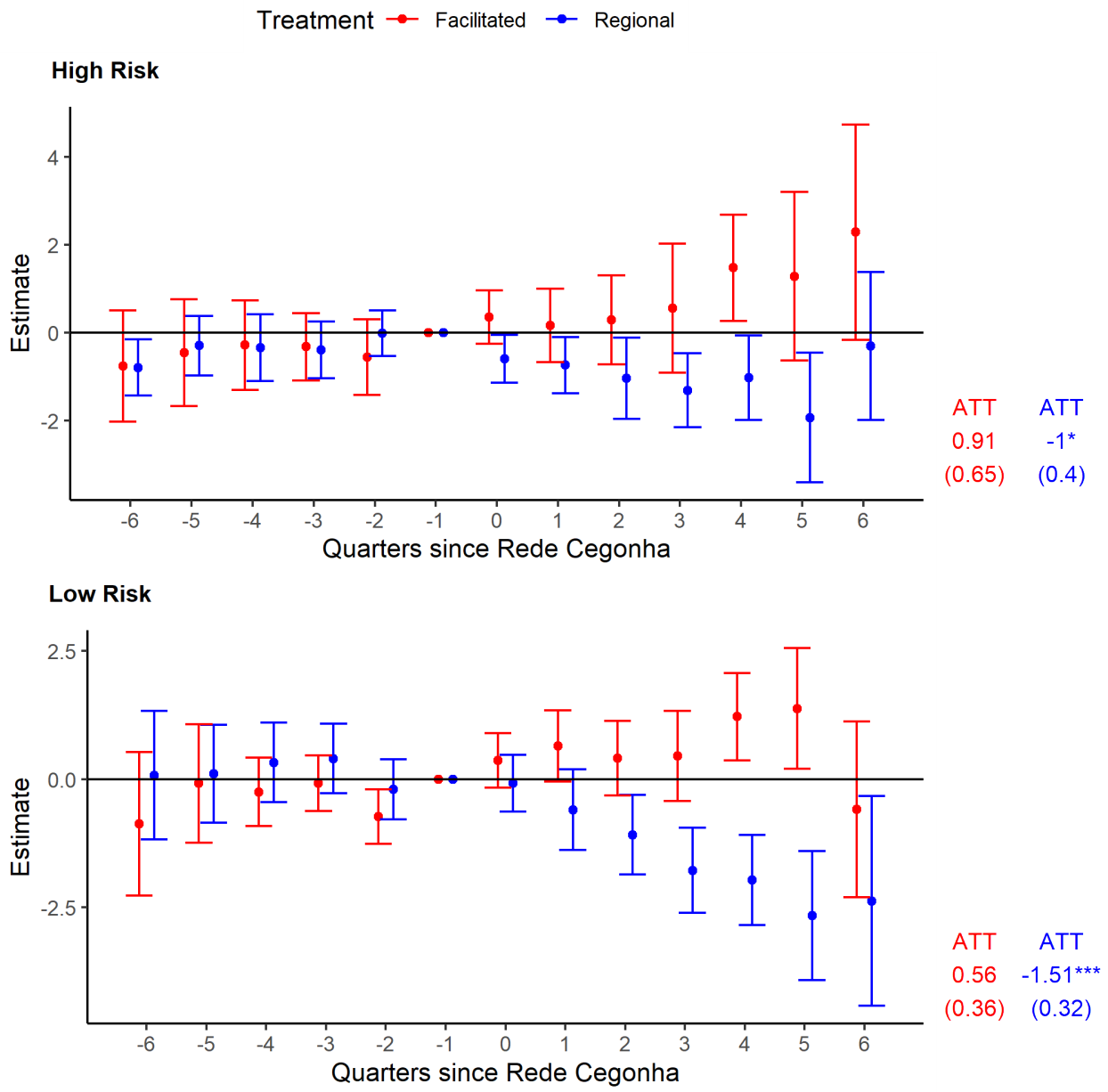


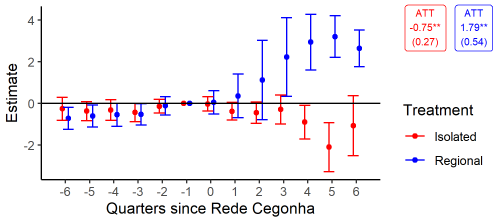
Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. For each dependent variable, we use the number of equipment divided by the number of births in the pre-treatment year 2010 and multiplied by 1000. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

In Figure 11, we present results for the effect of Rede Cegonha on Accessibility to Health Procedures. For the effect on the Fraction Of Deliveries In Health Facilities That Do Complete Blood Counts, we find a significant decrease of 0.71 percentage points of Rede Cegonha for Isolated adoption and a significant increase of 1.88 percentage points for Rede Cegonha Regional adoption. We do find evidence for the rejection of the parallel trends assumption for the effect of Regional Rede Cegonha adoption on the Fraction Of Deliveries In Health Facilities That Do Complete Blood Count. For the effect on the Fraction Of Deliveries In Health Facilities That Do Alpha-Fetoprotein Dosage, we find a significant increase of 0.65 percentage points of Rede Cegonha for Isolated adoption and a significant increase of 0.69 percentage points for Rede Cegonha Regional adoption. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adoption on the Fraction Of Deliveries In Health Facilities That Do Alpha-Fetoprotein Dosage. For the effect on the Fraction Of Deliveries In Health Facilities That Do Non-Treponemal Test For Syphilis Detection In Pregnant Women, we find a significant increase of 0.58 percentage points of Rede Cegonha for Isolated adoption and a significant increase of 0.85 percentage points for Rede Cegonha Regional adoption. We find no effect of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Do Human Chorionic Gonadotropin Dosage (Hcg, Beta Hcg) for Isolated adoption, and a significant increase of 1.19 percentage points for Regional adoption. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adoption on the Fraction Of Deliveries In Health Facilities That Do Human Chorionic Gonadotropin Dosage (Hcg, Beta Hcg). We find a significant increase of 0.03 percentage points of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Do Phenylalanine Dosage Tsh Or T4 And Hemoglobin Variant Detection (Component Of The Heel Prick Test) for Isolated adoption and a marginally significant increase of 0.07 percentage points for Regional adoption. We find a marginally significant increase of 0.64 percentage points of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Do Rapid Test For Hiv Detection In Pregnant Women Or Partners

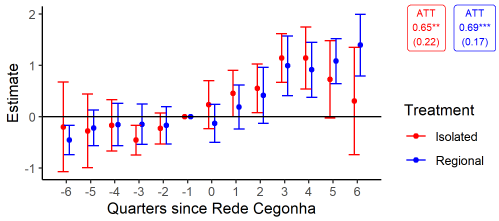
for Isolated adoption and a significant increase of 0.3 percentage points for Rede Cegonha Regional adoption. We do find evidence for the rejection of the parallel trends assumption for the effect of Isolated Rede Cegonha adoption on the Fraction Of Deliveries In Health Facilities That Do Rapid Test For Hiv Detection In Pregnant Women Or Partners. We find no effect of Rede Cegonha on the Fraction Of Deliveries In Health Facilities That Do Consultation For Growth And Development Monitoring (Pediatrics) for Isolated adoption and a significant increase of 0.58 percentage points for Regional adoption. Overall, the regional adhesion demonstrates broader and more reliable enhancements in accessibility to essential health procedures, suggesting that a coordinated, region-wide approach is more effective in improving healthcare accessibility and quality.

Figure 11: Effect of Rede Cegonha on Accessibility to Health Procedures

(a) Complete Blood Count

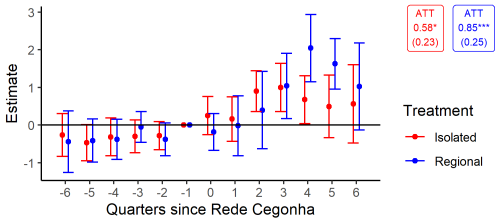


(b) Alpha-Fetoprotein Dosage

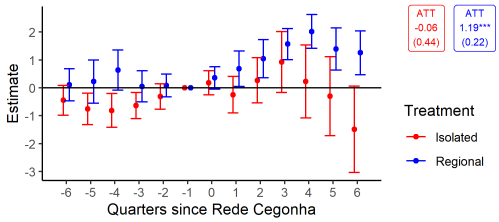


(c) Non-Treponemal Test for Syphilis Detection in Pregnant Women

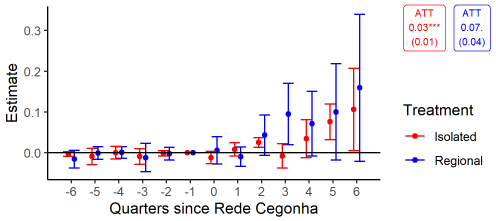
(d) Human Chorionic Gonadotropin Dosage (HCG, Beta HCG)



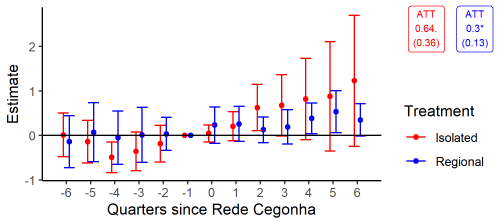
(e) Phenylalanine Dosage TSH or T4 and Hemoglobin Variant Detection (Component of the Heel Prick Test)



(f) Rapid Test for HIV Detection in Pregnant Women or Partner



(g) Consultation for Growth and Development Monitoring (Pediatrics)



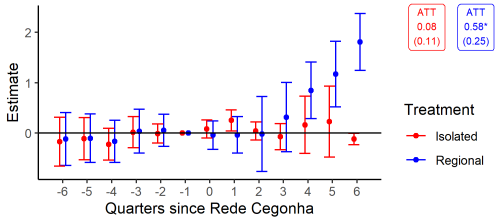


Figure display Callaway Sant'Anna difference in difference estimates of Rede Cegonha effects from -6 up to 6 quarters after treatment, using the -1 period as comparison. For each dependent variable, we use the number of equipment divided by the number of births in the pre-treatment year 2010 and multiplied by 1000. Overall ATT are also presented along with standard errors and significance in indicated by . - 10% significance level; $*$ - 5% significance level; $**$ - 1% significance level; and $***$ - 0.1% significance level.

6 Conclusion

In this study, we utilized various administrative data sources from the Ministry of Health to evaluate the impact of the Rede Cegonha program on maternal and child health outcomes in Brazil. By employing the Callaway and Sant'Anna (2021) differences-in-differences method, we compared the effects of Regional and Isolated Adhesion on healthcare delivery and outcomes. This approach allowed us to analyze the program's staggered implementation from 2011 to 2013, providing a comprehensive assessment of how coordination and integration within healthcare networks influence maternal and child health.

Our findings indicate that Regional Adhesion consistently leads to better health outcomes compared to Isolated Adhesion. Specifically, Regional Adhesion is associated with a significant reduction in maternal mortality at all stages of the childbirth process and a notable decrease in low-weight births and low APGAR scores. These results highlight the positive impact of enhanced coordination and logistics within the Rede Cegonha program, demonstrating that multi-agent coordination can generate significant synergies and efficiencies in the healthcare sector.

Furthermore, we observed that Regional Adhesion improves healthcare service accessibility, including hospital bed availability and prenatal care, more effectively than Isolated Adhesion. Regional municipalities also showed better integration with neighboring areas, facilitating access to specialized care. These improvements underscore the importance of a coordinated regional approach in addressing extremely poor healthcare conditions and optimizing overall healthcare service provision. The evidence strongly highlights the importance of coordination on good provision of health provision in a context of a large territory with sparse health service provision. Ultimately this improvement in health accessibility leads to better health outcomes.

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