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RESEARCH ARTICLE

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Diverging reproductive outcomes by maternal education during the Covid-19 pandemic across Brazilian and Colombian regions

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Abstract

This work contributes to the current understanding of the heterogeneous impact of the Covid-19 pandemic on fertility. Using more than 36.4 million birth and death records for Brazil and Colombia (2015–2021), we document state-level correlations between the intensity of the pandemic, measured by the current and 9-month lagged excess mortality, and the observed number of births relative to a Covid-19-free hypothetical scenario. We disaggregate these correlations according to maternal age and years of schooling to test the hypothesis that the influence of the Covid-19 pandemic on births interacted with pre-existing forms of social inequality. Results from multivariate linear models suggest that the association between the intensity of the pandemic and the relative number of births was negative for women with at least 8 years of schooling, while it was positive or null for women with fewer years of education. This result means that in subnational areas severely hit by the Covid-19 pandemic, women with few years of schooling did not delay fertility as most women potentially did. These results suggest that disadvantaged groups in Latin America and potentially in other contexts may suffer more acutely the consequences of the Covid-19 pandemic, which has been largely neglected by studies that assume homogeneous impacts of Covid-19 on population dynamics.

KEYWORDS

Covid-19, fertility, Latin America

1 | INTRODUCTION

There is an urgent need to understand the effects of the Covid-19 pandemic on population dynamics. These effects are proving profound, comprehensive, and likely to last decades (Jatrana et al., 2022). Since the start of the pandemic, demographers have highlighted the importance of considering the impacts of Covid-19 not only on mortality but also on fertility (Aassve et al., 2020; Pesando & Abufhele, 2023; Sobotka et al., 2021), fertility intentions (Emery & Koops, 2022; Lindberg et al., 2020; Luppi et al., 2020), and migration (Ferris & Sorrell, 2021; Guadagno, 2020). Researchers have also described the impact of the pandemic on other dimensions of demographic change, including household composition, population aging, territorial distribution, and kinship networks (Verdery et al., 2020). In addition, the question of how population projections should be adjusted to reflect the impact of the pandemic on fertility has been raised (Berrington et al., 2022).

Previous studies recognize that the Covid-19 pandemic influences on reproductive outcomes will likely vary between and within countries (Aassve et al., 2021). Between-country variation stems from differences in countries' capacities to respond to the pandemic due to factors such as the quality and coverage of national health systems, access to vaccines, the timing and duration of lockdowns, levels of financial support for families, and pre-existing patterns of reproductive behaviors and rights. Likewise, within-country disparities in these factors may induce variation in how the pandemic influences reproductive outcomes across subnational areas. Subnational heterogeneity in reproductive outcomes might be particularly strong for countries with socioeconomically heterogeneous populations, large geographical areas, and weak or absent welfare policies (Castro Torres et al., 2022; Schmertmann et al., 2008).

In such contexts, subnational differences in the severity of the pandemic are likely to play a role in the linkage between Covid-19 and fertility. Women residing in severely affected local regions are more likely to experience changes in their fertility outcomes and intentions than those in less severely hit areas. These differential effects will also likely vary according to women's resource availability and socioeconomic status (Aquino et al., 2022).

There is a lack of empirical studies that specifically examine how the Covid-19 pandemic has affected fertility by socioeconomic status. Existing research often assumes that the pandemic's impact on reproductive patterns is uniform due to the severity of the crisis.[1] In addition, the countries with the most significant socioeconomic disparities have lagged in providing timely assessments of the consequences of the pandemic, despite institutional efforts to assist them in collecting this information (Binstock et al., 2021; Pesando & Abufhele, 2023). Because of inequalities in data availability and quality across countries and subpopulations, the influence of the Covid-19 pandemic on population dynamics is better understood in high-income countries. Thus, there is an urgent need to study other parts of the world, particularly Latin America (LATAM), where the impact of the pandemic has been sizable.

Assuming there has been no underreporting, Covid-19-related deaths in LATAM have accounted for approximately one-quarter of the total, and, as of September 2022, three LATAM countries (Brazil, México, and Peru) were among the top 10 countries contributing to the total number of Covid-19 deaths (Schwalb et al., 2022). When looking at relative changes in mortality during 2020 and 2021, four LATAM countries suffered the most dramatic increases (Msemburi et al., 2023). Early overarching assessments of the consequences of the pandemic suggest that the impact of Covid-19 on fertility and migration in the region will be considerable (Economic Commission for Latin America and the Caribbean, 2021).

In the LATAM context, existing disparities in access to resources for coping with the pandemic, such as information, savings, and social networks across socioeconomic groups and subnational areas, will likely deepen the differential influence of the Covid-19 pandemic on fertility patterns. Because disadvantaged populations have historically been more exposed to the negative consequences of social, economic, and health crises (Mamelund & Dimka, 2021; Mamelund & Shelley-Egan, & Rogeberg, 2021), their reproductive patterns may be more affected by the pandemic than those in privileged positions (Lobkowicz et al., 2021; Schneider & Schneider, 1996). This is likely the case for millions of families in LATAM, where more than one out of every three people lives in poverty (Economic Commission for Latin America and the Caribbean, 2022a).

In light of this background, this paper examines the association between the intensity of the Covid-19 pandemic—measured by excess mortality—and the number of births by maternal age and years of schooling at the subnational levels in Brazil and Colombia. By January 2023, these were the only two countries in LATAM with publicly available birth records including information on place of delivery, maternal age, and mothers' years of schooling. Birth records from other countries with publicly available microdata such as Mexico, were not included because 2020 and 2021 births are severely underreported (Instituto Nacional de Estadística y Geografía, 2022).

2 | BACKGROUND AND STUDY CONTEXT

2.1 | Previous studies on births during the pandemic

Theoretically, the pandemic could affect fertility through various mechanisms. Mainly through its direct influence on morbidity but also via the effects of lockdowns and other restrictive measures imposed by governments and the responses of individuals of reproductive age to economic and social uncertainty.

Shortly after its onset, researchers assumed that the pandemic could lead to either an increase or a decrease in fertility rates in the short term, depending on which of these mechanisms prevailed. On the one hand, many pathways can lead to a decline in fertility. While the worsening of morbidity that affects maternal mortality, miscarriages, fecundity, or sexual activity (Karimi et al., 2021; Seymen, 2021) might not be extensive, the indirect consequences of social isolation, lockdowns, stress, and uncertainty can affect the number of conceptions (Pesando & Abufhele, 2023). The psychological and economic impact of the death of a loved one or close kin can increase the feeling of uncertainty and reinforce this mechanism, especially when the person who died is the breadwinner in disadvantaged families (Economic Commission for Latin America and the Caribbean, 2022b). Fertility may decline if (a) the union formation

[1]A notable exception is a recent compilation of studies including several Latin American countries (Hubert et al., 2022).

rate decreases or the union dissolution rate increases, or noncohabiting couples have less sexual activity due to physical distancing, and (b) increasing economic uncertainty and a deterioration in work-life balance lead cohabiting couples to decrease their fertility intentions (Aassve et al., 2020). Moreover, in countries with high maternal ages, assisted reproductive technology cycles may have been suspended during the pandemic (Gromski et al., 2021; Somigliana et al., 2021).

On the other hand, if the stress placed on healthcare systems during the pandemic reduced women's access to contraception and abortion, especially in low- and middle-income countries or among low-income families in high-income countries, fertility may increase via unintended births (Lin et al., 2021). Additionally, in the first months of isolation due to lockdowns and the fear of contagion, there was vague speculation about a *pandemic baby boom*, given that cohabiting couples were spending more time together and thus had the opportunity to have more frequent sexual encounters. However, this hypothesis received more media coverage than academic support (Lewis, 2021).

Human gestation takes, on average, 268 days. Thus, the lag between reproductive decisions and births prevented researchers from going beyond speculating about a Covid-19 baby boom/bust until almost the end of 2020—although some alternative methods were used to estimate how many pregnancies were developing during the year, such as Google searches of birth-related items and themes (Wilde et al., 2020). Studying historical fertility trends in response to previous pandemics and external shocks of a similar magnitude was also helpful. The most obvious point of reference was the 1918–1919 influenza pandemic, which triggered a decline in fertility—for example, a 13% decrease in the United States (Chandra et al., 2018)—due to the disproportionately increased morbidity and mortality among people of reproductive age, but also due to a deceleration in conceptions in a context characterized by social isolation and fear of the virus.

More recent historical episodes have reinforced the hypothesis that there is a connection between perceived uncertainty and a temporary decline in fertility. In particular, fertility was found to have decreased in high-income countries following the Great Recession of 2008–2009 (Comolli, 2021; Schneider, 2017; Sobotka et al., 2011). These experiences led to the development of different theories regarding the emotional pathways that may underlie the relationship between disasters and fertility preferences; and highlighted the relevance of subjective well-being, and especially of uncertainty and anxiety, in fertility decision-making (Comolli & Vignoli, 2021; Nitsche & Lee, 2021; Vignoli et al., 2020, 2022).

In a separate study, Sobotka et al. (2021) found that the baby boom hypothesis was wrong in the 21 high-income countries they analyzed. The results indicated that in Northern Hemisphere countries, fertility declined between November 2020 and February 2021, approximately 9 months after the onset of the pandemic. Compared with the same month of the previous year, the number of births dropped by an average of 5.1% in November, 6.5% in December, and 8.9% in January. However, the findings also showed that births did not decrease in Denmark, Finland, the Netherlands, or Norway. The declines were substantial in southern European countries, which generally have less robust welfare regimes than northern European countries (Rendall et al., 2010).

Aassve et. al. (2021) later assessed fertility declines using the crude birth rate in the same sample of countries but controlled for the ongoing trends during the Covid-19 pandemic. They found that the pandemic negatively affected fertility in seven countries: Austria, Belgium, Hungary, Italy, Portugal, Singapore, and Spain. More recent research has shown that this baby bust was a short-term effect followed by the reversion of fertility rates to prepandemic levels in most countries (United Nations Population Fund, 2021). A scenario of a partial recovery of fertility seems probable. However, fertility trends may also be unstable, characterized by cycles of busts and recoveries, similar to the processes of the pandemic.

Finally, as subnational data became available, researchers started disaggregating national patterns. The first study on subnational patterns was by Cohen (2021), who examined fertility in counties in Florida and Ohio in the United States. Nitsche, and Jasilioniene, Kniffka, et al. (2021) analyzed subnational fertility patterns in European countries. The results showed regional within-country heterogeneity in "excess births," with the most prominent fertility declines observed in places most affected by the pandemic in terms of infection rates and reductions in mobility.

2.2 | Similarities and differences between Brazil and Colombia

Over the past 50 years, Brazil and Colombia have had similar fertility trends (Guzmán et al., 2006), and their social stratification systems have also looked alike (Portes & Hoffman, 2003). However, the differences between these two countries in terms of their population size, internal political and armed conflicts, the functioning of national health systems, and economic development may account for some discrepancies in the Covid-19-fertility associations (Hubert et al., 2022).

When we look at the similarities between these two countries, we note that although their populations are still growing, their natural population growth rates have slowed considerably in recent years to below 1% per year. These relatively low growth rates can be attributed to rapid and sustained fertility declines throughout the second half of the 20th century, albeit with considerable variation across subnational areas and socioeconomic groups (Adsera & Menendez, 2011; Castro Torres, 2021). In Colombia, fertility has been declining from high levels since the 1960s and has been at below-replacement levels since 2015. In Brazil, fertility trends have followed a similar trajectory, with the most rapid period of decline beginning in the late 1970s. Fertility reached below-replacement levels in Brazil in the early years of the current century (Rios-Neto et al., 2018). Although adolescent fertility rates tend to be high in LATAM compared with other regions, social norms relating to stopping mechanisms and later motherhood transitions are emerging in both countries (Castanheira & Kohler, 2017; Urdinola & Ospino, 2015).

During 2020 and 2021, in Brazil and Colombia, there was a limited governmental response to the health and economic crises sparked by the spread of the virus (Hale et al., 2021). Additionally, in both countries, socioeconomic inequalities vary considerably across geographic regions, with Covid-19 mortality being highly correlated with the spatial distribution of ethnic minorities (Díaz Pinzón, 2022; Marinho et al., 2022) and with access to quality health services, including some State-led responses to the Covid-19 pandemic in light of perceived negligence from the national government in Brazil. Indeed, during the first pandemic wave, most Covid-19 deaths were among inhabitants of the Amazon regions of both countries (Orellana et al., 2020; Urrego, 2021). In the prepandemic years in Brazil and Colombia, overall mortality at the subnational level was higher in the least developed and the least populated zones, while large urban areas had the lowest mortality (Queiroz et al., 2020; Urdinola, 2021). This territorial heterogeneity was reflected in the resources available in each region due to its economic conditions, public infrastructure, and healthcare facilities—all of which were crucial for responding to the pandemic (Tan-Torres et al., 2020).

The primary differences between these two countries are their population size and geographical area. Brazil's population (213 million) is more than four times that of Colombia, and its area (8.5 million square kilometers) is more than eight times that of Colombia. Second, while both nations are ethnically diverse, the Afro-descendant population is much more prominent in Brazil than in Colombia (Woo-Mora, 2021). In addition, Brazil's economy is much more robust and developed than Colombia's (Williamson, 2010). Economic inequality is slightly higher in the latter than in the former country. The Gini index for 2020 was 48.9 in Brazil and 54.2 in Colombia (World Bank Group., 2022). This gap in the Gini index is similar in magnitude to the differences between the two countries reported in other inequality measures. For example, the income share of the top 1% in 2019 was 27% in Brazil and 19% in Colombia, which indicates that the income distribution is even more concentrated at the top in Brazil than in Colombia (World Inequality Lab, 2020).

According to WHO criteria, public health expenditures and health systems are better in Brazil than in Colombia (World Health Organization, 2022). Across several measures of health systems (e.g., health expenditures as a percentage of GDP, health expenditures per capita, and the number of hospital beds), Colombia ranks lower than Brazil not only in the levels but also in the pace of improvements in these indicators over time (Kanavos et al., 2019). These differences should be seen in the context of LATAM's long-standing deficits in health systems, despite some signs of improvement in recent decades (Ruano et al., 2021).

Finally, Colombia's decades-long internal armed conflict has affected demographic dynamics, including fertility and contraception (Castro Torres & Urdinola, 2019; Svallfors & Billingsley, 2019). This conflict has caused thousands of fatalities among civilians and led to there being more than eight million internally displaced individuals making Colombia the country with the second-largest internally displaced population, only surpassed by Syria as of 2018 (Ibáñez & Moya, 2010; United Nations High Commissioner for Refugees, 2019). The adverse effects of the Covid-19 pandemic will likely be more significant for the internally displaced population or other victims of the internal conflict.

Previous studies have assessed the effects of the pandemic on fertility rates and demographic dynamics, mainly in Brazil (Coutinho et al., 2020; Diniz Alvez, 2021). Fertility declines were detected in six major cities of Brazil (Lima et al., 2021) and some parts of Colombia toward the end of 2020 (Montaño Mendoza et al., 2021). However, these figures are subject to debate, as the United Nations Population Fund (2021) found that the pandemic had no apparent impact on births in Brazil and Colombia. These studies did not examine the effects of the pandemic on fertility from a comparative perspective by maternal age and years of schooling.

3 | EXPECTATIONS ON THE FERTILITY CONSEQUENCES OF CRISES IN SOCIOECONOMICALLY UNEQUAL CONTEXTS

In light of this background, we rely on the average duration of the gestational period to analyze how the intensity of the Covid-19 crisis, measured by excess mortality, potentially affects the observed number of births in a given month by maternal age and years of schooling. Excess mortality measures with varying lags serve us for measuring potential effects on conceptions and after-conception events leading to or precluding births. For example, a 9-month lag allows us to assess the potential influence of excess mortality on couples' intentions and capabilities to conceive. A negative correlation between 9-month lag excess mortality and the number of births may indicate that severe Covid-19 outbreaks led to postponed or forgone conceptions. By the same logic, shorter lag or zero-lag excess mortality would serve us to capture potential associations with postconception events leading (or not) to a live birth, such as carrying a pregnancy to term, spontaneous abortions, pregnancy interruptions, maternal mortality, and stillbirths.

More importantly, in a context of high socioeconomic inequalities, these influences are likely intertwined with women's social standing because they need resources to find a partner, conceive, continue or interrupt a pregnancy, and give birth. In addition, existing research has shown how socioeconomically vulnerable populations are more likely to suffer the negative consequences of disasters and crises (Aquino et al., 2022). Therefore, we interpret our findings from a materialist perspective that assumes that the unequal distribution of resources is a critical factor in the differential influence of the pandemic on demographic outcomes across subpopulations (Burawoy, 2018; Danna, 2021). This assumption aligns with the basic premises of the Reproductive Justice framework (Ross & Solinger, 2017). According to this framework, fertility is not a neutral field. The social value ascribed to reproduction varies across societal groups. This differential value translates into social gradients in fertility and birth outcomes, for example across racial/ethnic groups, or educational and occupational hierarchies (Colen, 1995; Johnson-Hanks et al., 2011).

In light of this framework, our argument goes as follows: During social, economic, and health crises, resource demand is high. Households and individuals require information, material resources, and social network support to make and enact reproductive decisions. These decisions include having, postponing, or avoiding childbearing. Social groups with lower resources or restricted access to them may face more significant constraints than those with greater resources as health crises undermine resource availability.

Although we cannot test our materialist assumptions, a divergent association between the subnational severity of Covid-19 and fertility by maternal age and years of schooling might suggest that this interpretation is plausible. Young mothers with relatively lower educational attainment are more vulnerable than highly educated adult mothers; these two groups of women are likely to live in distinct contexts in terms of household composition, family structures, and material and social resources beyond their differential age and educational attainment (Esteve et al., 2022; Juárez & Gayet, 2014). Therefore, the fertility consequences of a social and health crisis are likely to diverge along these two variables. Because the potential effects of the pandemic on fertility could be positive and negative, we are agnostic as to the specific direction of this association. We do expect, instead, divergent associations across socioeconomic groups.

4 | DATA AND METHODS

4.1 | Baseline and relative measures of births and deaths

Our data come from official records of registered live births from 2015 to 2021 published by the Department of Informatics of the Brazilian National Health System (DATASUS) and the Colombian National Bureau of Statistics (DANE). These data comprise over 95% of live births and are publicly available on each institution's website. The lack of population figures by age and years of schooling prevents us from computing fertility rates. Therefore, we standardize the observed births by the expected number in a hypothetical Covid-19-free scenario. We draw on more than 36 million vital records (24.5 million births and 11.9 million deaths) registered in these two countries from 2015 to 2021. We use the 2015–2019 information to predict the monthly number of births and deaths for 2020 and 2021 in a Covid-19-free counterfactual scenario; these predictions are compared with the observed data to assess the relationship between the Covid-19 pandemic severity and the relative changes in the number of births. We use a relative measure of changes in birth counts to account for pre-existing differences in fertility levels and population size across subnational areas.

We did not find any indication in the data or the literature that birth reporting practices changed in Brazil or Colombia during the pandemic. We use the information on 20.0 million births in Brazil and 4.5 million in Colombia, distributed across 27 and 33 subnational units, respectively. Some subnational areas in Colombia with relatively small populations were grouped to ensure consistent monthly births by the maternal characteristics of interest (i.e., age and years of schooling). The states of Risaralda, Quindio, and Caldas were grouped as "Eje Cafetero"; Arauca, Casanare, Meta, and Vichada were grouped into "Orinoquia"; and Amazonas, Caqueta, Guainia, Guaviare, Putumayo, and Vaupes were labeled together as "Amazonia." These groupings comprised neighboring states consistent with the Demographic and Health Survey regional classification of Colombian states. Due to the small number of registered births and lack of neighboring states for a sensible grouping, the analyses did not include information for the state of San Andres y Providencia (0.06% of births in Colombia). Regional grouping was not necessary for the Brazilian data.

We use the 2015–2019 information to calculate the monthly expected numbers of births and prediction intervals for all subnational areas in 2020 and 2021 in a hypothetical Covid-19-free scenario. These predictions are stratified by maternal years of schooling (0–7, 8–11, 12 or more) and age groups (10–19, 20–29, 30–39, and 40 or more). Additionally, time trends and within-year seasonality are taken into account. Disaggregation by maternal age allows us to account for the age pattern of fertility, and the years of schooling groups serve as a proxy for women's socioeconomic status. Given the nature of the educational systems and the characteristics of the labor markets in these two countries, the years of schooling groups are a good proxy for women's human capital accumulation but also their socioeconomic status (De Ferranti et al., 2004; Sánchez-Ancochea, 2021). Births with missing data in maternal age (0.01% in Brazil and 0.12% in Colombia) and years of schooling (1.34% in Brazil and 3.86% in Colombia) were distributed to age and years of education groups according to the observed distribution in each subnational unit.

We calculated our dependent variable—the relative change in the number of births (relative birth change [RBC] hereafter)—using observed and predicted data by comparing the monthly observed number of births in 2020 and 2021 against the prediction interval of the hypothetical Covid-19-free scenario. If the observed number of births lay within the 80% prediction interval (i.e., nondetectable change in childbirth), we set the *RBC* to zero (i.e., no changes in fertility) to avoid the influence of random fluctuations in fertility. If the observed number of births lay outside the 80% prediction interval, we compute the percentage change between observed and expected births. To test the sensibility of our estimates, we perform a robustness with two scenarios. One with a 60% prediction interval and another that does not consider prediction intervals. The results were highly consistent.

We supplement our data on *RBC* with subnational estimates of monthly excess mortality in 2020 and 2021. Excess mortality is the difference between all-cause observed and expected mortality in a hypothetical Covid-19-free scenario. All-cause excess mortality measurements avoid comparability issues deriving from different Covid-19-related death definitions and reporting protocols—that is, dying with Covid-19 versus dying from Covid-19, thus avoiding a potential source of error (Binstock et al., 2021).

We estimate baseline mortality by fitting a generalized additive model (Wood, 2017) to weekly deaths between January 2015 and

March 2020, which accounts for secular and seasonal variations in mortality, and changes in population over time (Ebeling et al., 2022). Our measure of excess mortality uses the *p*-score index, which indicates the percentage difference between the observed deaths relative to the mortality baseline (Helleringer & Queiroz, 2022). Similar to the relative measures of birth counts changes, using *p*-scores allows us to compare excess mortality across different populations, regardless of differences in prepandemic mortality levels and population sizes. We cannot account for differences in population age structures, as the weekly mortality series in Colombia has no information on age. Detailed information about estimating Covid-19-free predictions for the number of births and deaths can be found in the Appendix.

4.2 | Models and estimations

Using multivariate linear models, we correlate monthly subnational excess mortality *p*-scores with monthly *RBC* by maternal age and years of schooling groups from April 2020 to December 2021. We weight each combination of subnational area, month, maternal age, and years of schooling groups by the share of births in each cell relative to the total number of births in the country. This weighting strategy improves the representativeness of our results. We accomplish this by giving more weight to age groups where fertility is concentrated, subnational areas with larger populations, and years of schooling groups that account for the most significant shares of births. Equation 1 presents our baseline model specification (M1).

$$RBC_{ijkt} = \beta_0 + AG_j \times \beta_j + YS_k \times \beta_k + EM_{it} \times \beta_{cm} + EM_{i(t-9)} \times \beta_{lm} + \varepsilon_{ijtk}. \tag{1}$$

In Equation 1, *RBC* represents the relative birth change in the subnational area *i*, age group (A.G.) *j*, years of schooling group (Y.S.) *k*, and month *t*. We use two versions of the *p*-scores as predictors: one for the current month (EM_{it}) and a 9-month lagged *p*-score ($EM_{i(t\text{-}9)}$). The ε_{ijtk} represents the error term. Models were fitted separately for each country.

This modeling framework β_{cm} measures the short-term influence of the pandemic on fertility—for example, due to the worsening of reproductive health-related services and changes in the number of pregnancy interruptions or fetal deaths, as miscarriage and stillbirth risks are expected to increase in the context of crises (Buitrago & Moreno-Serra, 2021; Valente, 2015). And β_{lm} captures the potential influence of the pandemic on fertility decisions as couples may have postponed or abandoned their fertility plans, and conception rates may have changed due to changes in sexual activity during lockdowns. To test the robustness of M1 and assess differential associations of excess mortality and *RBC*, we estimate four additional model specifications (M2 to M5). We account for pre-existing subnational differences in the capacity to respond to the pandemic by using dummy variables for subnational areas in M2, and the 2019 subnational Human Development Index (SHDI) in M3 (Smits & Permanyer, 2019). Model specifications M4 and M5 test the interaction between current and lagged excess mortality (one at a time) and maternal years of schooling and age, respectively. These two specifications include dummy variables for subnational areas given the better fit of M2 compared with M3. We compute the Bayesian Information Criterion (BIC) for each model specification to assess the model's goodness of fit penalizing for its complexity. We focus on the one with the lowest BIC, indicating improved fit and greater parsimony.

The differences in the excess mortality timing (i.e., lagged vs. contemporary) allow us to capture potential influences of the Covid-19 pandemic on different moments of the fertility process, namely from conception (i.e., 9-month lagged excess mortality) to the delivery (i.e., current excess mortality). An additional 7-month lagged measure is used as a robustness check to explore the sensitivity of our conclusions to the lag period. A 7-month lag also corresponds with early pregnancies that are arguably easier to interrupt than pregnancies with more than 12 weeks of gestation, particularly in the LATAM context, where legal access to abortion is highly exceptional.

5 | RESULTS

Panel A in Table 1 displays descriptive statistics for the number of births and deaths, the RBC, and the *p*-scores for current and 9-month-lagged excess mortality. According to this table, across maternal years of schooling groups, age groups, and subnational units, from 2015 to 2021 there were, on average, 693 and 188 births in Brazil and Colombia per month, respectively. During 2020 and 2021, on average, monthly figures of the observed births were not different from what was expected in Brazil (mean = 1.00, SD = 0.16), and they were 11 percentage points higher in Colombia (mean = 1.11, SD = 0.63). According to these figures, RBCs in Colombia are higher, on average, and more heterogeneous than in Brazil. This means that at the subnational level, changes in fertility in Colombia were more significant and more diverse than those in Brazil during the analysis period.

As for excess mortality, the average deviations from expected are apparent in both countries. On average, monthly deaths were at least 23 percentage points higher than expected. The standard deviation of these excess mortality measures ranged from 31 to 39 percentage points, suggesting that subnational variation in the Covid-19 impact was substantial. Together, these measures demonstrate the differential magnitude of the mortality crisis (i.e., +23 percentage point increases in all-cause mortality) versus the more reduced magnitude of changes in fertility during 2020 and 2021.

Panel B offers some initial confirmation of our expectations. In both countries across subnational levels and months, the mean RBC among women with 0–7 years of schooling is the highest across years of schooling groups, and the first age group (10–19) ranks second compared with the others, meaning that socially and economically disadvantaged women may have experienced more births than expected. This panel also shows substantial variability in the relative change in births, particularly in Colombia among the least educated

TABLE 1 Descriptive statistics for the monthly number of births, deaths, relative birth changes, current *p*-score excess mortality, and 9-month-lagged *p*-score mortality (Panel A). Descriptive statistics for the relative birth changes and the monthly number of births distribution by mothers' age and years of schooling (Panel B).

Panel A

	Means 2015–2021		Relative birth change (RBC)		Excess mortality (*p*-scores)			
					Current		Lagged	
Country	Births	Deaths	Mean	SD	Mean	SD	Mean	SD
Brazil	693	5110	1.00	0.16	1.23	0.31	1.24	0.33
Colombia	188	1203	1.11	0.63	1.30	0.39	1.23	0.31

Panel B

	Relative birth changes (RBC)					Monthly births		
	Mean	SD	Min	Median	Max	Mean	Total (thousand)	%
Age groups								
Brazil								
10–19	1.01	0.27	0.00	1.00	3.80	383	744	14
20–29	0.99	0.09	0.63	0.99	1.58	1354	2633	49
30–39	0.95	0.10	0.59	0.94	1.42	933	1814	34
40–54	1.03	0.22	0.35	1.00	2.22	103	200	4
							5391	100
Colombia								
10–19	1.16	1.18	0.00	1.01	26.25	138	228	18
20–29	1.13	1.23	0.00	1.02	30.45	404	668	54
30–39	1.06	0.38	0.00	1.02	8.58	192	317	25
40–54	1.19	0.55	0.00	1.11	5.27	19	32	3
							1245	100
Years of schooling groups (Y.S.)								
Brazil								
0–7 y.s.	1.01	0.15	0.46	1.00	2.01	310	803	15
8–11 y.s.	0.99	0.12	0.35	0.98	1.92	1313	3404	63
12 or more y.s.	0.98	0.26	0.00	0.96	3.80	456	1183	22
							5391	100
Colombia								
0–7 y.s.	1.20	1.14	0.00	1.08	30.45	80	176	14
8–11 y.s.	1.08	0.31	0.00	1.03	4.24	329	727	58
12 or more y.s.	1.13	1.05	0.00	0.98	26.25	155	342	28
							1245	100

Note: The unit of analysis are combinations of year, month, mothers' years of schooling groups, age groups, and subnational units with at least one registered birth. In 55% of the observations, the expected number of births lay within the 80% prediction interval in both countries. In all these cases, RBCs were set to 1.00. Likewise, to favor the inclusiveness of data points, lagged mortality for September 2020 backward was set to 1.00, assuming no excess mortality before the onset of the pandemic (April 2020).

(Min = 0, Max = 30.45). In all ages and years of schooling groups, virtually half of the units of analysis display higher than expected births (i.e., median RBC above or very close to 1.00). Finally, the monthly mean and the total number of births speak to the robustness and scope of our analysis. The spatiotemporal dynamics of these indicators are explored in the following sections.

5.1 | Births and mortality trends in subnational areas

Figure 1 shows the temporal trends of subnational excess mortality from January 2020 to December 2021. According to this figure, the pandemic's timing and intensity were different in our study cases.

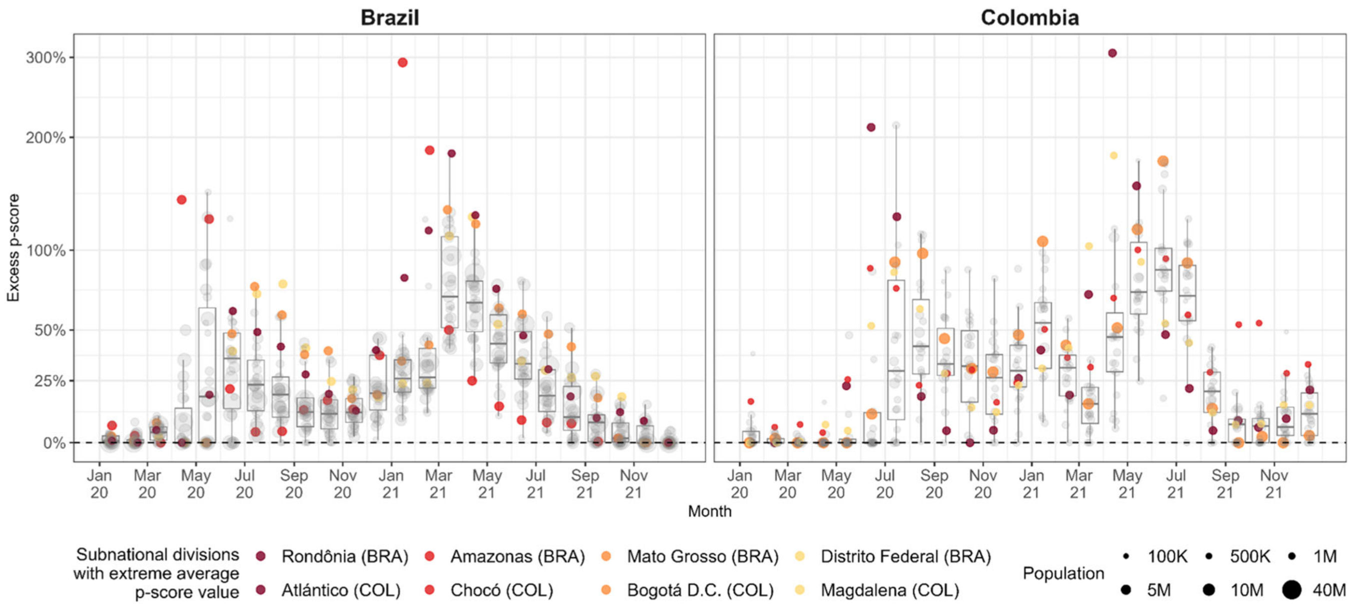

FIGURE 1 Monthly current mortality *p*-score trends by subnational areas in Brazil and Colombia from January 2020 to December 2021. Colored dots represent the four states with the highest average *p*-score for the entire analysis period in each country. Dark shades represent a higher average *p*-score. The *p*-scores of excess mortality capture departs from expected mortality patterns in relative terms. High *p*-scores indicate a notably higher mortality risk in a given subnational area.

In Brazil, excess mortality in several subnational areas was already positive and substantial by April 2020. Indeed, in Amazonas, the observed mortality in April was more than twice the expected level (*p*-score above 100%). In contrast, by the same month, excess mortality in Colombia was positive and considerably lower only in a handful of states. Figure 1 also indicates that as the pandemic evolved, excess mortality in Colombia increased and stayed higher than in Brazil during the last two quarters of 2020. This relationship reversed in March and April 2021, when *p*-scores were positive in all Brazilian subnational areas. Excess mortality from April 2021 onward remained high in Colombia and decreased in Brazil, further highlighting the pandemic's changing nature (Nicolelis et al., 2021). Figure 1 also reveals substantial within-country heterogeneity (*y*-axis range) and that subnational units with relatively small populations had the highest levels of excess mortality. The changes in the four subnational units with the highest excess mortality levels indicate the spatial dynamics within the countries.

In this spatially dynamic context of excess mortality, the association between the pandemic and the total number of births varied by maternal years of schooling. Figure 2 displays the monthly observed (dots) and predicted (lines) number of births by maternal years of schooling groups. According to this figure, most registered births from 2015 to 2021 were to women with 8–11 years of schooling. Roughly, these years of schooling imply finishing basic (8 y.s.) and secondary education (11 y.s.), which likely corresponds to women from lower or middle-lower social classes. Middle-upper and upper-class women are more likely to have some postsecondary years of schooling before becoming mothers, namely, at least 12 years of education (Castro Torres, 2021; Esteve & Florez-Paredes, 2018).

The number of births to mothers with less than 7 years of schooling is the lowest of all schooling groups, yet, these are not demographically unimportant. From April 2020 to December 2021, mothers with 0–7 years of schooling gave birth to 696,411 and 154,380 babies in Brazil and Colombia, respectively, which accounted for 15% and 14% of all births during the Covid-19 pandemic. It is worth noting that 7 years of schooling provide only basic numeracy and literacy skills, which puts these women at the very bottom of the LATAM stratification systems (Balan, 2013; Sánchez-Ancochea, 2021).

Continuing with Figure 2, time trends after March 2020 (vertical line) suggest a significant negative association between the pandemic and the number of births to women with 12 years of schooling or more. According to the annotated percentage differences, from April 2020 to December 2021 in Brazil, women with 12 or more years of schooling display the largest percent difference between observed and expected births (−6.9%); this figure is similar to that of Colombian women with the same years of schooling (−5.7%). These percentage differences are less negative or positive for women with 8–11 years of schooling (−3.7% and 0.6%). As for the lowest years of schooling group, Colombian women display the largest positive percentage difference (6.3%), whereas their educational counterparts in Brazil display a marginally negative figure (−0.2%). Changes in the educational composition of the population are unlikely to affect these results because the time frame is short (i.e., 22 months).

5.2 | The association between excess mortality and RBC

Figure 3 displays the scatter plots of current excess mortality and the *RBC* by country from April 2020 to December 2021. Both measures are on a logarithmic scale, and the axes are labeled according to the

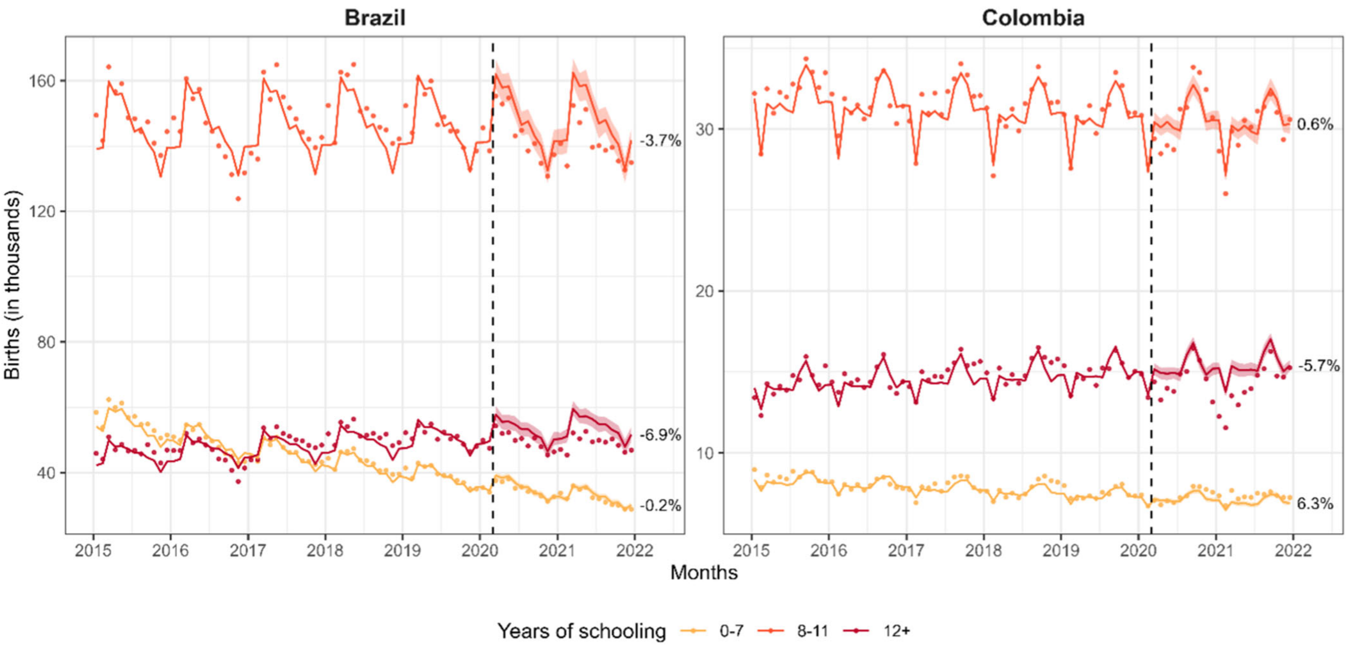

FIGURE 2 Monthly total number of births by maternal years of schooling groups in Brazil and Colombia from 2015 to 2021. The lines represent the expected number of births based on time and seasonality trends from January 2015 to March 2020. Prediction intervals for April 2020 onwards are set at 80%. Annotated numbers indicate the percentage difference between observed and predicted births from April 2020 to December 2021. Original educational attainment and years of schooling are as follows. Brazil: "Nehuma," "1 to 3," "4 to 7," "8 to 11," "12 or more," and "Unknown." Colombia: "Pre-school," "Primary," "Secondary basic," "Secondary academic," "Technical," "Normal," "Technical professional," "Technological," "Professional," "Unknown," and "Missing information." Recoding files are available upon request from the corresponding author.

percentage difference to improve readability. Each dot represents a combination of the year-month, maternal age groups (colors), years of schooling groups (panels), and the subnational areas. Empty circles represent RBCs where the observed number of births lay within the 80% prediction interval and, therefore were set to zero (i.e., birth counts as expected) in the multivariate analyses. The lack of pattern among the empty circles suggests that our results are not driven by setting nondetectable change to zero. The size of each point is proportional to the population of the subnational area in 2020, and robust local regression lines (lowess) are included for each age group and the pooled data (overall). The black cross indicates the mean value of each variable.

In line with our expectations, the average RBCs were positive for women with fewer than 8 years of schooling and closer to zero or negative for the other years of schooling groups. In addition, the association between the immediate severity of the Covid-19 pandemic and the *RBC* was contingent on women's years of schooling. The higher the years of education, the more negative the link between excess mortality and the *RBC*, as depicted by the robust-local-regression lines. On the contrary, the proximity of these lines suggests no differences by maternal age groups. The only exception is 40–54-year-old mothers in Colombia, a group that contributes less than 5% to the total number of births in the analysis. This group of women displays higher RBC than other age groups, particularly among women with 0–7 years of schooling. We lagged excess mortality by 9 months to measure the potential influence of the pandemic on fertility decisions and changes in sexual activity. This analysis revealed a flat pattern across almost all years of schooling and maternal age groups (Figure A1). The last age group depicted deviations from the flat pattern, potentially driven by the greater sensitivity of low counts of births that result in outliers in the RBCs.

Figures 3 and A1 indicate that current and 9-month-lagged excess mortality influenced the number of observed births differently across years of schooling groups. Whereas current excess mortality was positively associated with RBC among women with fewer years of schooling, this association was null or negative among women with more years of schooling. As for lagged mortality, there is a negative association for all years of schooling groups. The following multivariate models measure and test the statistical significance of these patterns.

5.3 | Excess mortality and RBCs in a multivariate framework

Table 2 summarizes the regression coefficients for the excess mortality measures and the *RBC* according to the above-mentioned models (M1–M5). The excess mortality and RBC estimates entered the model on the logarithmic scale to enhance the models' performance and interpretability. The coefficients represent the percentage point change in RBC associated with one standard

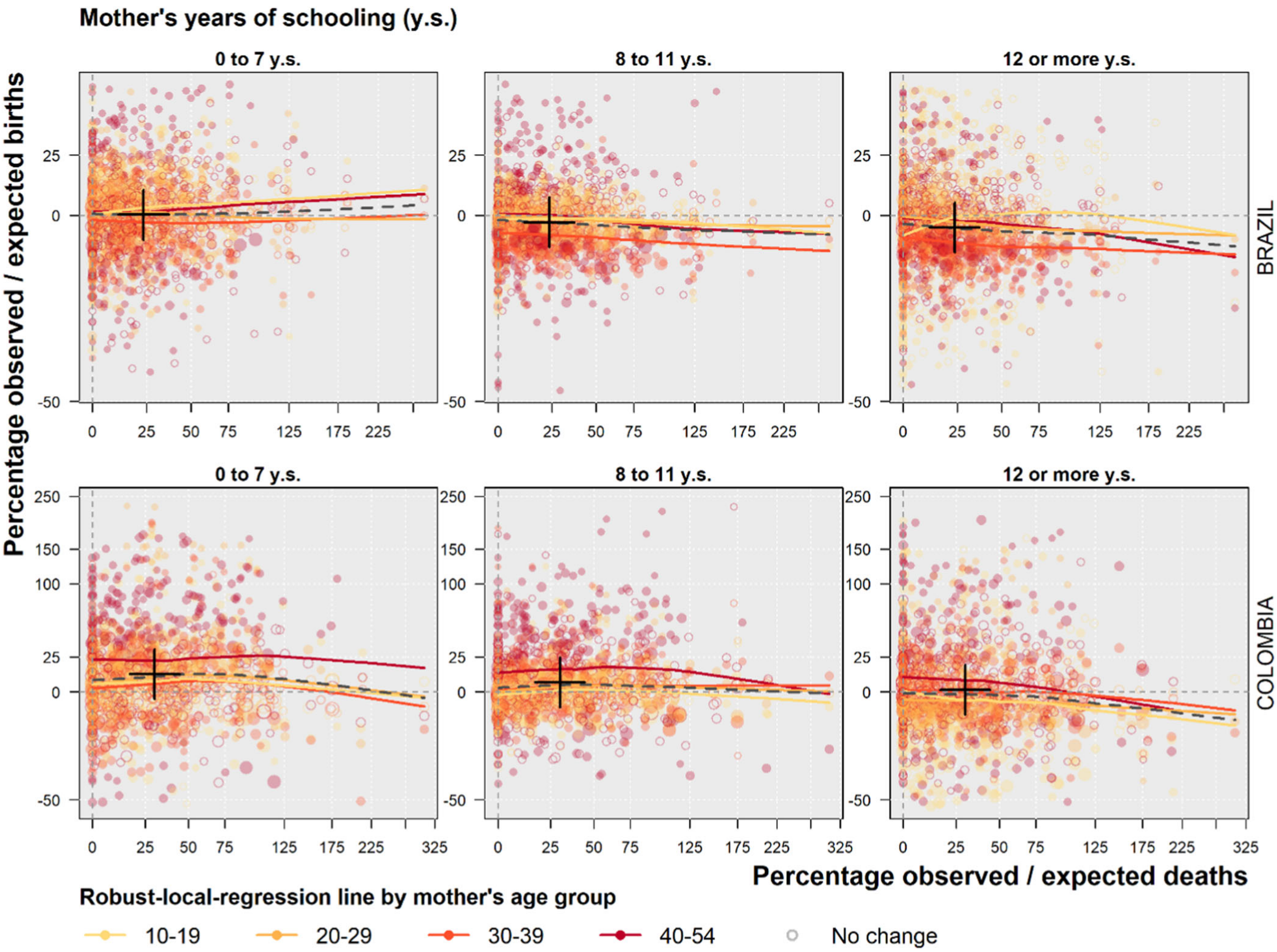

FIGURE 3 Subnational-level associations between current excess mortality and relative birth changes (*RBC*) in 2020 and 2021 by mother's age and years of schooling groups in Brazil and Colombia. Empty circles represent units where the observed number of births laid within the 80% prediction interval (i.e., no detectable change in the number of births). The cross markers indicate the mean of each axis.

deviation increase in excess mortality. We first discuss results for current excess mortality and then move on to those with a 9-month lag.

In model specifications M1–M3, the association between excess mortality and the *RBC* is negative and significant for Brazil, meaning that increased current mortality is associated with fewer than expected births. This is not the case in Colombia, where this association is positive, but only significant for M3. In terms of goodness of fit and parsimony, M2 yields a lower BIC than M3 and therefore we use it to test interactions between excess mortality and mothers' education (M4) and age (M5).

The similarity between the BIC of M4 and M2 suggests, although weakly, that there may be a significant interaction between excess mortality and mothers' schooling. Some coefficients for M4 confirm this weak evidence and therefore we focus on this specification. The association between current excess mortality and the RBC was positive for women with 0–7 years of schooling: 0.5 and 0.8 percentage points in Brazil and Colombia, respectively, and negative for women in all other years of schooling groups, particularly the higher-educated ones. The regression coefficients for the interaction between excess mortality and 12 to more years of schooling are −2.3 (Sig. = 0.000) and −1.8 (Sig. = 0.001) for Brazil and Colombia, respectively, suggesting a negative relationship between current excess mortality and *RBC* among highly educated women.

Finally, M5 displays a slightly higher BIC than M4 in Brazil and slightly lower in Colombia. In the first case, the interaction between maternal age groups and current excess mortality is less critical than between maternal years of schooling groups and current excess mortality. A few additional insights can be gained from M5 compared with M4. If anything, older mothers display more negative coefficients than younger.

The results for lagged excess mortality yield negative coefficients for both countries in M1, M2, and M3. These coefficients display much lower uncertainty than those of current mortality (Sigs. < 0.03), suggesting that, contrary to the association between immediate mortality shocks and ongoing pregnancies, residing in subnational areas with high excess mortality may have discouraged fertility plans and thus been associated with its postponement. M2 yielded the

TABLE 2 Associations between current and 9-month-lagged excess mortality and the relative birth changes (*RBC*) according to five model specifications (M1–M5).

	Current excess mortality				Nine-month lagged excess mortality			
	Brazil		Colombia		Brazil		Colombia	
Model specifications (M1–5) Dependent variable:	Coefficient	*p* Value	Coefficient	*p* Value	Coefficient	*p* Value	Coefficient	*p* Value
Relative birth changes (RBC)								
M1	−1.0 (0.09)	0.000	0.1 (0.19)	0.549	−0.8 (0.10)	0.000	−0.6(0.19)	0.003
BIC	−8993		−494		−8993		−494	
M2	−1.0 (0.09)	0.000	0.1 (0.16)	0.510	−1.0 (0.09)	0.000	−0.5 (0.16)	0.004
BIC	−9304		−2412		−9304		−2412	
M3	−1.0 (0.09)	0.000	0.4 (0.19)	0.023	−0.9 (0.10)	0.000	−0.4 (0.19)	0.020
BIC	−8999		−813		−8999		−813	
M4: Years of schooling (y.s.) × Excess mortality (excess m.)								
[0–7 y.s.] × excess m.	0.5 (0.07)	0.021	0.8 (0.14)	0.082	−0.2 (0.07)	0.366	0.7 (0.14)	0.116
8–11 y.s. × excess m.	−1.6 (0.08)	0.000	−0.2 (0.15)	0.609	−0.7 (0.08)	0.010	−1.2 (0.15)	0.012
12 or more y.s. × excess m.	−2.3 (0.09)	0.000	−1.8 (0.16)	0.001	−1.5 (0.10)	0.000	−1.6 (0.16)	0.003
BIC	−9349		−2416		−9311		−2404	
M5: Mothers' age × Excess mortality (excess m.)								
[10–19 y.o.] × excess m.	0.0 (0.23)	0.834	0.6 (0.37)	0.118	−0.2 (0.24)	0.402	0.3 (0.37)	0.460
20–29 y.o. × excess m.	−0.9 (0.26)	0.001	−0.2 (0.43)	0.673	−0.2 (0.27)	0.510	−1.1 (0.43)	0.008
30–39 y.o. × excess m.	−1.4 (0.28)	0.000	−1.4 (0.48)	0.005	−2.0 (0.29)	0.000	−0.5 (0.48)	0.306
40–49 y.o. × excess m.	−0.9 (0.52)	0.082	−1.0 (1.03)	0.345	−1.1 (0.54)	0.039	−0.4 (1.05)	0.729
BIC	−9304		−2399		−9367		−2395	
Number of observations	6800		5703		6800		5703	

Note: Coefficients represent the percentage point changes associated with a one standard deviation increase in excess mortality *p*-scores. Significance, standard errors, and goodness of fit measures are displayed next and underneath excess mortality coefficients. The number of observations corresponds to all combinations of year-month, subnational areas, age groups, and years of schooling groups with at least one observed birth from April 2020 to December 2021. The model specifications for current mortality control for lagged mortality, and vice versa. Besides the excess mortality *p*-scores, M1 includes dummy variables for maternal age and years of schooling groups (Equation 1). M2 adds dummy variables for subnational units. M3 substitutes dummy variables for the subnational Human Development Index in 2019 (SHDI). Because M2 yields a better fit than M3, interaction terms are added to M2 in M4 and M5. M4 includes the interaction between maternal years of schooling groups and current and lagged excess mortality, one at a time. And, M5 includes the interaction between maternal age groups and current and lagged excess mortality, one at a time.

lowest BIC, indicating that subnational dummies improve the models' goodness of fit without excessive model complexity in both countries.

When lagged-excess mortality interacted with maternal years of schooling groups in Brazil, the model slightly improved, as reflected by the lower BIC of M4 compared with M2. The negative coefficients for the highest years of schooling groups are statistically significant. In contrast, those for mothers with fewer than 8 years of schooling are not distinguishable from zero. These patterns suggest that the association between lagged mortality and the RBC, again, varied by maternal years of schooling group, being negative only for those who completed at least primary education. Finally, M5 results do not suggest a clear age-specific pattern. Only for Brazil, the BIC of M5 is more negative than M4, meaning a better-fit accounting for models' parsimony.

6 | DISCUSSION

The heterogeneous associations we found between current and lagged excess mortality and excess fertility underline how the negative consequences of the pandemic interacted with pre-existing forms of social inequality regarding access to resources and opportunities to enact reproductive preferences. While we did not observe noteworthy differences in most maternal age groups, there was considerable heterogeneity by mothers' education. Highly educated and resourced women had fewer than expected children during the pandemic months, and their fertility was negatively associated with the intensity of the Covid-19 crisis. The reverse was true for women with fewer years of schooling.

Remarkably, this aligns with the study of Marteleto et al. (2020) on the impact of the Zika virus on fertility rates in Brazil. The fact that the Brazilian government provided official recommendations to postpone fertility during the Zika epidemic and did not do so during the Covid-19 pandemic further highlights the importance of our results.

It seems plausible that, in contexts of more significant excess mortality, women with higher resources (proxied by their years of schooling) could terminate pregnancies or postpone births leading to below-expected births; women with fewer resources could not. As for the lagged excess mortality associations, results suggest that all women in high excess mortality contexts curtailed their fertility plans (i.e., births that should have occurred 9 months in the future had the pandemic not occurred), although to different degrees. Our interpretation is consistent with the extant and cited literature on the connection between fertility patterns and social stratification (Colen, 1995; Ross & Solinger, 2017), and with a recent review on the unequal consequence of macro-level disruptive events, such as economic recessions and natural disasters, for individuals and families (Aquino et al., 2022).

Understanding the long-term effects of the Covid-19 pandemic on demographic patterns requires conceiving fertility differentials and outcomes regarding reproductive justice. Assuming that health crises would impact women's reproduction differently according to their socioeconomic status is a sensible premise for shedding light on existing injustices and how crises could make them more acute. This assumption is especially important for countries with high or rising levels of socioeconomic inequality and weak or nonexistent welfare states, as well as for population subgroups who may not fully benefit from welfare policies due to their minority, sexual identity, or migration/citizenship status. Also, ethnic, migration status, and sexual minorities in high-income countries may experience the consequences of the Covid-19 pandemic differently than most of the population, especially those in socioeconomically privileged positions.

The contribution of this study to the literature on the so-called *pandemic babies* stems from the above-mentioned assumption and our materialist perspective (Danna, 2021). Previous studies have identified many logical mechanisms that could lead to higher or lower fertility during health crises. These mechanisms include higher maternal mortality; miscarriages; restricted access to sexual health-related services, including contraception, family planning, and abortion; and fertility postponement due to financial, social, and emotional uncertainty. However, this list of mechanisms does not specify the material conditions under which they are prevalent or effective.

Assuming that every woman is equally susceptible to any mechanism—for example, voluntary fertility postponement—confuses the "things of logic" and the "logic of things." (Burawoy, 2018). There is a myriad of logical mechanism that could explain lower or higher fertility ("the things of the logic"), yet only some are plausible for certain populations. A materialistic perspective assumes that there are material conditions necessary for mechanisms to operate ("the logic of things"); which is likely the case in the studied LATAM societies and elsewhere. Our findings suggest that these mechanisms are contingent on women's access to the material resources for controlling reproduction (e.g., social network support, access to contraception, abortion, and family planning), which may be particularly scarce or reduced for specific populations, due to weakened health systems, economic crises, and mobility restrictions. Besides, Colombian women might have been more strongly associated with these mechanisms, potentially due to the country's legacy of armed conflict and weaker health systems than Brazil. In any case, future research on fertility preferences and contraception during the pandemic should corroborate the hypothetical mechanisms in play.

Those avenues of future research that test the validity of the mechanisms through which a health crisis can affect fertility should distinguish between social groups with varying abilities to avoid the pandemic's negative consequences. Given that socioeconomic inequalities are likely to be exacerbated by the negative impacts of Covid-19, we would expect to observe ongoing differential associations between the pandemic and the number of births across socioeconomic groups over the short to medium term.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Aassve, A., Cavalli, N., Mencarini, L., Plach, S., & Livi Bacci, M. (2020). The COVID-19 pandemic and human fertility. *Science*, *369*(6502), 370–371. https://doi.org/10.1126/science.abc9520

Aassve, C. N., Mencarini, L., Plach, S., & Sanders, S. (2021). Early assessment of the relationship between the COVID-19 pandemic and births in high-income countries. *Proceedings of the National Academy of Sciences*, *118*(36):e2105709118. https://doi.org/10.1073/pnas.2105709118

Adsera, A., & Menendez, A. (2011). Fertility changes in Latin America in periods of economic uncertainty. *Population Studies*, *65*(1), 37–56. https://doi.org/10.1080/00324728.2010.530291

Aquino, T., Brand, J. E., & Torche, F. (2022). Unequal effects of disruptive events. *Sociology Compass*, *16*(4):e12972. https://doi.org/10.1111/soc4.12972

Balan, J. (2013). Introduction – Latin American higher education systems in a historical and comparative perspective, In *Latin America's new knowledge economy* (1st ed., pp. 7–20). IIEBooks Fulfillment Center.

Berrington, A., Ellison, J., Kuang, B., Vasireddy, S., & Kulu, H. (2022). Scenario-based fertility projections incorporating impacts of COVID-19. *Population, Space and Place*, *28*(2):e2546. https://doi.org/10.1002/psp.2546

Binstock, G., Nathan, M., Pardo, I., & Pelaez, E. (2021). *Desafíos para el avance de la Agenda 2030 en América Latina y el Caribe en el marco de la COVID-19*. Asociación Latinoamericana de Población-ALAP.

Buitrago, G., & Moreno-Serra, R. (2021). Conflict violence reduction and pregnancy outcomes: A regression discontinuity design in Colombia. *PLoS Medicine*, *18*(7):e1003684. https://doi.org/10.1371/journal.pmed.1003684

Burawoy, M. (2018). The poverty of philosophy: Marx Meets Bourdieu. In T. Medvetz, & J. J. Sallaz (Eds.), *The Oxford handbook of Pierre Bourdieu* (Vol. 1). Oxford University Press. https://doi.org/10.1093/oxfordhb/9780199357192.013.16

Castanheira, H. C., & Kohler, H.-P. (2017). Social determinants of low fertility in Brazil. *Journal of Biosocial Science*, *49*(S1), S131–S155. https://doi.org/10.1017/S0021932017000396

Castro Torres, A. F. (2021). Analysis of Latin American fertility in terms of probable social classes. *European Journal of Population*, *37*(2), 297–339. https://doi.org/10.1007/s10680-020-09569-7

Castro Torres, A. F., Batyra, E., & Myrskylä, M. (2022). Income inequality and increasing dispersion of the transition to first birth in the Global South. *Population and Development Review*, *48*(1), 189–215. https://doi.org/10.1111/padr.12451

Castro Torres, A. F., & Urdinola, B. P. (2019). Armed conflict and fertility in Colombia, 2000–2010. *Population Research and Policy Review*, *38*(2), 173–213. https://doi.org/10.1007/s11113-018-9489-x

Chandra, S., Christensen, J., Mamelund, S.-E., & Paneth, N. (2018). Short-term birth sequelae of the 1918–1920 influenza pandemic in the United States: State-level analysis. *American Journal of Epidemiology*, *187*(12), 2585–2595. https://doi.org/10.1093/aje/kwy153

Cohen, P. N. (2021). Baby bust: Falling fertility in US counties is associated with COVID-19 prevalence and mobility reductions [Preprint]. SocArXiv. https://doi.org/10.31235/osf.io/qwxz3

Colen, S. (1995). "Like a Mother to Them": Stratified reproduction and West Indian childcare workers in New York. In Ginsburg F. D., & Rapp R. (Eds.), *Conceiving the new world order: The global politics of reproduction* (1st ed., p. 78). University of California Press.

Comolli, C. (2021). Resources, aspirations and first births during the Great Recession. *Advances in Life Course Research*, *48*, 100405. https://doi.org/10.1016/j.alcr.2021.100405

Comolli, C. L., & Vignoli, D. (2021). Spreading uncertainty, shrinking birth rates: A natural experiment for Italy. *European Sociological Review*, *37*(4), 555–570. https://doi.org/10.1093/esr/jcab001

Coutinho, R. Z., Conceição de Lima, L., Antunes Leocádio, V., & Bernardes, T. (2020). Considerações sobre a pandemia de Covid-19 e seus efeitos sobre a fecundidade e a saúde sexual e reprodutiva das brasileiras. *Revista Brasileira de Estudos de População*, *37*, 1–21. https://doi.org/10.20947/S0102-3098a0130

Schneider, D. (2017). Non-marital and teen fertility and contraception during the Great Recession. *RSF: The Russell Sage Foundation Journal of the Social Sciences*, *3*(3), 126. https://doi.org/10.7758/rsf.2017.3.3.06

Danna, D. (2021). *Procreation and population in historical social science*. Anthem Press.

Díaz Pinzón, J. E. (2022). Letalidad por SARS-CoV-2 en Colombia años 2020 y 2021. *Revista Repertorio de Medicina y Cirugía*, *31*, 52–56. https://doi.org/10.31260/RepertMedCir.01217372.1341

Diniz Alvez, J. E. (2021). O impacto da pandemia da covid-19 na dinâmica demográfica brasileira. Revista Longeliver. https://revistalongeviver.com.br/index.php/revistaportal/article/view/917/978

Ebeling, M., Acosta, E., Caswell, H., Meyer, A. C., & Modig, K. (2022). Years of life lost during the Covid-19 pandemic in Sweden considering variation in life expectancy by level of geriatric care. *European Journal of Epidemiology*, *37*(10), 1025–1034. https://doi.org/10.1007/s10654-022-00915-z

Economic Commission for Latin America and the Caribbean. (2021). *Covid-19* MORTALITY. EVIDENCE AND SCENARIOS (Demographic Observatory).

Economic Commission for Latin America and the Caribbean. (2022a). *Social Panorama of Latin America 2021* (p. 231).

Economic Commission for Latin America and the Caribbean. (2022b). *The sociodemographic impacts of the COVID-19 pandemic in Latin America and the Caribbean* (LC/CRPD.4/3).

Emery, T., & Koops, J. C. (2022). The impact of COVID-19 on fertility behaviour and intentions in a middle income country. *PLoS One*, *17*(1):e0261509. https://doi.org/10.1371/journal.pone.0261509

Esteve, A., Castro-Martín, T., & Castro Torres, A. F. (2022). Families in Latin America: Trends, singularities, and contextual factors. *Annual Review of Sociology*, *48*(1), 485–505. https://doi.org/10.1146/annurev-soc-030420-015156

Esteve, A., & Florez-Paredes, E. (2018). The stability paradox: Why expansion of women's education has not delayed early union formation or childbearing in Latin America. *Studies in Family Planning*, *49*(2), 127–142. https://doi.org/10.1111/sifp.12055

De Ferranti, D., Perry, G., Ferreira, F., & Walton, M. (2004). *Inequality in Latin America: Breaking with history?* World Bank.

Ferris, E., & Sorrell, E. (2021). The impacts of pandemics on migration. In V. Bozkurt, G. Dawes, H. Gülerce, & P. Westenbroek (Eds.), *The societal impacts of Covid-19: A transnational perspective* (pp. 123–142). Istanbul University Press. https://doi.org/10.26650/B/SS49.2021.006.09

Gromski, P. S., Smith, A. D. A. C., Lawlor, D. A., Sharara, F. I., & Nelson, S. M. (2021). 2008 financial crisis versus 2020 economic fallout: How COVID-19 might influence fertility treatment and live births. *Reproductive BioMedicine Online*, *42*(6), 1087–1096. https://doi.org/10.1016/j.rbmo.2021.03.017

Guadagno, L. (2020). *Migrants and the COVID-19 pandemic an initial analysis*. https://publications.iom.int/system/files/pdf/mrs-60.pdf

Guzmán, J. M., Rodríguez, J., Martínez, J., Contreras, J. M., & González, D. (2006). The Demography of Latin America and the Caribbean since 1950. *Population (English edition)*, *61*(5–6), 519–576. https://doi.org/10.3917/pope.605.0519

Hale, T., Angrist, N., Goldszmidt, R., Kira, B., Petherick, A., Phillips, T., Webster, S., Cameron-Blake, E., Hallas, L., Majumdar, S., & Tatlow, H. (2021). A global panel database of pandemic policies (Oxford COVID-19 Government Response Tracker. *Nature Human Behaviour*, *5*(4), 529–538. https://doi.org/10.1038/s41562-021-01079-8

Helleringer, S., & Queiroz, B. L. (2022). Commentary: Measuring excess mortality due to the COVID-19 pandemic: Progress and persistent challenges. *International Journal of Epidemiology*, *51*(1), 85–87. https://doi.org/10.1093/ije/dyab260

Hubert, C., Miranda-Ribeiro, P., & Salinas, V. (2022). Fecundidad, salud sexual y reproductiva en tiempos de la COVID-19 en Latinoamérica. Asociación Latinoamericana de Población-ALAP. https://chuva-inc.github.io/galoa-static-files/realm/alap/Fecundidad_SSR_ILAPOn2.pdf

Ibáñez, A. M., & Moya, A. (2010). Vulnerability of victims of civil conflicts: Empirical evidence for the displaced population in Colombia. *World Development*, *38*(4), 647–663. https://doi.org/10.1016/j.worlddev.2009.11.015

Instituto Nacional de Estadística y Geografía. (2022). *COMUNICADO DE PRENSA (No. 552/22)*. https://www.inegi.org.mx/contenidos/saladeprensa/boletines/2022/NR/NR2021.pdf

Jatrana, S., Temple, J., Wilson, T., & Payne, C. (2022). Demography and COVID-19: Risks, responses and impacts. *Journal of Population Research*, *39*(4), 475–478.

Johnson-Hanks, J., Bachrach, C. A., Morgan, P., & Kohler, H.-P. (2011). *Understanding family change and variation: Toward a theory of conjunctural action* (1st ed.). Springer.

Juárez, F., & Gayet, C. (2014). Transitions to adulthood in developing countries. *Annual Review of Sociology*, *40*, 521–538. https://doi.org/10.1146/annurev-soc-052914-085540

Kanavos, P., Colville Parkin, G., Kamphuis, B., & Gill, J. (2019). *Latin America healthcare system overview. A comparative analysis of fiscal* *space in healthcare*. The London School of Economics and Political Science.

Karimi, L., Makvandi, S., Vahedian-Azimi, A., Sathyapalan, T., & Sahebkar, A. (2021). Effect of COVID-19 on mortality of pregnant and postpartum women: A systematic review and meta-analysis. *Journal of Pregnancy*, *2021*, 1–33. https://doi.org/10.1155/2021/8870129

Lewis, T. (2021). The pandemic caused a baby bust, not a boom. *Scientific American*. https://www.scientificamerican.com/article/the-pandemic-caused-a-baby-bust-not-a-boom/

Lima, E. E. C., Soares, C. F., & Monteiro da Silva, J. H. C. (2021). *Baby bust: Births fall in Brazilian major cities during the Covid-19 pandemic* [Preprint]. Open Science Framework. https://doi.org/10.31219/osf.io/a3n6s

Lin, T. K., Law, R., Beaman, J., & Foster, D. G. (2021). The impact of the COVID-19 pandemic on economic security and pregnancy intentions among people at risk of pregnancy. *Contraception*, *103*(6), 380–385. https://doi.org/10.1016/j.contraception.2021.02.001

Lindberg, L. D., VandeVusse, A., Mueller, J., & Kirstein, M. (2020). Early impacts of the COVID-19 pandemic: Findings from the 2020 Guttmacher Survey of Reproductive Health Experiences. Guttmacher Institute. https://doi.org/10.1363/2020.31482

Lobkowicz, L., Power, G. M., De Souza, W. V., Montarroyos, U. R., Martelli, C. M. T., de Araùjo, T. V. B., Bezerra, L. C. A., Dhalia, R., Marques, E. T. A., Miranda-Filho, D. B., Brickley, E. B., & Ximenes, R. A. A. (2021). Neighbourhood-level income and Zika virus infection during pregnancy in Recife, Pernambuco, Brazil: An ecological perspective, 2015–2017. *BMJ Global Health*, *6*(12):e006811. https://doi.org/10.1136/bmjgh-2021-006811

Luppi, F., Arpino, B., & Rosina, A. (2020). The impact of COVID-19 on fertility plans in Italy, Germany, France, Spain, and the United Kingdom. *Demographic Research*, *43*, 1399–1412. https://doi.org/10.4054/DemRes.2020.43.47

Mamelund, S.-E., & Dimka, J. (2021). Not the great equalizers: Covid-19, 1918–20 influenza, and the need for a paradigm shift in pandemic preparedness. *Population Studies*, *75*, 179–199. https://doi.org/10.1080/00324728.2021.1959630

Mamelund, S.-E., Shelley-Egan, C., & Rogeberg, O. (2021). The association between socioeconomic status and pandemic influenza: Systematic review and meta-analysis. *PLoS One*, *16*(9):e0244346. https://doi.org/10.1371/journal.pone.0244346

Marinho, M. F., Torrens, A., Teixeira, R., Brant, L. C. C., Malta, D. C., Nascimento, B. R., Ribeiro, A. L. P., Delaney, R., de Paula, P. C. B., Setel, P., Sampaio, J. M., & Nogales-Vasconcelos, A. M. (2022). Racial disparity in excess mortality in Brazil during COVID-19 times. *European Journal of Public Health*, *32*(1), 24–26. https://doi.org/10.1093/eurpub/ckab097

Marteleto, L. J., Guedes, G., Coutinho, R. Z., & Weitzman, A. (2020). Live births and fertility amid the Zika epidemic in Brazil. *Demography*, *57*(3), 843–872. https://doi.org/10.1007/s13524-020-00871-x

Montaño Mendoza, V. M., Velilla, P. A., Tamayo Hussein, S., & Cardona Maya, W. (2021). Impact of the Covid-19 pandemic on birth rates in 2020: The case of Colombia. *Revista Brasileira de Ginecologia e Obstetrícia/RBGO Gynecology and Obstetrics*, *43*(06), 492–494. https://doi.org/10.1055/s-0041-1731380

Msemburi, W., Karlinsky, A., Knutson, V., Aleshin-Guendel, S., Chatterji, S., & Wakefield, J. (2023). The WHO estimates of excess mortality associated with the COVID-19 pandemic. *Nature*, *613*(7942), 130–137. https://doi.org/10.1038/s41586-022-05522-2

Nicolelis, M. A. L., Raimundo, R. L. G., Peixoto, P. S., & Andreazzi, C. S. (2021). The impact of super-spreader cities, highways, and intensive care availability in the early stages of the COVID-19 epidemic in Brazil. *Scientific Reports*, *11*(1), 13001. https://doi.org/10.1038/s41598-021-92263-3

Nitsche, N., Jasilioniene, A., Kniffka, M., Myrskylä, M., & Nissen, J. (2021). *Pandemic babies? The fertility response to the first Covid-19 wave across European regions*. Pandemic Babies? The Covid-19 Pandemic and Its Impact on Fertility and Family Dynamics.

Nitsche, N., & Lee, S. (2021). *Emotion and fertility in times of disaster*: *Conceptualizing fertility responses to the COVID-19* pandemic and beyond. population association of America - Annual Meeting.

Orellana, J. D. Y., Cunha, G. M., Marrero, L., Horta, B. L., & Leite, I. C. (2020). Explosão da mortalidade no epicentro amazônico da epidemia de COVID-19. *Cadernos de Saúde Pública*, *36*(7), e00120020. https://doi.org/10.1590/0102-311x00120020

Pesando, L. M., & Abufhele, A. (2023). Declining quantity and quality of births in Chile amidst the COVID-19 pandemic. *Population and Development Review*. https://doi.org/10.1111/padr.12541

Portes, A., & Hoffman, K. (2003). Latin American class structures: Their composition and change during the neoliberal era. *Latin American Research Review*, *38*(1), 41–82. https://doi.org/10.1353/lar.2003.0011

Queiroz, B. L., Gonzaga, M. R., Vasconcelos, A. M. N., Lopes, B. T., & Abreu, D. M. X. (2020). Comparative analysis of completeness of death registration, adult mortality and life expectancy at birth in Brazil at the subnational level. *Population Health Metrics*, *18*(S1), 11. https://doi.org/10.1186/s12963-020-00213-4

Rendall, M., Aracil, E., Bagavos, C., Couet, C., Derose, A., Digiulio, P., Lappegard, T., Robert-bobe, I., Rønsen, M., Smallwood, S., & Verropoulou, G. (2010). Increasingly heterogeneous ages at first birth by education in Southern European and Anglo-American family-policy regimes: A seven-country comparison by birth cohort. *Population Studies*, *64*(3), 209–227. https://doi.org/10.1080/00324728.2010.512392

Rios-Neto, E. L. G., Miranda-Ribeiro, A., & Miranda-Ribeiro, P. (2018). Fertility differentials by education in Brazil: From the conclusion of fertility to the onset of postponement transition. *Population and Development Review*, *44*(3), 489–517.

Ross, L. J., & Solinger, R. (2017). *Reproductive justice: An introduction*. University of California Press.

Ruano, A. L., Rodríguez, D., Rossi, P. G., & Maceira, D. (2021). Understanding inequities in health and health systems in Latin America and the Caribbean: A thematic series. *International Journal for Equity in Health*, *20*(1), 94. https://doi.org/10.1186/s12939-021-01426-1

Sánchez-Ancochea, D. (2021). *The costs of inequality in Latin America: Lessons and warnings for the rest of the world*. Bloomsbury Publishing Plc. https://doi.org/10.5040/9781838606275

Schmertmann, C. P., Potter, J. E., & Cavenaghi, S. M. (2008). Exploratory analysis of spatial patterns in Brazil's fertility transition. *Population Research and Policy Review*, *27*(1), 1–15. https://doi.org/10.1007/sl

Schneider, J., & Schneider, P. (1996). *Festival of the poor. Fertility decline and the ideology of class* (1st ed.). The university of Arizona press.

Schwalb, A., Armyra, E., Méndez-Aranda, M., & Ugarte-Gil, C. (2022). COVID-19 in Latin America and the Caribbean: Two years of the pandemic. *Journal of Internal Medicine*, *292*(3), 409–427. https://doi.org/10.1111/joim.13499

Seymen, C. M. (2021). The other side of COVID-19 pandemic: Effects on male fertility. *Journal of Medical Virology*, *93*(3), 1396–1402. https://doi.org/10.1002/jmv.26667

Smits, J., & Permanyer, I. (2019). The Subnational Human Development Database. *Scientific Data*, *6*(1), 190038. https://doi.org/10.1038/sdata.2019.38

Sobotka, T., Jasilioniene, A., Galarza, A. A., Zeman, K., Nemeth, L., & Jdanov, D. (2021). Baby bust in the wake of the COVID-19 pandemic? First results from the new STFF data series [Preprint]. SocArXiv, https://doi.org/10.31235/osf.io/mvy62

Sobotka, T., Skirbekk, V., & Philipov, D. (2011). Economic recession and fertility in the developed world. *Population and Development Review*, *37*(2), 267–306. https://doi.org/10.1111/j.1728-4457.2011.00411.x

Somigliana, E., Esposito, G., Viganò, P., Franchi, M., Corrao, G., & Parazzini, F. (2021). Effects of the early phase of the COVID-19 pandemic on natural and ART-mediated birth rates in Lombardy Region, Northern Italy. *Reproductive BioMedicine Online*, *43*(4), 765–767. https://doi.org/10.1016/j.rbmo.2021.07.017

Svallfors, S., & Billingsley, S. (2019). Conflict and contraception in Colombia. *Studies in Family Planning*, *50*(2), 87–112. https://doi.org/10.1111/sifp.12087

Tan-Torres edejer, T., Hanssen, O., Mirelman, A., Verboom, P., Lolong, G., Watson, O. J., Boulanger, L. L., & Soucat, A. (2020). Projected health-care resource needs for an effective response to COVID-19 in 73 low-income and middle-income countries: A modelling study. *The Lancet Global Health*, *8*(11), e1372–e1379. https://doi.org/10.1016/S2214-109X(20)30383-1

United Nations Population Fund. (2021). *How will the COVID-19 pandemic affect births?* [Technical Brief].

United Nations High Commissioner for Refugees. (2019). *Forced displacement in 2018* (GLOBAL TRENDS). United Nations.

Urdinola, B. P., & Ospino, C. (2015). Long-term consequences of adolescent fertility: The Colombian case. *Demographic research*, *32*(1), 1487–1518. https://doi.org/10.4054/DemRes.2015.32.55

Urdinola, P. (2021). Demografía colombiana: En preparación para la era del envejecimiento, In *Descifrar el futuro. La economía colombiana en los próximos diez año* (pp. 111–175). Penguin.

Urrego, D. (2021). Aspectos demográficos, sociales y económicos potencialmente asociados a los resultados de la pandemia por el Covid-19 en Colombia, con enfoque especial en el departamento del Amazonas [Pontificia Universidad Javeriana]. https://repository.javeriana.edu.co/handle/10554/57950

Valente, C. (2015). Civil conflict, gender-specific fetal loss, and selection: A new test of the Trivers–Willard hypothesis. *Journal of Health Economics*, *39*, 31–50. https://doi.org/10.1016/j.jhealeco.2014.10.005

Verdery, A. M., Smith-Greenaway, E., Margolis, R., & Daw, J. (2020). Tracking the reach of COVID-19 kin loss with a bereavement multiplier applied to the United States. *Proceedings of the National Academy of Sciences*, *117*(30), 17695–17701. https://doi.org/10.1073/pnas.2007476117

Vignoli, D., Mencarini, L., & Alderotti, G. (2020). Is the effect of job uncertainty on fertility intentions channeled by subjective well-being? *Advances in Life Course Research*, *46*, 100343. https://doi.org/10.1016/j.alcr.2020.100343

Vignoli, D., Minello, A., Bazzani, G., Matera, C., & Rapallini, C. (2022). Narratives of the future affect fertility: Evidence from a laboratory experiment. *European Journal of Population*, *38*, 93–124. https://doi.org/10.1007/s10680-021-09602-3

Wilde, J., Chen, W., & Lohmann, S. (2020). COVID-19 and the future of US fertility: What can we learn from Google? (WP-2020-034; 0 ed., p. WP-2020-034). Max Planck Institute for Demographic Research. https://doi.org/10.4054/MPIDR-WP-2020-034

Williamson, J. G. (2010). Five centuries of Latin American income inequality. *Revista de Historia Económica/Journal of Iberian and Latin American Economic History*, *28*(02), 227–252. https://doi.org/10.1017/S0212610910000078

Wood, S. N. (2017). *Generalized additive models: An introduction with R* (2nd ed.). Chapman and Hall/CRC. https://doi.org/10.1201/9781315370279

Woo-Mora, L. G. (2021). Unveiling the cosmic race: Racial inequalities in Latin America. *Social Science Research Network*, 60.

World Bank Group. (2022). GINI index (World Bank estimate).

World Health Organization. (2022). *WHO global health expenditure database*. World health Organization. https://apps.who.int/nha/database

World Inequality Lab. (2020). World inequality database. https://wid.world/data/

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APPENDIX: DETAILED INFORMATION ON DATA SOURCES AND METHODS FOR RETRIEVING INFORMATION

For Brazil, we downloaded individual birth records from National Information Systems on Livebirths (Sistema de Informações sobre Nascidos Vivos, SINASC/DATASUS).[2] For Colombia, individual birth records were obtained from the National Statistical Office (Departamento Nacional de Estadística DANE).[3]

Weekly death counts and annual population counts by subnational division were retrieved from DATASUS in Brazil and DANE in Colombia. We obtained weekly population exposures as of July 1 in each subnational division by dividing the annual population counts by the number of weeks in each year, and we computed the population exposures for the remaining weeks through cubic spline interpolation.

Fertility change model: We calculate independent baseline fertility (i.e., expected) for each years of schooling (y.s.) and maternal age groups, within each subnational division in Brazil and Colombia. The model is defined as:

$$\log(births_{i,j,k,t}) = \beta_0 + \beta_1 t + CS(m),$$

where $births_{i,j,k,t}$ refers to the birth counts in each combination subnational region *i*, years of schooling group *j*, mother's age group *k*, and month *t*. β_0 indicates the intercept and $\beta_1 t$ indicates the log-linear secular trend. The term $CS(m)$ refers to a cyclic p-spline function applied to months *m* within a year (from 1 to 12 in all years) to account for fertility seasonality. The model uses a logarithmic link function with quasi-Poisson distribution to account for overdispersion.

We measured fertility changes in each schooling *s*, age *a*, region *r*, and month *t* using the *relative birth changes* (*RBC*) index, which indicates the percentage difference between the observed births relative to the fertility baseline. The *RBC* index is defined as $RBC_{i,j,k,t} = \frac{births_{i,j,k,t}}{baseline^{b}_{i,j,k,t}} - 1$, where $births_{i,j,k,t}$ and $baseline^{b}_{i,j,k,t}$ are, respectively, the observed and the expected births of mothers living in region *i*, with schooling years *j*, in the age group *k*, and during the month *t*.

Excess mortality model: We calculate independent baseline mortality (i.e., expected deaths) for each group of years of schooling

[2]Source: Sistema de Informações sobre Nascidos Vivos. https://opendatasus.saude.gov.br/

[3]Source: Archivo Nacional de Datos. https://sitios.dane.gov.co/anda-index/

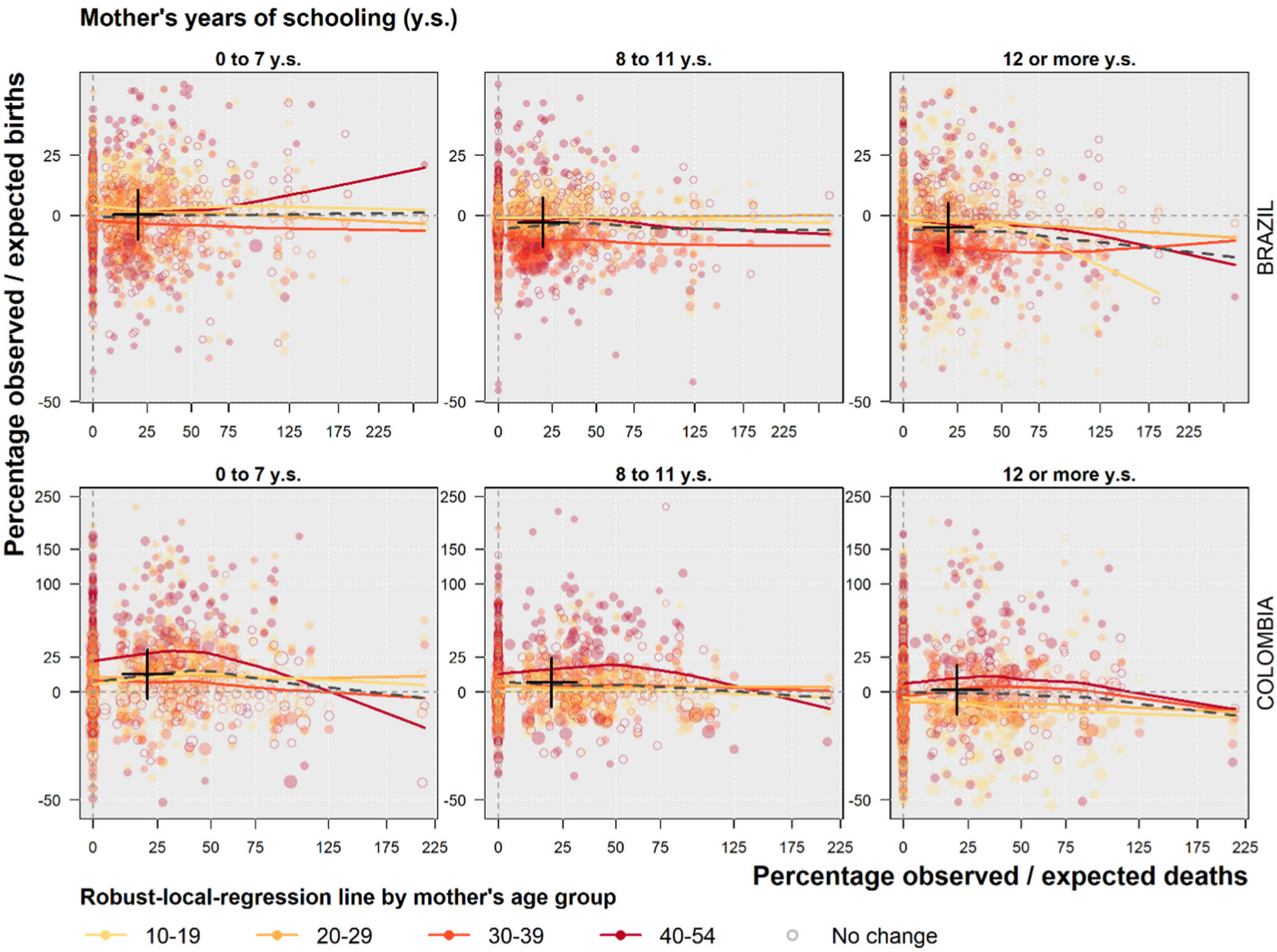

FIGURE A1 Subnational-level associations between 9-month lagged excess mortality and relative birth changes (*RBC*) in 2020 and 2021 by mother's age and years of schooling groups in Brazil and Colombia. Empty circles represent units where the observed number of births laid within the 80% prediction interval (i.e., no detectable change in the number of births). The cross markers indicate the mean of each axis.

TABLE A1 Associations between current and 9-month-lagged excess mortality and the relative birth changes (*RBC*) according to five model specifications (M1–M5).

	Current excess mortality				Nine-month lagged excess mortality			
	Brazil		Colombia		Brazil		Colombia	
Model specifications (M1–5) Dependent variable:	Coefficient	*p* Value	Coefficient	*p* Value	Coefficient	*p* Value	Coefficient	*p* Value
Relative birth changes (RBC)								
M1	−1.0 (0.09)	0.000	0.1 (0.20)	0.466	−0.9 (0.10)	0.000	−0.5 (0.20)	0.007
BIC	−8648		−100		−8648		−100	
M2	−1.0 (0.09)	0.000	0.1 (0.17)	0.414	−1.0 (0.10)	0.000	−0.4 (0.17)	0.013
BIC	−8946		−2009		−8946		−2009	
M3	−1.0 (0.09)	0.000	0.5 (0.19)	0.016	−0.9 (0.10)	0.000	−0.4 (0.20)	0.042
BIC	−8652		−416		−8652		−416	
M4: Years of schooling (y.s.) × Excess mortality (excess m.)								
[0–7 y.s.] × excess m.	0.5 (0.07)	0.018	0.8 (0.14)	0.098	−0.2 (0.07)	0.415	0.5 (0.14)	0.311

TABLE A1 (Continued)

Model specifications (M1–5) Dependent variable:	Current excess mortality				Nine-month lagged excess mortality			
	Brazil		Colombia		Brazil		Colombia	
	Coefficient	p Value	Coefficient	p Value	Coefficient	p Value	Coefficient	p Value
8–11 y.s. × excess m.	−1.6 (0.08)	0.000	−0.1 (0.15)	0.777	−0.7 (0.08)	0.009	−0.9 (0.16)	0.070
12 or more y.s. × excess m.	−2.2 (0.09)	0.000	−1.8 (0.17)	0.001	−1.6 (0.10)	0.000	−1.2 (0.17)	0.025
BIC	−8985		−2015		−8954		−1997	
M5: Mothers' age × Excess mortality (excess m.)								
[10–19 y.o.] × excess m.	0.0 (0.24)	0.981	0.6 (0.39)	0.111	−0.2 (0.24)	0.410	0.4 (0.39)	0.338
20–29 y.o. × excess m.	−1.0 (0.27)	0.000	−0.2 (0.44)	0.669	−0.2 (0.28)	0.455	−1.2 (0.45)	0.006
30–39 y.o. × excess m.	−1.3 (0.28)	0.000	−1.3 (0.50)	0.011	−2.0 (0.30)	0.000	−0.4 (0.50)	0.421
40–49 y.o. × excess m.	−0.9 (0.53)	0.078	−1.7 (1.06)	0.120	−1.4 (0.56)	0.014	−1.1 (1.09)	0.308
BIC	−8942		−1994		−8999		−1993	
Number of observations	6800		5703		6800		5703	

Note: Coefficients represent the percentage point changes associated with a one standard deviation increase in excess mortality *p*-scores. Significance, standard errors, and goodness of fit measures are displayed next and underneath excess mortality coefficients. Reference categories are in squared brackets. The number of observations corresponds to all combinations of year-month, subnational areas, age groups, and years of schooling groups with at least one observed birth from April 2020 to December 2021. The model specifications for current mortality control for lagged mortality, and vice versa. Besides the excess mortality *p*-scores, M1 includes dummy variables for maternal age and years of schooling groups (Equation 1). M2 adds dummy variables for subnational units. M3 substitutes dummy variables for the subnational Human Development Index in 2019 (SHDI). Because M2 yields a better fit than M3, interaction terms are added to M2 in M4 and M5. M4 includes the interaction between maternal years of schooling groups and current and lagged excess mortality, one at a time. And, M5 includes the interaction between maternal age groups and current and lagged excess mortality, one at a time.

TABLE A2 Associations between 7-month-lagged and 9-month-lagged excess mortality and the relative birth changes (*RBC*) according to five model specifications (M1–M5).

Model specifications (M1–5) Dependent variable:	Seven-month lagged excess mortality				Nine-month lagged excess mortality			
	Brazil		Colombia		Brazil		Colombia	
	Coefficient	p Value	Coefficient	p Value	Coefficient	p Value	Coefficient	p Value
Relative birth changes (RBC)								
M1	0.4 (0.11)	0.001	−0.9 (0.20)	0.000	−1.0 (0.11)	0.000	−0.2 (0.20)	0.235
BIC	−8889		−218		−8889		−218	
M2	0.4 (0.10)	0.001	−0.7 (0.16)	0.000	−1.1 (0.11)	0.000	−0.2 (0.17)	0.220
BIC	−9195		−2167		−9195		−2167	
M3	0.4 (0.11)	0.001	−0.7 (0.19)	0.000	−1.0 (0.11)	0.000	−0.1 (0.19)	0.603
BIC	−8900		−531		−8900		−531	
M4: Years of schooling (y.s.) * Excess mortality (excess m.)								
[0–7 y.s.] * excess m.	0.7 (0.07)	0.006	0.4 (0.13)	0.399	−0.4 (0.07)	0.109	1.0 (0.14)	0.030
8–11 y.s. * excess m.	−0.3 (0.08)	0.230	−1.2 (0.15)	0.011	−0.7 (0.08)	0.013	−1.2 (0.15)	0.011
12 or more y.s. * excess m.	−0.5 (0.09)	0.085	−1.3 (0.16)	0.009	−1.5 (0.10)	0.000	−1.6 (0.16)	0.003
BIC	−9180		−2157		−9201		−2158	
M5: Mothers' age × Excess mortality (excess m.)								
[10–19 y.o.] × excess m.	0.7 (0.24)	0.003	−0.4 (0.36)	0.304	−0.4 (0.24)	0.132	0.5 (0.37)	0.151
20–29 y.o. × excess m.	0.1 (0.27)	0.614	−0.7 (0.42)	0.086	−0.2 (0.27)	0.528	−1.1 (0.42)	0.008

(Continues)

TABLE A2 (Continued)

Model specifications (M1–5) Dependent variable:	Seven-month lagged excess mortality				Nine-month lagged excess mortality			
	Brazil		Colombia		Brazil		Colombia	
	Coefficient	*p* Value	Coefficient	*p* Value	Coefficient	*p* Value	Coefficient	*p* Value
30–39 y.o. × excess m.	−1.2 (0.28)	0.000	0.2 (0.47)	0.641	−2.0 (0.29)	0.000	−0.5 (0.48)	0.302
40–49 y.o. × excess m.	−1.3 (0.53)	0.016	−0.7 (1.02)	0.486	−1.1 (0.55)	0.042	−0.3 (1.04)	0.740
BIC	−9220		−2148		−9256		−2149	
Number of observations	6800		5703		6800		5703	

Note: Coefficients represent the percentage point changes associated with a one standard deviation increase in excess mortality *p*-scores. Significance, standard errors, and goodness of fit measures are displayed next and underneath excess mortality coefficients. Reference categories are in squared brackets. The number of observations corresponds to all combinations of year-month, subnational areas, age groups, and years of schooling groups with at least one observed birth from April 2020 to December 2021. The model specifications for current mortality control for lagged mortality, and vice versa. Besides the excess mortality *p*-scores, M1 includes dummy variables for maternal age and years of schooling groups (Equation 1). M2 adds dummy variables for subnational units. M3 substitutes dummy variables for the subnational Human Development Index in 2019 (SHDI). Because M2 yields a better fit than M3, interaction terms are added to M2 in M4 and M5. M4 includes the interaction between maternal years of schooling groups and current and lagged excess mortality, one at a time. And, M5 includes the interaction between maternal age groups and current and lagged excess mortality, one at a time.

(y.s.) and maternal age, within each subnational division in Brazil and Colombia. The model is defined as:

$$\log(deaths_{i,j,k,t}) = \beta_0 + \beta_1 t + CS(w) + \log(exposure_{i,j,k,t}),$$

where $deaths_{i,j,k,t}$ and $exposure_{i,j,k,t}$ refer to the deaths counts and population exposures for each region i, year of schooling group j, and maternal age group k combination in week t. β_0 indicates the intercept and $\beta_1 t$ indicates the log-linear secular trend in mortality. The term $CS(w)$ refers to a cyclic p-spline function applied to weeks w within a year (from 1 to 52 in regular years and from 1 to 53 in leap years) to account for mortality seasonality. The model uses a logarithmic link function with quasi-Poisson distribution to account for overdispersion. We used the R package *mgcv* for fitting the models (Wood, 2017). Excess deaths by trimester were obtained by adding the weekly excess deaths in each quarter year, and fractionating the deaths of the overlapping weeks according to the days in each trimester.

We measured monthly excess mortality using the *p*-score index, which indicates the percentage difference between the observed deaths relative to the mortality baseline in each schooling s, age a, and region r categories, and month t. This index is defined as $p - score_{i,j,k,t} = \frac{deaths_{i,j,k,t}}{baseline^{d}_{i,j,k,t}} - 1$, where $deaths_{i,j,k,t}$ and $baseline^{d}_{i,j,k,t}$ are, respectively, the observed and the expected deaths in month t.

See Tables A1 and A2.