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The COVID-19 pandemic and birth outcomes in 2020: The role of prenatal care and other channels

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ABSTRACT

We use national birth data to assess the associations between the COVID-19 pandemic during 2020 and birth outcomes in Uruguay. Employing interrupted time series difference-in-differences techniques, we find mixed results, with some pregnancies showing increases in the likelihood of very preterm or very-low-weight births, and some others showing decreases in the incidence of moderate prematurity and moderate low birth weight. Adverse outcomes are more likely among women with low education, women with previous children, and with risk factors, such as smoking or being older than 34. We observe improvements in health at birth for children of non-smokers, women younger than 35, and women with no other children. We underscore the role of health care by showing that women in the private sector, who suffered the strongest contraction in face-to-face prenatal care use, experienced more adverse birth outcomes. Our results also suggest that the economic recession and an increased burden of childcare were behind the increases in preterm and very-low-weight births. Because pollution is an unlikely channel for the positive results, we hypothesize that for some pregnancies, the pandemic improved the intrauterine habitat by leading to a quieter and healthier lifestyle.

1. Introduction

The COVID-19 pandemic may have affected maternal and newborn health either directly, through virus infection in pregnancy, or indirectly, through changes in socioeconomic determinants (e.g., decreased employment, lower income), increases in risk factors (e.g. changes in diets due to lower availability of fresh products), higher levels of stress (due to fear of contagion during pregnancy, anxiety and depression associated with maternal fear of vertical transmission of the virus, negative economic shocks, or lack of support and containment derived from physical distancing), decreased access to health care services (either due to supply side restrictions or to a lower demand arising from fear of contagion), lower pollution, or a more relaxed lifestyle due to decreased mobility.

In this paper, we use a national database of births from Uruguay in 2020 to analyze the associations between the pandemic and its containment measures on birth outcomes. Employing an interrupted time-series difference-in-differences model, we perform multiple analyses that help us shed light on the drivers of the results. We restrict our analysis to births conceived prior to the irruption of COVID-19 in the country, bypassing any effects of the pandemic on fertility, and dismiss direct biological explanations, as very few pregnant women were infected with the virus in Uruguay in 2020.

On average, we find mixed effects of the pandemic on birth outcomes. On the one hand, we find an increase in the incidence of very preterm births (births with less than 32 weeks of gestation) and very low weight births (below 1500 g). On the other hand, we find a decrease in the incidence of moderate low birth weight (weight between 1500 and 2500 g) and moderate prematurity (between 32 and 37 weeks of gestation). These results do not suggest a shift towards the more severe tail of the health-at-birth distribution, but reflect stark heterogeneities in the impact of the pandemic across mothers’ characteristics. Births with adverse outcomes are more likely among mothers of lower education, higher pregnancy risks (smokers and older women), and binding time constraints (proxied by other children at home). Conversely, we find improvements in birth outcomes among non-smoking and younger mothers, and among mothers with no previous children. We provide suggestive evidence of several mechanisms behind the observed adverse outcomes, including a decrease in prenatal care, negative economic shocks, and a higher time burden for women with other children.

We contribute to several strands of the literature. First, we add to the public health literature by providing one of a few rigorous analyses of
the effects of the pandemic on birth outcomes in a developing country using national level data. Our analysis considers not only lockdown periods, but the full impact of the pandemic in 2020. We also refine the estimation methodology relative to prior research by accounting for pre-trends and seasonality, and by anchoring the analysis on the expected, rather than the effective (endogenous to the pandemic) date of birth. Second, we provide suggestive evidence on the mechanisms behind our findings, connecting with the literature on the production of health (Grossman, 1972), and in particular on the production of birth outcomes (Rosenzweig and Schultz, 1983; Corman et al., 2018). We are able to exclude direct biological (infection) effects or effects on fertility as drivers of the results. We underscore the role played by decreases in access to face-to-face prenatal care (Grossman and Joyce, 1990; Corman et al., 2019), and discuss the relevance of income shocks (Mocan et al., 2015; Chung et al., 2016) and time constraints. We discard lower pollution as an explanation for the improvements in birth outcomes (Chay and Greenstone, 2003; Currie and Neidell, 2005), and conjecture that the observed beneficial effects could be associated with lower levels of stress stemming from a quieter and healthier lifestyle (Dehejia and Lleras-Muney 2004, Aizer et al., 2016; Torche, 2011; Currie and

Fig. 1. Indicators of the COVID-19 pandemic in Uruguay during 2020. Notes: The Oxford Stringency Index (Hale et al., 2021) is a composite measure based on nine response indicators including school closures, workplace closures, and travel bans, rescaled to a value from 0 to 100 (100 = strictest). The COVID-19 Google Community Mobility Reports (Google LLC, 2021) show how peoples’ movements changed throughout the pandemic. Based on anonymized data provided by apps such as Google Maps, the reports measure daily visitor numbers to specific locations (such as retail stores and workplaces) and changes in duration of time spent at home, and compares the change to the median value of the five-week period going from January 3rd to February 6th 2020. We obtain new COVID-19 cases and new deaths by million population from Johns Hopkins University CSSE COVID-19. All figures present daily data smoothed at the biweekly level.

(a) The source of employment figures is the Uruguayan Household Survey (INE), 2019 and 2020. (b) The source for air quality concentration is the Air Quality Monitoring Network (Municipal Government of Montevideo).
Rossin-Slater, 2013). Finally, our paper relates to the literature associating economic recessions with health outcomes (Ruhm, 2000). As in De Cao et al. (2022), we find heterogeneous effects of the economic crisis on birth outcomes. Adverse birth outcomes increase among women of lower socioeconomic status, but health at birth improves for healthier and higher income women. As in Dehejia and Lleras Muney (2004), we find that the economic recession induced by COVID-19 did not increase risky behaviors among pregnant women. Unfortunately, we are unable to explore longer-term impacts on the health of these families and their offspring, although prior evidence suggests that the adverse effects of a recession on health may appear in the longer run (Janke et al., 2020).

2. Background

2.1. Health and health care in Uruguay

Uruguay is a middle-income country in South America with 3 million population. In terms of its epidemiologic profile, its largest burden of disease comes from non-communicable and non-transmissible conditions. Uruguay has a National Integrated Health System, which guarantees the right to healthcare for all residents, through public or private providers. The main insurance scheme, covering 80% of the population, is the National Health Insurance, funded by mandatory social security contributions from workers, retirees, and employers. It finances healthcare for formal workers, their children, disabled dependents, and partner children, and retired individuals, and allows beneficiaries to choose care from either private providers or from a unique public provider (80% opt for private providers).

Most of the population not covered by the National Health Insurance are low socioeconomic status individuals who are entitled to get health care from a public safety net. The public provider covering these individuals must offer the same services as private providers, although waiting times are often longer. The rest of the population (a small fraction) pays for private insurance out-of-pocket.

Both in the private and public sectors, access to maternal care is universal, free, and of good quality. Almost all deliveries take place in hospitals and are taken care of by obstetricians.

2.2. The COVID-19 pandemic in Uruguay

After the first case of SARS-CoV-2 appeared in Uruguay in March 13, 2020, the government declared a state of health emergency. Even though it did not mandate a lockdown, it took measures to restrict circulation, such as the closure of schools, the suspension of public shows, the closure of large shopping centers, and exhortations to stay at home. According to the Stringency index from the Oxford COVID-19 Government Response Tracker (Hale et al., 2021), shown in the upper left panel of Fig. 1, the stringency of the government’s response to the pandemic reached a level of 70% in March, and stayed at 60% until mid-June. Between July and November, the policy stringency level decreased to 40%, but grew again to 60% in December, when Uruguay faced its first significant wave of infections. While there was not a lockdown mandate, most people adhered to the government exhortations to stay at home, and between March and May 2020, mobility decreased substantially. As shown in the right top panel of Fig. 1, mobility in retail spaces suffered a decline of between 60% and 40% in the March - May period, and mobility in workplaces dropped by between 40% and 20% in the same period. Since then, mobility increased gradually to achieve nearly normal levels in workplaces between September and November, when it began to fall again in response to the first COVID-19 wave. In terms of infections (see the middle panels in Fig. 1), Uruguay had a very low risk up to October (green level, according to the Index developed by the Harvard Global Health Institute, with less than 0.1 case per million population), passing then to yellow (0.1–1 cases per million population), and orange by half November 2020 (1–2.4 cases per million). The number of deaths due to COVID-19 was also very low until December 2020. Among pregnant women, the number of infections in 2020 was barely 104 in approximately 35,000 pregnancies and there was no registered death due to COVID-19.

After the declaration of a state of health emergency in March 2020, the Ministry of Public Health provided specific guidelines regarding the assistance of pregnant women and newborns in the context of the pandemic generated by COVID-19. All health care providers, both public and private, were encouraged not to suspend the scheduled visits and to evaluate remotely whether face-to-face obstetric controls could be delayed without affecting the safety and quality of care. The Ministry also suggested that obstetric routines and ultrasound be performed once the epidemiological situation allowed it, as long as the treating obstetrician found it reasonable (for example, ultrasound and 3rd trimester routines could be temporarily deferred). The Ministry of Public Health issued also a series of recommendations regarding the risks and care of pregnant women and newborns infected with SARS-CoV-2.

In terms of the macroeconomic impact of the COVID-19 pandemic, the gross domestic product fell by 5.9% in Uruguay in 2020, with a parallel contraction in employment (see bottom left panel of Fig. 1). By April 2020, the number of workers was 7.7% below 2019 levels, and although employment recovered slightly between June and December, it remained 5% below. In addition, among those considered employed, a large number was sent to partial unemployment insurance, which meant that the worker was either suspended temporarily from work or working for less hours. During April and May, around 9% of the total workforce had a temporary suspension and additional workers experienced reductions in the hours worked, implying further contractions in household income. Using the 2020 Uruguayan Continuous Household Survey (ECH-INE), Amarante et al. (2021) show that, net of unemployment insurance benefits, labor income (measured as the ratio of total remunerations plus insurance benefits to the economically active population) decreased approximately 6% in real terms in 2020 relative to 2019.

Finally, and unlike other countries, Uruguay did not register improvements in the air quality during the pandemic as a consequence of the reduced mobility. Air quality in Uruguay is generally good. The air concentration of particulate matter (PM) 2.5 is below 12 μg/m³ in most months of the year, except for a couple of months in winter, in which it is between 12 and 35 μg/m³, considered a moderate level. The bottom right panel in Fig. 1 shows that the levels of PM 2.5 in 2020 in Montevideo (where 50% of the population lives) did not suffer significant changes when compared to 2019. While there was less circulation of vehicles, there was an increase in the burning of wood to heat houses, which is one of the main sources of pollution in the country in winter.

2.3. Background literature on the impact of the pandemic on birth outcomes

There is limited empirical evidence with national level data on the impact caused by confinement strategies, care protocols, and the health and economic crisis itself on birth outcomes. The evidence focuses primarily on developed economies, studies mainly the impact of lockdown periods, and focuses on samples of specific hospitals. The few national level studies carried out by Been et al. (2020) for Netherlands, Hedemann et al. (2020) for Denmark and Caniglia et al. (2021) for Botswana.
found that lockdown reduced preterm births,\(^3\) although these findings have been heterogeneous. Been et al. (2020) find a significant decrease in the incidence of births with 32–36 weeks of gestation, mostly among high income communities, and Hedermann et al. (2020) show that the decrease occurs in pregnancies with less than 28 weeks of gestation. In contrast, Pasternak et al. (2021) for Sweden and Main et al. (2021) for California find no effects on average on gestational age during the lockdown period.\(^1\) Main et al. (2021) do find, however, increases in the incidence of preterm births for Latino and Hispanic communities.\(^7\)

Additionally, even though some hospital-level studies found that health containment measures increased the incidence of stillbirth (De Curtis et al. (2021) for Italy, Mor et al. (2021) for Israel, Ashish et al., 2020 for Nepal and Khalil et al., 2020 for England), other national level studies found no significant effects (Pasternak et al., 2021 for Sweden, Main et al. (2021) for California, Stowe et al., 2021 for England).

Regarding the impact of lockdown on birthweight, Philip et al. (2020) and Kirchengast and Hartmann (2021) found a reduction in low birthweight in hospitals located in Munster (Ireland) and Vienna (Austria), respectively. In contrast, Ashish et al. (2020) and Arnaez et al. (2021) found no significant effects for a sample of hospitals from different regions of Nepal and Castilla-y-Leon in Spain.

In sum, international evidence shows mixed effects of the COVID-19 pandemic on newborn health. In this sense, it should be noted that the evolution of infections was different in each country, as were the health and economic measures implemented by the authorities to counteract the adverse effects of the pandemic on the population. We are unaware of any paper delving into the analysis of concrete mechanisms. Moreover, existing differences in the methodologies used by each study further prevents drawing general conclusions.

Conceptually, our paper relates to the economics literature on the production of birth outcomes. As in Corman et al. (1985), our analysis is rooted on a model based on Grossman’s (1972) seminal work, where parents value children’s health at birth, in addition to their own consumption, and demand inputs for its production, including prenatal care, nutritious food, clean air, exercise, or rest, among others. The demand for each input depends on its price and availability, income, time constraints, social norms and environmental factors, as well as on maternal endowments and preferences. The pandemic changed sharply many of these features. As we will show, it decreased the supply of prenatal care for some groups of women, it contracted family income, it increased time constraints for women with previous children, while for others it provided a quieter and healthier environment. Although we are not fully able to isolate the role of each input, we provide suggestive evidence of the incidence of several of these drivers.

3. Data

We consider pregnancies with expected date of birth between December 5, 2018 and December 4, 2020, registered in the Perinatal Information System (SIP by its acronym in Spanish), a national database that contains information on 97% of newborns in the country (N = 71,257 births). This period considers pregnancies with expected date of birth during the first year of the COVID-19 pandemic, as well as a comparison group with pre-pandemic expected dates of birth. We operationalize the expected date of birth as the date of conception plus 38 weeks.\(^8\)

The dataset includes information on characteristics of the mother, the pregnancy, and the newborn’s health. Our main outcomes are health at birth and prenatal care. Regarding the former, we consider birthweight (BW) in grams; moderate low birthweight (MLBW), which is a binary variable that takes the value 1 if the weight of the newborn is between 1500 and 2500 g, and 0 otherwise; very low birthweight (VLBW), which takes the value 1 if the weight is below 1500 g, and 0 otherwise; moderate preterm birth (MPTB), a binary variable taking the value 1 if the delivery occurs between the 32nd and 36th week of gestation; very preterm birth (VPTB), which takes the value 1 if the delivery occurs before the 32nd week; and stillbirth (SB), which is a binary variable that takes the value 1 if the child died before or during delivery. We define the prematurity outcomes on the basis of the date of conception reported by the physician in the woman’s medical history (SIP). We choose to distinguish VLBW and VPTB from MLBW and MPTB because, despite their low prevalence, the former births account for a large fraction of total newborn’s health care costs (Schnitt et al., 2006; Russell et al., 2007). In recent work, some studies have shown important effects of maternal distress on severe birth outcomes (Currie et al., 2022).

In terms of prenatal care, we consider if the mother initiated prenatal care in the 1st trimester of pregnancy, the number of visits per trimester, and whether the mother completed at least nine visits during the pregnancy. We also take into consideration the mode of delivery, specifically whether it was a cesarean section versus a natural birth.

We account for mother characteristics that could affect both the required care and the health of the newborn. The mother’s age includes five binary variables for age 16 and below, 17–19, 20–34, 35–39, and over 40. The highest level of education achieved are represented by binary variables that indicate whether the woman did not complete 9 years of formal education, completed between 9 and 11 years of formal education, and completed 12 or more. Marital status distinguishes single women from those who are married or in an unmarried partner relationship. We capture the reproductive history of the woman through four dichotomous variables that account for the number of previous live births (0, 1, 2, 3 and 4 or more). Based on the mother’s BMI prior to pregnancy, we construct three dichotomous variables: underweight (BMI<18.5), normal weight (18.5 ≤BMI<25), overweight (25 ≤BMI<30) and obese (BMI≥30). We consider whether the pregnancy is multiple and if the mother had hypertension prior to getting pregnant. In addition, we consider whether the health care provider is public or private, the region of birth,\(^6\) and the gender of the child. In order not to eliminate observations with missing data, we impute a few dichotomous variables, assigning a value of 0 to these variables if the data is missing and adding an indicator that the variable was imputed.\(^9\)

4. Methodology

We define pregnancies exposed to the pandemic as those with an expected date of birth between March 14, 2020, the day after the first case of COVID-19 appeared in the country, and December 4, 2020. These

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\(^3\) Additionally, other studies conducted at the hospital level also found positive effects of lockdown on newborn health: Matheson et al. (2021) for Australia, Huseynova et al. (2021) for Saudi Arabia, Meyer et al. (2021) for Israel, De Curtis et al. (2021) for Italy, Berghella et al. (2020) for Philadelphia and Bian et al. (2021) for Wuhan (China).

\(^4\) Also found by Arnaez et al. (2021) in 13 hospitals from Castilla-y-León in Spain and Wood et al. (2021) and Handley et al. (2021) for 4 and 2 hospitals in Massachusetts and Philadelphia, respectively.

\(^5\) Lin et al. (2021) also find increases in the rate of prematurity in a Shanghai hospital. Similarly, in an analysis of the main public maternity ward in Uruguay (addressing low income population), Briozzo et al. (2021) find an increase in the incidence of prematurity, low birth weight and small for gestational age.

\(^6\) The date of conception is based on the date of the last menstruation plus 2 weeks.

\(^7\) Uruguay is divided in 19 administrative regions, called departments. Montevideo is one of them, in addition to being the capital of the country.

\(^8\) For each imputed variable, we created an additional dichotomous variable that took the value of 1 if the observation had been imputed and 0 otherwise. Except for the BMI categories, that require imputing 15% of the observations, the fraction of imputed observations does not exceed 6% for other variables (6% for education, 4% for marital status, 2.2% for parity, and 4% for hypertension).
were pregnancies conceived between June 21, 2019 and March 13, 2020. We choose to anchor our analysis around the expected date of birth (conception + 38 weeks) because the actual date of birth is endogenous to the pandemic. To discard potential effects of the pandemic on maternal fertility, we restrict our data to pregnancies conceived between June 21, 2019 and March 13, 2020. We choose to anchor our analysis around the expected date of birth (conception + 38 weeks) because the actual date of birth is endogenous to the pandemic. To discard potential effects of the pandemic in 2020 relative to pregnancies a few months before, we define four periods based on the pregnancy expected date of birth (see Fig. 2). Let \( T_{id} \) define the expected year of birth for pregnancy of women \( i \) with expected date of birth \( d; T_{id} = 1 \) for pregnancies with expected date of birth between December 5, 2019 and December 4, 2020, whereas \( T_{id} = 0 \) for pregnancies with expected date of birth in the previous 12-month period, from December 5, 2018 to December 4, 2019. Let \( C_{id} \) indicate a set of specific set of calendar days within each of the two 12-month periods, that coincide with the dates of exposition to the pandemic in 2020: \( C_{id} = 1 \) for pregnancies with expected date of birth between March 14 and December 4, and \( C_{id} = 0 \) for pregnancies with expected date of birth between December 5, 2019 and March 13, 2020. Pregnancies with expected date of birth during the pandemic are represented by \( T_{id} = 1 \) and \( C_{id} = 1 \), the shaded area in Fig. 2.

Our analysis pursues the following exercise. The IT-DD parameter of interest is \( \beta \), defined as follows:

\[
\beta = (\bar{y}_{11} - \bar{y}_{10}) - (\bar{y}_{01} - \bar{y}_{00}),
\]

where \( \bar{y}_{1i} \) represents the average outcome for pregnancies in \( T_{id} = 1 \) and \( C_{id} = 1 \), \( \bar{y}_{0i} \) represents the average outcome for pregnancies in \( T_{id} = 1 \) and \( C_{id} = 0 \), \( \bar{y}_{10} \) represents the average outcome for pregnancies in \( T_{id} = 0 \) and \( C_{id} = 1 \), and \( \bar{y}_{00} \) represents the average outcome for pregnancies in \( T_{id} = 0 \) and \( C_{id} = 0 \). Expressed in terms of \( T_{id} \) and \( C_{id} \), and considering covariates, the equation we estimate is:

\[
y_{id} = \alpha_0 + \alpha_1 T_{id} + \alpha_2 C_{id} + \beta T_{id} C_{id} + \alpha_3 X_{id} + \epsilon_{id},
\]

where \( y_{id} \) represents an outcome variable (health at birth or prenatal care use) for mother \( i \) with expected date of birth \( d \). \( X_{id} \) is a set of control variables that include mother’s age, marital status, education, number of previous live births, maternal pre-pregnancy BMI categories and hypertensive condition, whether the healthcare provider is public or private, region of birth, the gender of the child, and an indicator of multiple pregnancy. \( \epsilon_{id} \) is an idiosyncratic error term.\(^9\)

The estimate of \( \beta \) that results from Eq. (2) avoids confounding pandemic effects with pre-trends in outcomes and with seasonal effects by differencing out pre-trends and seasonal effects from the before/after comparison. Still, the coefficient cannot be strictly interpreted as a

\(^9\) Fig. 2 can help understand the link between Eqs. (1) and (2);

\[
\begin{align*}
\alpha_0 &= E(y_{id}|T_{id} = 0, C_{id} = 0) \\
\alpha_1 &= E(y_{id}|T_{id} = 1, C_{id} = 0) - E(y_{id}|T_{id} = 0, C_{id} = 0) = \bar{y}_{00} - \bar{y}_{01} \\
\alpha_2 &= E(y_{id}|T_{id} = 0, C_{id} = 1) - E(y_{id}|T_{id} = 0, C_{id} = 0) = \bar{y}_{00} - \bar{y}_{00} \\
\beta &= [E(y_{id}|T_{id} = 1, C_{id} = 1) - E(y_{id}|T_{id} = 1, C_{id} = 0)] + \frac{1}{3}
\end{align*}
\]

The table shows the four periods used in the analysis to construct the difference in differences. EDB = Expected Date of Birth. The shaded area depicts pregnancies exposed to the pandemic. The estimate of \( \beta \) avoids confounding pandemic effects with pre-trends in outcomes and with seasonal effects by differencing out pre-trends and seasonal effects from the before/after comparison. Still, the coefficient cannot be strictly interpreted as a
causal effect as it does not arise from the comparison with a counterfactual, that is, a control group of pregnant women over the same times period unaffected by the pandemic.

We estimate Eq. (2) by ordinary least squares for the full sample, accounting for multiple hypotheses testing using the Romano and Wolf (2005) stepdown method.\textsuperscript{10} For outcomes that are statistically significant on average, we explore heterogeneity by women’s education; type of health care provider (public or private); mother’s risk factors (as proxied by mother’s age and mother’s smoking status); and mother’s time constraints, captured by the number of previous children. We use the Romano Wolf algorithm to adjust for the testing of multiple outcomes and multiple samples within each category. Additionally, in order to analyze heterogeneity by the timing of exposure of the pregnancy to different periods of the pandemic, we perform an event study that provides average estimates by expected month of birth. To provide further credibility to our estimates, we show that pre-trends in outcomes are similar across the two periods and discard changes in the composition of pregnancies as a potential driver of the results. In addition, we run a traditional interrupted time series analysis with a linear trend and seasonal effects that confirms the previous estimates. We also analyze heterogeneity by mother’s characteristics. In Section 6, we explore different channels behind the findings.

5. Results

5.1. Descriptive statistics

Table 1a presents descriptive statistics for the outcome variables. The rate of MLBW is 6.7%, 1.4% of pregnancies have VLBW, 8.3% are MPTB, 1.5% have VPTB, and 0.5% are born dead (SB). Regarding prenatal care, 81.2% initiate prenatal care in the first trimester and 69.0% have at least 9 prenatal care visits. The average number of visits during the 1st, 2nd, and 3rd trimesters is 2.81, 2.87, and 2.84, respectively.

Table 1b depicts pregnancy and mother characteristics. Regarding age, 70.8% of the women are aged 20–34, 11.7% are adolescents and 17.5% are 35 or older. In terms of education, the sample is almost split in thirds between mothers with less than 9 years of completed education, mothers with between 9 and 11 years, and mothers with 12 or more. 82.7% of women are married or in an unmarried partner relationship, and 2.6% have hypertension before pregnancy. 43% have no other children. One in four women is overweight, 18.3% are obese and 2.6% have hypertension before pregnancy. 43% have no other children. Three out of five pregnancies are cared for by a private provider and delivered in a private hospital, and 53.5% of births take place in Montevideo.

\textsuperscript{10} The Romano Wolf correction returns multiple-testing adjusted p-values that do not suffer from inflated rates of Type I error. The difference with more traditional adjustments, such as the Bonferroni correction, is that the Romano Wolf procedure considers the dependence structure of test statistics via resampling and has a stepwise nature, which results in an improved ability to correctly reject the false null hypotheses (Clarke et al., 2020).
We find that it is associated with increases in the rates of VLBW and VPTB of 16.2% and 13.1% respectively relative to the sample means. We also both MLBW and MPTB by 1.1% point (pp), representing decreases of 0.4 pp, a rise of 28.6% and 26.7% respectively. All of these estimates are robust to the Romano Wolf adjustment for multiple hypotheses testing.

When assessing the direct epidemiologic mechanisms behind the results, we find that the major driver of VLBW is an increase in VPTB, whereas for pregnancies that improve outcomes, the decreases in MLBW are associated with a lower incidence of MPTB. In both cases, effects on birthweight appear to work through the length of gestation rather than through a slower intrauterine growth.

In Panel B of Table 2, we open the above effects by the extent of exposure of the pregnancy to the pandemic. We consider three groups. The first one includes pregnancies with expected date of birth during the most stringent period of policy responses (first three months of the pandemic, from March 14 to June 13, 2020). These were exposed to the pandemic during their 2nd trimester. The second group considers pregnancies with expected date of birth between June 14 and September 13, 2020 (months 4–6 from the start of the pandemic), when mobility restrictions were substantially relaxed. These pregnancies faced the most stringent policy response period during their 2nd trimester.

Finally, the third group includes pregnancies with expected date of birth from September 14 to December 5, 2020 (7–9 months after the start of the pandemic). These pregnancies were fully or almost fully exposed to the pandemic, with the most stringent mobility period occurring during their 1st trimester.

We find that pregnancies in the second and third groups (with expected dates of birth 4–9 months after March, 2020) were more likely to decrease MLBW and MPTB and to increase VPTB and VLBW. The impacts on MLBW and MPTB are larger in magnitude, more precisely estimated, and more likely to be robust to multiple hypotheses testing for pregnancies with expected date of birth in the last period (7–9 months after March 2020), which were exposed to the pandemic during their three trimesters of pregnancy. The effects on VLBW and VPTB are slightly larger and more precisely estimated, on the other hand, for pregnancies with expected date of birth 4–6 months after the arrival of the virus in the country, although the effects are marginally non-significant after adjusting for multiple hypotheses. These are pregnancies exposed to the pandemic during their 2nd and 3rd trimesters.

Considering that the most disruptive period occurred in the first three months of the pandemic, and assuming that pregnancies were more likely to be affected during this period, the above results indicate that the pandemic affected pregnancy outcomes (both positively and negatively) mainly during their 1st and 2nd trimesters. We cannot dismiss, however, that other periods had also an impact, and our analysis does not allow us to completely identify periods of the pandemic from trimesters of pregnancy.\(^{12}\)

\(^{11}\) We also run the analysis on low birth weight (birthweight < 2500 g), aggregating the low and moderate low birth weight outcomes. We find a coefficient of 0.07 (p = 0.11), marginally insignificant, but suggestive that the decreases in MLBW prevail over the increases in VLBW. We keep the outcomes separate because they disclose one of our key findings: the fact that the pandemic adversely affected birth outcomes for certain pregnancies, but improved them for others.

\(^{12}\) As mentioned before, pregnancies in the first group were only exposed during their third trimester, while pregnancies in the third group were the only ones to be exposed during their first trimester.
Fig. 3 expands the analysis above by expected month of birth. The x-axis shows the number of months between the date the pandemic arrived in the country and the pregnancy’s expected date of birth. Period 0 includes the 31 days ending in March 13, 2020. The figure shows difference-in-differences coefficients for each expected month of birth. Unlike the analysis in Table 2, which uses the three months before the pandemic to estimate the first difference, the estimates in Fig. 3 use only one pre-pandemic month for comparison. We do this in order to test the hypothesis of no pre-trends. We also run alternative event studies using two and three pre-pandemic months as comparison groups, and results remain robust.13

13 Results are available upon request.

5.3. Event study

Fig. 3 expands the analysis above by expected month of birth. The x-axis shows the number of months between the date the pandemic arrived in the country and the pregnancy’s expected date of birth. Period 0 includes the 31 days ending in March 13, 2020. The figure shows difference-in-differences coefficients for each expected month of birth. Unlike the analysis in Table 2, which uses the three months before the pandemic to estimate the first difference, the estimates in Fig. 3 use only one pre-pandemic month for comparison. We do this in order to test the hypothesis of no pre-trends. We also run alternative event studies using two and three pre-pandemic months as comparison groups, and results remain robust.13

13 Results are available upon request.
pregnancy parity, hypertensive condition, multiple pregnancy, region of birth, and type of hospital (public or private).

As in the previous analysis, we observe mixed results. We find both decreases in MLBW and MPTB and increases in VLBW and VPTB. There is not a clear pattern, though, with respect to the timing of the effects. The estimates for MLBW are negative and statistically significant for pregnancies with expected dates of birth 2, 5 and 8 months after the start of the pandemic. Most other point estimates are also negative, although imprecisely estimated. There is some evidence of a larger drop in MLBW in MPTB. As in the aggregate analysis, the decreases in MLBW appear to be led by decreases in MPTB.

Regarding the more severe outcomes (VPTB and VLBW), Fig. 3 shows positive, although imprecisely estimated, effects. Both VPTB and VLBW are low incidence events, affecting our power to reject the null when significant effect for pregnancies with expected date of birth in July 2020 (consistent with the findings in Table 2, Panel B). As in the aggregate analysis, the decreases in MLBW appear to be led by decreases in MPTB.

The fact that we find opposite effects in VLBW/VPTB and MLBW/MPTB raises the question of whether we are observing a shift in the distribution of birth outcomes to the left; whether pregnancies that would have ended in a moderate low birth weight in the absence of the pandemic end up with very low birth weight. We do not find support for this conjecture. If the results were due to a shift in the distribution, we should see the largest increases in VLBW/VPTB in the same expected months of birth we observe the largest decreases in MLBW/MPTB. We do not observe such pattern. Note also that there is a decrease of 1.1 pp on MLBW but an increase of only 0.4 pp on VLBW (nearly three times smaller), suggesting that the number of women with improved birth outcomes exceeds the number with more adverse outcomes. We further reinforce this point when assessing heterogeneity.

Our analysis assumes that, in the absence of the external shock, pregnancies with expected date of birth during the pandemic (between March 14, 2020 and December 4, 2020) would have had the same linear trends in outcomes as those with expected date of birth some months before. We can check this assumption by looking at the pre-trends in the event study in Table 3. We find no statistically significant effects for pregnancies with expected date of birth between mid-December 2019 and mid-March 2020 (not exposed to the pandemic), supporting the hypothesis of no pre-trends.

As in the previous analysis, we observe mixed results. We find both decreases in MLBW and MPTB and increases in VLBW and VPTB. There is not a clear pattern, though, with respect to the timing of the effects. The estimates for MLBW are negative and statistically significant for pregnancies with expected dates of birth 2, 5 and 8 months after the start of the pandemic. Most other point estimates are also negative, although imprecisely estimated. There is some evidence of a larger drop in MLBW in MPTB. As in the aggregate analysis, the decreases in MLBW appear to be led by decreases in MPTB.

Regarding the more severe outcomes (VPTB and VLBW), Fig. 3 shows positive, although imprecisely estimated, effects. Both VPTB and VLBW are low incidence events, affecting our power to reject the null when assessing effects by month. We can only identify one statistically significant effect for pregnancies with expected date of birth in July 2020 (4 months after March 14, 2020). These pregnancies faced the end of their second trimester and beginning of their 3rd trimester during the first months of the pandemic (March-May 2020), when the levels of mobility decreased most.\textsuperscript{14} We do not find strong evidence of changes in BW or SB.

\textsuperscript{14} Because VPTB implies that the birth happened at least 8 weeks before time, the real levels of exposure to the pandemic were less than 4 months.
5.4. Robustness

We first check for robustness by running an interrupted time series analysis as follows:

\[ y_{it} = y_0 + \gamma_1 L_{it} + \delta P_{it} + \gamma X_{it} + \mu_{m(it)} + \epsilon_{it}, \]

(3)

where \( L_{it} \) is a linear time trend capturing pre-pandemic trends in the outcome, \( P_{it} \) is a dichotomous variable equal to 1 for pregnancies with expected date of birth between March 14, 2020 and December 4, 2020 (the pandemic period), and 0 if the expected date of birth was between December 5, 2018 and March 13, 2020 (the pre-pandemic period). \( X_{it} \) is the same set of covariates described in Eq. (2), and \( \mu_{m(it)} \) are calendar month fixed effects included to address seasonality. We use the same sample as in the previous analysis. Results are depicted in Appendix Table A1 and are very similar to those in Table 2.

One concern is that mothers’ composition may have changed during the period. Appendix Table A2 shows unadjusted DD estimates when the dependent variable is one of the covariates (mother or pregnancy characteristics) used in the main analysis. Women expected to deliver in the pandemic period are slightly more likely to be aged 20–24, and to be obese, but only at a significance level of 10%. At a 5% level of significance, we only find a lower proportion of married women, and a higher proportion of women in unmarried partner relationships. This finding captures a cultural change in Uruguayan society, but does not translate into changes in the composition of births, as these mothers are very similar in terms of birth outcomes. None of the other characteristics correlates with the pandemic. Estimates for the full sample remain practically identical to those in Table 2 when re-estimating the DD without controls, confirming that composition changes are not the drivers of the results.\(^{15}\)

Finally, the composition of births during the pandemic could have changed due to changes in the number of abortions. In Uruguay, abortion is legal up to the 12th week of pregnancy since December 2012. Due to higher barriers to access, such as less frequent public transportation, lack of information about the operating schedules of clinics, or fear about infection, the pandemic could have led to decreases in abortions in pregnancies conceived just before March 13, 2020. Based on monthly data on abortion for the full country, we estimate the DD between abortions in May-June and abortions in January-March across the years 2020 and 2019, and find a small decrease of 36 pregnancies voluntarily aborted. Based on monthly data on abortion for the full country, we estimate the DD between abortions in May-June and abortions in January-March across the years 2020 and 2019, and find a small decrease of 36 pregnancies voluntarily aborted.\(^{16}\)

Table 3 depicts heterogeneity in birth outcomes by mother’s education, type of health care provider, number of other children, and maternal risk factors (smoking status and age). Panel A shows that the observed increases in VLBW and VPTB occur mainly in births to women with less than 9 years of education. Both estimates are around 1 pp, representing quite large increases relative to the pre-pandemic average rates of 1.4% and 1.5%, respectively. The VLBW coefficient remains statistically significant at the 5% level once we adjusting for multiple hypotheses testing,\(^{17}\) but the p-value for the VPTB estimate marginally loses statistical significance (\( p = 0.104 \)).

Results in Panel B suggest that the higher rates of VLBW are also most apparent for mothers delivering in the private sector (0.6 pp). The decrease in MLBW, on the other hand, appears to occur mainly in the public sector (–1.6 pp). Both effects, however, become marginally insignificant (\( p = 0.12 \)) once we correct for multiple hypotheses testing. These results are somehow unexpected as, conditional on the level of education, women in the public sector tend to be of lower socioeconomic status than women in the private sector; they are less likely to work, to have a formal job or to be the partners of a formal worker and have higher pregnancy risks. On the other hand, as we will see later, the findings are consistent with a larger decrease in prenatal care use in the private sector.

In Panel C of Table 3 we find that the incidence of VLBW is higher among women with previous children. Having other children at home increases VLBW by 0.6 pp, an effect statistically significant even after adjusting for multiple hypotheses. Panel D shows that smoking mothers are more likely to experience increases in the incidence of VLBW and VPTB, although these effects lose statistical significance once we adjust for multiple hypotheses. On the contrary, we find positive associations between the pandemic and birth outcomes (lower likelihoods of MLBW and MPTB) only among non-smoking mothers, with effects of –1.3 pp in both cases and robust to multiple hypotheses testing. Panel E shows suggestive evidence that improvements in health at birth (lower MLBW) are more likely among younger mothers (below 35), while adverse effects (higher VLBW and VPTB) are more likely among mothers 35 or older. We fail again, however (marginally), to reject the null of zero effect after adjusting for multiple hypotheses testing.

As with the event study in Fig. 3, the results above indicate that we are not observing a shift in the general distribution of birth outcomes towards more severe results. On the contrary, we are able to identify distinct groups of women that either experience improvements, or suffer adverse outcomes. Mothers with low education, other children, and smokers are more likely to experience adverse results, whereas we observe better outcomes among non-smoking and younger mothers.

6. Mechanisms

The pregnancies we study here were unlikely to suffer from complications due to infections with SARS-CoV-2. As noted before, there were very few infections among pregnant women in Uruguay in 2020, none with lethal outcomes, and all of them between October and December, eliminating concerns about the detected effects being led by SARS-CoV-2 infections. In addition, while the spread of COVID-19 may have also affected family’s fertility decisions, the births analyzed here were conceived before COVID-19 broke into the country.

There are several environmental and socioeconomic reasons, however, why the pandemic may have affected inputs required for the production of a healthy pregnancy (Grossman, 1972; Corman et al., 2019). In what follows, we explore how changes in inputs such as prenatal care or environmental characteristics, as well as changes in time and income, relate to the production of birth outcomes during the pandemic.

6.1. Lower access to prenatal care

As mentioned in Section 2, on April 2020 the Ministry of Public Health recommended obstetricians to evaluate whether they could delay on-site obstetric controls in the case of low-risk pregnancies, without affecting their safety and quality. This led many obstetricians to shift prenatal visits to a remote (mostly on-the-phone) modality. Due to the way prenatal visits are registered (the pregnant woman must bring a pregnancy card to each visit, which is completed by the obstetrician),

\[^{15}\text{Results of this exercise are available upon request.}\]

\[^{16}\text{Source: DIGESA, Ministry of Public Health.}\]

\[^{17}\text{Note that for each panel, we adjust for multiple hypotheses that consider the different outcomes and the different samples. For example, in Panel A we adjust for the fact that we test 12 hypotheses (4 outcomes and 3 samples).}\]
remote visits were unlikely to be registered in the pregnancy records.\(^{18}\) Therefore, a decrease in the number of prenatal visits does not necessarily reflect the total absence of controls, but decreases in on-site visits.

Table 4 analyzes the association between the COVID-19 pandemic and prenatal care use for the full sample of births, employing the same method as in Eq. (2). The number of prenatal care visits falls by 5.5% during the 2nd trimester of pregnancy, a decrease of 0.158 visits compared to a pre-pandemic mean of 2.85 visits. The number of visits in the 3rd trimester falls by 0.068, 1.5% below the pre-pandemic sample mean of 4.61 visits. The likelihood of having at least 9 visits falls by 5.5 pp (7.7%). We find no statistically significant coefficient on the initiation of health care in the 1st trimester, the number of prenatal care visits in the 1st trimester, or the likelihood of a C-section.\(^{19}\) Visits during the 2nd trimester and the likelihood of at least nine visits are robust to the Romano Wolf adjustment for multiple hypothesis (p < 0.01), while the effect on 3rd trimester visits marginally exceeds the 10% level after this adjustment.\(^{20}\)

The event study in Fig. 4 depicts prenatal care use by mother’s expected month of birth. The largest drops in prenatal care occur in the trimesters that coincide with the pandemic’s period of lower mobility (March-May 2020). Pregancies with expected date of birth in the first months after the pandemic arrived in the country, suffered decreases in access to prenatal care during their 3rd trimester. Pregancies with expected date of birth 4–6 months after March 14, 2020 experienced the largest drops in prenatal visits during their 2nd trimester. And pregnancies with expected date of birth towards the end of 2020 were more likely to delay their initiation of care and showed a lower access to face to face visits during the 1st and 2nd trimesters of pregnancy.

Table 5 analyzes heterogeneous associations between the pandemic and the use of prenatal care by maternal education and provider type, for outcomes that were statistically significant in Table 4. Results in Panel A show decreases in the number of visits in the 2nd trimester and in the likelihood of having at least nine prenatal care visits for mothers of all education levels. Mothers with less than 9 years of education show a lower number of visits in the 3rd trimester. There is a stark difference, however, between mothers getting care from public versus private providers (see Panel B). Mothers in the private sector experience almost three times the decrease in the number of visits during the 2nd trimester relative to those in the public sector. And their likelihood of having at least nine prenatal care visits falls by 7 pp, doubling the reduction of 3.6 pp observed for mothers in the public sector.

In terms of the relationship between visits and birth outcomes, we saw in Table 3 (Panel B) that higher rates of VLBW were most likely among mothers delivering in the private sector, while lower MLBW occurred mainly in the public sector. These findings are consistent with the stronger declines in the use of prenatal care by women in the private health care sector and with prior literature showing that prenatal care is positively associated with birth outcomes (Grossman and Joyce, 1990; Currie and Grogger, 2002; Balsa and Triunfo, 2015; Corman et al., 2019). The lower use of face-to-face prenatal care in the private sector, however, was quite unexpected. Women in the private sector usually show higher levels of prenatal care use than those in the public sector, leading us to conjecture that the additional reduction in private care must have been induced by supply forces.

6.2. Negative economic shocks

As mentioned in Section 2.2, the economy suffered an important contraction during 2020. We do not have income information in the data, so we assess socioeconomic status by mother’s level of education. In Table 3, Panel A, we found that VLBW and VPTB increased mainly for women with less than 9 years of education. Because income per capita for these women ranges around the poverty line, a decrease in income may have led to unsatisfied basic needs, in particular food insecurity, and high levels of economic stress.\(^{22}\) Our results are consistent with the findings in Kaplan et al. (2017) and De Cao et al. (2022), who show that higher unemployment increases low birth weight for infants born to mothers of lower socioeconomic status.

6.3. Time constraints

The decreased mobility disrupted childcare arrangements, increasing time, physical and emotional demands on mothers with other children, in particular of working mothers who had to make working from home compatible with childcare. Not only were schools and preschools closed from March 15 to July 2020, but families could not count on the elderly or other caregivers to take care of their children due to the sanitary risks involved. Moreover, women were more likely to work from home than men,\(^{23}\) in particular women with higher education and of higher socioeconomic status (Amarante et al., 2021; Espino et al.,

\(^{18}\) The data we use (SIP) are digitalized directly by the health care institution at the time of birth, based on the information contained in the mother’s pregnancy card, which is in paper format in the woman’s hands and, unfortunately, not available online.

\(^{19}\) The rate of C-section in Uruguay is quite high, in particular in the private sector. We initially conjectured that we would find an increase in C-sections in the private sector given its higher prevalence and the way hospitals managed deliveries during the first months of the pandemic (women in labor were isolated and, for a while, not allowed to have a partner during labor). The lack of an effect on C-sections, however, suggests this was not the case. Furthermore, increased prematurity is unlikely to respond to increases in medically indicated C-sections relative to spontaneous births.

\(^{20}\) As in the analysis of birth outcomes, we analyze pre-trends across the two comparison samples, and find that the assumption of similar pre-trends holds. We do not show these results for the sake of space, but they are available upon request.

\(^{21}\) In a survey of Uruguayan families with young children, Balsa et al. (2021) find that households with lower levels of education and recipients of state assistance were more likely to suffer from negative economic shocks linked to COVID-19, including unemployment, income declines, debt, and food insecurity.

\(^{22}\) Women are more likely to work in sectors such as communications, services to firms and community services, which were more adaptable to hybrid formats than other sectors.
Fig. 4. Event Study: Prenatal Care Outcomes by Expected Date of Birth. Notes: The x-axis denotes the pregnancy’s expected month of birth, relative to period 0, which corresponds to pregnancies with expected date of birth between February 12 and March 13, 2020. The period – 3 has larger standard errors because it is shorter than the others (it includes pregnancies with expected date of birth between December 5-December 19, 2019).
reinforcing the gender gaps in non-remunerated work in these households. According to a survey administered in Uruguay in April 2020, women passed from allocating 6.9–8.1 daily hours to childcare and household chores, while men increased their contribution from 3.9 to 4.6 daily hours (ONU Mujeres and UNICEF, 2020). Several studies suggest that mothers with children who worked from home during 2020 were at higher risk of burnout. For example, a study for Mexico found that women assumed the reconfiguration of childcare arrangements in 2020 at the cost of their work performance and personal life, with an unprecedented exacerbation of risks to their physical and mental health (PNUD, 2021). For Uruguay, Balsa et al. (2021) surveyed families with children below the age of two, and found that households with higher education were more likely to report difficulties in reconciling care and work, and with the management of time. Households reporting these difficulties also showed higher levels of maternal depression, and a higher probability of psychological aggression towards the child.

In Table 3, Panel C, we find that the higher incidence of VLBW is larger among women with previous children, even after accounting for other factors such as maternal education, age, region, marital status, previous comorbidities, and type of provider. Our results are consistent with the hypothesis that higher time demands for women with previous children increased maternal stress and deteriorated pregnancy intrauterine conditions.

### 6.4. Risky behaviors and pregnancy risks

Higher stress due to the economic crisis could have also led women to increase their engagement in risky behaviors. Based on data on smoking status by trimester of pregnancy, we explore whether women that were smoking in the 1st trimester were less likely to quit by the 3rd trimester during the pandemic. Appendix Table A3 shows that approximately 46% of women quit smoking during pregnancy, but quitting rates are not different across pandemic and pre-pandemic periods. This result is in line with previous literature (Dehejia and Lleras-Muney, 2004) showing that fertility-aged women do not engage in riskier health behaviors during recessions.

While the pandemic does not seem to have increased risky behaviors, or at least smoking during pregnancy, its adverse effects were definitely stronger among mothers with risk factors. In Panel D of Table 3, we showed suggestive evidence that smoking mothers were more likely to experience increases in VLBW and VPTB, while positive effects (lower MLBW and MPTB) were more likely among non-smoking mothers. These results are similar to those in Alessie et al. (2018), who find that higher unemployment decreases birthweight for children born to older and smoking mothers. Other literature has even identified a positive association between recessions and healthy behaviors, including exercise, sleep and nutrition (Ruhm, 2000). We are unable to check this with our data, but healthier habits could also help explain the improvements in birth outcomes.

#### 6.5. Pollution

We already mentioned in Section 2 that the levels of PM 2.5 in Montevideo did not suffer important changes between 2020 and 2019 and that air quality is generally good in the country. Thus, better air quality does not seem to be the reason behind the observed decreases in MLBW and MPTB.

#### 6.6. A quieter and healthier lifestyle

Lower access to prenatal health care, negative economic shocks, and difficulties with the increased burden of childcare are all potential explanations for the higher incidence of VPTB and VLBW. There is a less clear explanation for the decreases in MLBW and MPTB. Because lower pollution is unlikely to be the trigger, the one hypothesis that is compatible with the data is that some women experienced improvements in the intrauterine habitat as a consequence of the stay at home restrictions (Phillips et al., 2020; Hedermann et al., 2020). For these women, the environmental changes associated with the pandemic could have led to a reduction in the tensions related to work and

### Table 5

| Education | N visits 2nd trim. | N visits 3rd trim. | At least 9 prenatal care visits |
|-----------|-------------------|-------------------|--------------------------------|
| DD Less than Middle School, < 9 yrs (N = 19,877) | -0.133 ** | -0.136 * | -0.054 ** |
| DD Incomplete High School, 9≤ yrs < 12 (N = 21,793) | -0.159 ** | 0.013 | -0.042 ** |
| DD Completed High School, yrs ≥12 (N = 25,009) | -0.188 ** | -0.079 | -0.071 ** |

Notes: *p < 0.1; **p < 0.05; ***p < 0.01. Coefficients and robust standard errors in parentheses. Romano Wolf p-values that adjust for multiple hypotheses testing within each panel are reported in squared brackets (250 replications). Regressions adjust for mother age, education, marital status, pre-pregnancy body mass index, pregnancy parity, hypertensive condition, multiple pregnancy, region of birth, and type of hospital (public or private).

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23 Amarante et al. (2021) show that the incidence of teleworking was 4% in March 2020, 14% in the second trimester of 2020, and 9% in the rest of the year. Among workers with less than 12 years of education, only 2% report working from home, but this is 30% for those with 16 or more years of education. Espino et al. (2021) show that teleworking for women almost doubled working from home, but this is 30% for those with 16 or more years of education. Espino et al. (2021) show that teleworking for women almost doubled working from home, but this is 30% for those with 16 or more years of education.
transportation, lower exposure to infections (due to lower social interactions and increased focus on hygiene), and more opportunities for exercising and eating healthier at home.

Our results in Table 2, panel B, together with the event study analysis, suggest that the decreases in MLBW and MPTB were more likely among pregnancies exposed to the most stringent mobility restrictions during their 1st and 2nd trimesters. Other studies have found an association between exposure to stress during the early stages of the pregnancy and adverse health at birth (Camacho, 2008; Quintana-Domeque and Rödenas-Serrano, 2017; Bravo and Castello, 2021). Our analysis indicates that the mobility restrictions improved the intrauterine habitat during the initial stages of pregnancy, probably by reducing stress and exposure to unhealthy environments.

7. Conclusions

In this paper, we use an interrupted time series difference-in-differences technique to assess the association between the COVID-19 pandemic during 2020 and birth outcomes in Uruguay. We find important heterogeneities across pregnant women. On the one hand, we find improvements in birth outcomes (decreases in MLBW and MPTB), among non-smoking and younger women. Such results relate to those encountered at the national level by Caniglia et al. (2021), Hedermann et al. (2020), and Been et al. (2020), and many others at the local level, who find that the pandemic decreased preterm births. On the other hand, our results show an increase in VLBW and VPTB for women of low education and in private health care, in line with those found by Main et al. (2021) for Latino and Hispanic communities in California.

We discuss several hypotheses consistent with our negative findings. First, we consider the role played by prenatal care in explaining the adverse outcomes. We find that private providers were more likely to decrease face-to-face visits than public providers, and that outcomes were worse in the private sector. Our results also suggest that the economic recession, with its material and psychological consequences, and an increased burden of stress related to childcare during the pandemic impacted also in the deterioration in birth outcomes.

In terms of the positive results, we discard improvements in air quality as a mediator, and conjecture that the pandemic may have induced a quieter and healthier lifestyle for certain groups of women (middle income women with no children and non-smokers). Infection with SARS-CoV-2 was not an issue among Uruguayan pregnant women in 2020.

We improve upon prior literature by using national level rather than single center data, anchoring the analysis around pregnancies with the same expected date of birth, using an interrupted time-series difference in difference to account for pre-trends and seasonality, and refining the analysis of mechanisms (Goldenberg and McClure, 2021). We are unaware of other papers exploring the distinctive influences of the various channels triggered by the COVID-19 pandemic on health at birth.

Our findings have several implications for policy and future research. First, they identify the groups hit the hardest by the pandemic and contribute to orient policy makers aiming at mitigating its impacts. The identification and follow-up of children born with very low weight or very prematurely may contribute to avoid future health and developmental disparities. Second, our results contribute to shed light on the mechanisms behind the effects, which can help understand the consequences of future shocks on birth outcomes. Third, in the context of a new post-pandemic scenario, in which hybrid health care is here to stay, our findings underscore the importance of improving information systems, defining online alerts that can identify pregnancy risks and help obstetricians make informed decisions about whether to recommend a face-to-face rather than an online visit, or remind the patient about the relevance of showing up. Results also call for reducing barriers to access for those women with low education and for incentivizing providers to deliver quality care, defining protocols for telemedicine and enforcing the implementation of such protocols. Fourth, the economics literature has explored earthquakes, hurricanes, plant layoffs, or domestic violence (Torche, 2011; Currie and Rossin-Slater, 2013; Carlson et al., 2015; Currie et al., 2022) to assess the effect of stress on pregnancy outcomes. However, there is hardly any evidence on the reverse effect: the passage to a less stressful and healthier environment. Future research should explore the specificities behind the pandemic’s contribution to a better intrauterine habitat.

Acknowledgments

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Appendix

See appendix Table A1, Table A2, Table A3.

Table A1

| Birthweight (BW) | Moderate low birth weight (MLBW) (1500 ≤ kg < 2500) | Very low birth weight (VLBW) (<1500 g) | Moderate Preterm (MPTB) (32≤wks<37) | Very Preterm Birth (VPTB) (<32 wks.) | Stillbirth (SB) |
|------------------|-----------------------------------------------|--------------------------------------|--------------------------------------|--------------------------------------|----------------|
| Exposed to the pandemic | 4.912 | -0.009 ** | 0.004 ** | -0.009 ** | 0.005 *** | 0.001 |
| Pre-pandemic mean | (8.785) | (0.004) | (0.002) | (0.004) | (0.002) | (0.001) |
| Outcome mean | 3261.291 | 0.068 | 0.014 | 0.084 | 0.015 | 0.005 |

Notes: *p < 0.1; **p < 0.05; ***p < 0.01. The table shows coefficients and robust standard errors in parentheses for \( p_d \) (an indicator of exposure to the pandemic) in Eq. (3). Romano Wolf p-values that adjust for multiple hypotheses testing within each panel are reported in squared brackets (250 replications). Regressions adjust for mother’s age, education, marital status, pre-pregnancy body mass index, pregnancy parity, hypertensive condition, multiple pregnancy, region of birth, and type of hospital (public or private).
Table A2
Difference-in-Differences in Pregnancies’ and Mothers’ Characteristics.

|                 | Period 00 | Period 01 | Period 10 | Period 11 | DD [(4)-(3)] - [(2)-(1)] |
|----------------|-----------|-----------|-----------|-----------|--------------------------|
| **Age**        |           |           |           |           |                          |
| Under 16       | 0.026     | 0.025     | 0.023     | 0.022     | 0.001                    |
| 17 – 19        | 0.097     | 0.096     | 0.089     | 0.089     | 0.001                    |
| 20 – 24        | 0.241     | 0.230     | 0.233     | 0.234     | 0.012 *                  |
| 25 – 34        | 0.468     | 0.473     | 0.476     | 0.477     | -0.004                   |
| 35 – 39        | 0.131     | 0.136     | 0.142     | 0.139     | -0.009                   |
| Over 40        | 0.037     | 0.039     | 0.038     | 0.039     | -0.001                   |
| **Education**  |           |           |           |           |                          |
| Incomplete     | 0.316     | 0.303     | 0.296     | 0.274     | -0.009                   |
| high school, 9 | 0.327     | 0.326     | 0.324     | 0.329     | 0.005                    |
| Completed high | 0.358     | 0.371     | 0.380     | 0.385     | -0.008                   |
| school, ≥12    |           |           |           |           |                          |
| **Marital Status** |         |           |           |           |                          |
| Single         | 0.164     | 0.170     | 0.164     | 0.164     | -0.005                   |
| Married        | 0.194     | 0.203     | 0.204     | 0.199     | -0.013 **                |
| Unmarried partner |        |           |           |           |                          |
| relationship   | 0.635     | 0.622     | 0.627     | 0.630     | 0.017 **                  |
| **BMI (Pre-Pregnancy)** |       |           |           |           |                          |
| Underweight    | 0.052     | 0.053     | 0.044     | 0.048     | 0.003                    |
| Normal Weight  | 0.516     | 0.506     | 0.506     | 0.492     | -0.003                   |
| Overweight     | 0.258     | 0.261     | 0.276     | 0.267     | -0.012                   |
| Obese          | 0.173     | 0.181     | 0.173     | 0.193     | 0.012 *                  |
| **Number of Children** |      |           |           |           |                          |
| No Other Children | 0.432    | 0.433     | 0.424     | 0.429     | 0.004                    |
| One            | 0.340     | 0.338     | 0.342     | 0.340     | -0.000                   |
| Two            | 0.140     | 0.142     | 0.147     | 0.144     | -0.005                   |
| Three          | 0.049     | 0.051     | 0.048     | 0.051     | 0.001                    |
| Four or more   | 0.039     | 0.036     | 0.039     | 0.036     | -0.001                   |
| **Comorbidities** |          |           |           |           |                          |
| High Blood Pressure | 0.026   | 0.026     | 0.024     | 0.027     | 0.004                    |
| **Pregnancy Characteristics** |       |           |           |           |                          |
| Multiple Birth | 0.027     | 0.029     | 0.025     | 0.027     | 0.001                    |
| Male           | 0.524     | 0.508     | 0.519     | 0.511     | 0.008                    |
| Place of delivery |          |           |           |           |                          |
| Public Healthcare Provider, Montevideo | 0.212 | 0.200     | 0.205     | 0.194     | 0.000                    |
| Private Healthcare Provider, Montevideo | 0.340 | 0.339     | 0.329     | 0.330     | 0.001                    |
| Public Healthcare Provider, Rest of the Country | 0.184 | 0.194     | 0.207     | 0.222     | 0.006                    |
| Private Healthcare Provider, Rest of the Country | 0.264 | 0.267     | 0.259     | 0.254     | -0.008                   |

Notes: The table shows means of mother and pregnancy characteristics for the full sample and the full period analyzed (all mothers giving birth in Uruguay with expected date of birth between December 5, 2018 and December 4, 2020) and for each of the periods used in the analysis. Period 00 corresponds to pregnancies with expected date of birth between December 5, 2018 and March 13, 2019; period 01 includes pregnancies with expected date of birth between March 14, 2019 and December 4, 2019; period 10 considers pregnancies with expected date of birth between December 5, 2019 and March 13, 2020; and period 11 considers pregnancies with expected date of birth between March 14, 2019 and December 4, 2020. Column (5) shows the DD in these characteristics. *p < 0.1; **p < 0.05; ***p < 0.01.

Table A3
Difference-in-differences in the probability of quitting smoking by the 3rd trimester of pregnancy.

| Period of gestation | Period 00 | Period 01 | Period 10 | Period 11 | DD [(4)-(3)] - [(2)-(1)] |
|---------------------|-----------|-----------|-----------|-----------|--------------------------|
| Changes in Smoking Habits |          |           |           |           |                          |
| Smokes in the 1st trimester and quits | 0.480 | 0.462 | 0.482 | 0.460 | -0.011 | (0.021) |

Notes: The table shows the average rates of quitting smoking during the 3rd trimester for pregnant women that smoked in the 1st trimester, for each of the periods under analysis. Column (5) shows the DD coefficient and robust standard errors in parentheses of a regression that adjusts in addition for mother’s age, education, marital status, pre-pregnancy body mass index, pregnancy parity, hypertensive condition, multiple pregnancy, region of birth, and type of hospital (public or private).

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