Barcelona, April 22, 2022

Drs. Muttarak and Wilde,

Editors

*Population and Development Review*

Dear Drs. Muttarak and Wilde,

We are delighted to submit our manuscript entitled “Heterogeneous associations between the Covid-19 pandemic and births across subnational areas in Brazil and Colombia. A registry data-based analysis” to be considered for publication in the *Population and Development Review* supplement on the Covid-19 pandemic and its impact on fertility and family dynamics.

Thank you for considering our work.

Sincerely yours, also on behalf of Drs. Sacco, Pardo, Urdinola, and Acosta,

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**Heterogeneous associations between the Covid-19 pandemic and births across subnational areas Brazil and Colombia. A registry data-based analysis**

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**Abstract**

This work contributes to the current understanding of the potentially heterogeneous influence of the Covid-19 pandemic on changes in the number of births by maternal age and educational attainment in contexts characterized by high socioeconomic inequality and relatively poor institutional responses to the health and economic crises triggered by the Covid-19 pandemic. Using register data on births and deaths for Brazil and Colombia, we document state-level correlations between the intensity of the pandemic, measured by the current, nine-month lagged, and cumulative 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 educational attainment to test the hypothesis that the immediate influence of the Covid-19 pandemic on births interact with pre-existing forms of social inequality, which could further deepen the socioeconomic gaps between subpopulations in these two countries. We argue that highlighting the socioeconomic-specific consequences of the pandemic is of vital importance, as these effects may vary depending on individuals’ years of schooling, ethnicity, migration status, and sexual minority status in many contexts, including in high-income countries. Thus, certain subpopulations may suffer more acutely from the consequences of the Covid-19 pandemic than the majority of the population.

**Introduction**

There is an urgent need to better understand the effects of the Covid-19 pandemic on population dynamics. These effects are proving to be profound, as they extend to every dimension of population dynamics, and are likely to last for decades. Since the start of the pandemic, demographers have highlighted the importance of considering the effects of Covid-19 not only on mortality, but also on fertility (Tomas Sobotka et al. 2021; Aassve et al. 2020), fertility intentions (Emery and Koops 2022; Lindberg et al. 2020; Luppi, Arpino, and Rosina 2020), and migration (Ferris and Sorrell 2021; Guadagno 2020). Researchers have also described the impact of the pandemic on other dimensions of demographic change, including on 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).

Because of the magnitude and the scope of the Covid-19 pandemic, the theorization of most such studies has hinged on the assumption that the pandemic is having a far-reaching impact on population dynamics. However, the extent to which the Covid-19 pandemic is influencing reproductive behaviors and outcomes is likely to vary between and within countries (Aassve et al. 2021). Between-country variation may arise from differences in countries’ capacities to respond to the pandemic due to factors such as the quality and the coverage of national health systems, access to vaccines, the timing and the duration of the lockdowns, levels of financial support for families and companies, and pre-existing patterns of reproductive behaviors and rights (e.g., fertility levels, the prevalence of contraception, access to contraception and other forms of family planning, and abortion regulations). Analogously, subnational disparities along these dimensions are potential sources of within-country variation in the degree to which the pandemic has been and is influencing reproductive outcomes, particularly for countries with socioeconomically heterogeneous populations, large geographical areas, and weak or absent welfare policies.

Few empirical studies have focused on the differential influence of the Covid-19 pandemic on reproductive patterns by socioeconomic status, particularly in populations suffering from substantial socioeconomic cleavages. 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). 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 measure these disparities in the rest of the world, particularly in Latin America and the Caribbean (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 March 2022, three LATAM countries (Brazil, México, and Peru) were among the top 10 countries contributing to the total number of Covid-19 deaths. While less is known about impact of the pandemic on fertility and migration in the region, it is likely to be considerable (ECLAC 2021).

At the individual and the household level, large disparities in access to crucial resources for coping with the pandemic (e.g., information, savings, and social networks) are likely to deepen the potential differences in the influence of the Covid-19 pandemic on fertility patterns across socioeconomic groups. A recent review on the unequal effects of micro- and macro-level disruptive events supports this claim (Aquino, Brand, and Torche 2022). Moreover, as disadvantaged populations have historically been more exposed to the negative consequences of social, economic, and health crises (Mamelund and Dimka 2021; Mamelund, Shelley-Egan, and Rogeberg 2021), their reproductive patterns may be more affected by the pandemic (Lobkowicz et al. 2021; J. Schneider and Schneider 1996). This is likely the case for millions of families in LATAM, a region where more than one out of every three people lives in poverty (ECLAC 2022).

In light of this context, this paper examines the association between the intensity of the Covid-19 pandemic – measured by excess mortality – and relative changes in the total number of births by maternal age and years of schooling at the subnational levels in Brazil and Colombia. We draw on more than 30 million vital records (23 million births and seven million deaths) registered in these two countries from 2015 to 2019 to reconstruct time trends in overall mortality and the number of births by maternal age and education, and to predict these trends for 2020 and 2021. These predictions are our baseline for measuring changes in mortality (excess mortality) and relative birth changes (*rbc*). Next, we examine trimester data on *rbc* and excess deaths during 2020 and 2021, and find differential associations between excess mortality and *rbc* by maternal years of schooling. Whereas the relative change in the number of births to women with eight or more years of schooling seems to have been unaffected by excess mortality, the relative change in the number of births to less-educated women – particularly to those with less than three years of schooling – appears to be positively associated with excess mortality. We observe stronger associations and associations with the reverse sign when we correlate nine-month lagged excess mortality and the *rbc*. These associations are found to be negative in Brazil and positive in Colombia among less-educated women, and to be null or slightly negative for highly-educated women in both countries.

We interpret these findings from a materialist perspective; i.e., we assume that the unequal distribution of material resources is a critical factor in the differential influence of the pandemic on demographic outcomes across subpopulations (Danna 2021). Our argument goes as follows. During periods marked by social, economic, and health crises, the demand for resources is high. Social groups with lower levels of or restricted access to resources are more likely to be affected by such crises. These effects can be positive or negative for fertility, as has been observed for periods of conflict in Colombia (Castro Torres and Urdinola 2019), or of forced sterilization in Brazil (Caetano and Potter 2004), respectively. Accordingly, groups in socioeconomically privileged positions are more likely to be able to mobilize and use their resources to cope with the challenges associated with these crises (e.g., by traveling abroad to gain access to medical services if the national health system is overwhelmed). Although we are unable to specifically test our materialist assumptions, our finding that the association between Covid-19 mortality and fertility differed by maternal years of schooling in both countries suggests that this interpretation is plausible. Moreover, following the argument by Sanchez-Ancochea (2021) that the experiences observed in LATAM (ongoing inequality, poor political leadership from economic elites, and the lack of a welfare state) are applicable to other countries, we believe that our results could shed light on the Covid-19-fertility link in other countries where the fertility regime (*quantum* and timing) is similar to that of Brazil or Colombia, the level of inequality is high or rising, and the welfare state is absent or is failing to meet the needs of the population.

**Background**

*Births during the pandemic*

Theoretically, the pandemic could affect fertility through various mechanisms, including through its direct influence on morbidity, but also via the effects of lockdowns and other restrictive measures imposed by governments, and the responses of men and women 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 itself (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. Fertility may decline if a) the union formation rate decreases or the union dissolution rate increases, or non-cohabiting 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 health care 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 have increased 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 actual academic support.

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, Chen, and Lohmann 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 1918-19 influenza pandemic, which triggered a decline in fertility – e.g., a 13% decrease in the U.S. (Chandra et al. 2018) – due to the disproportionately increased morbidity 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 following the Great Recession of 2008-2009 (Tomáš Sobotka, Skirbekk, and Philipov 2011; Comolli 2021; D. Schneider 2017). These experiences led to the development of different theories regarding the emotional pathways that may underlie the relationshipbetween disasters and fertility preferences; and highlighted the relevance of subjective well-being, and especially of uncertainty and anxiety, in fertility decision-making (Comolli and Vignoli 2021; Nitsche and Lee 2021; Vignoli, Mencarini, and Alderotti 2020; Vignoli et al. 2022).

In a separate study, Sobotka et al. (2021) found that the baby boom hypothesis was largely 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 nine months after the onset of the pandemic. Compared to 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; and that the declines were particularly large 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 had a net negative effect on 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 that was followed by the reversion of fertility rates to pre-pandemic levels in most countries (UNFPA 2021). A scenario of a partial recovery of fertility seems probable, although fertility trends may also be unstable, characterized by cycles of busts and recoveries, similar to the cycles of the pandemic.

Finally, subnational data are becoming available that will allow researchers to examine these trends in a more disaggregated manner. The first study on subnational patterns was by Cohen (2021), who examined fertility in counties in Florida and Ohio in the U.S. (see Nitsche et. al. (2021) for an analysis of subnational fertility patterns in European countries). The results showed that there was regional within-country heterogeneity in “excess births,” with the largest fertility declines being observed in places that were most affected by the pandemic in terms of infection rates and reductions in mobility.

*The case of Brazil and Colombia*

We have chosen to study the influences of the Covid-19 pandemic on births in Brazil and Colombia because these two countries have similar overall fertility trends (Guzmán et al. 2006) and social stratification systems (Portes and Hoffman 2003). However, the differences between these two countries in terms of their population size, their geographical area, the functioning of their national health system, and their economic development may account for some of the discrepancies in the Covid-19-fertility associations. Importantly, over the past seven decades, Colombia has witnessed an undeclared civil war involving the official forces, paramilitary groups, and guerrillas – the longest internal armed conflict of the LATAM region. This conflict has left thousands of fatalities among civilians, and more than eight million internally displaced individuals making Colombia the second country with the largest internally displaced population only surpassed by Syria as of 2018 (United Nations High Commissioner for Refugees 2019).

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 geographic regions and socioeconomic groups (Adserà and 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 even earlier in Brazil than in Colombia, in the early years of the current century (Rios-Neto, Miranda-Ribeiro, and Miranda-Ribeiro 2018). Although the fertility patterns in LATAM are unlike those in many other low-fertility contexts (e.g., adolescent fertility rates tend to be high), social norms relating to stopping mechanisms and to a later transition to motherhood are emerging in both countries (Castanheira and Kohler 2017; B. P. Urdinola and Ospino 2015).

In both Brazil and Colombia, there has been a limited governmental response to the health and economic crises sparked by the spread of the virus (Hale et al. 2021). Moreover, both countries have low rankings in international measures of countries’ responses to the pandemic, such as in the Covid Performance Index of the Lowy Institute[[1]](#footnote-1). 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, 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. In the pre-pandemic 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; P. Urdinola 2021). This territorial heterogeneity was reflected in the levels of resources available in each region due to its economic conditions, public infrastructure, and health care facilities – all of which were key to responding to the pandemic (Tan-Torres et al. 2020).

The primary differences between these two countries are related to their population size and their 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 larger 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 former than in the latter country: i.e., the Gini index for 2019 was 53.4 in Brazil and 51.3 in Colombia (World Bank Group 2020). This gap in the Gini index is similar in magnitude to the differences between the two countries reported in other measures of inequality. 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 it is in Colombia (World Inequality Lab 2020).

Although the inequality levels are higher in Brazil than in Colombia, the public health expenditures and health systems are better in the former than in the latter country. These differences should be seen in the context of the long-standing deficits in health systems in LATAM, despite some signs of improvement in recent decades (Ruano et al. 2021). Importantly, 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).

Finally, the decades-long internal armed conflict in Colombia has affected demographic dynamics, including fertility and contraception, in that country (Svallfors and Billingsley 2019). A large share of the Colombian population (e.g., more than eight million internally displaced people) have been suffering from the negative consequences of this internal violence (Ibáñez and Moya 2010). It is likely that the negative consequences of the Covid-19 pandemic will be greater for the internally displaced population or other victims of the internal conflict.

Against this background, we can expect to observe a differential association between the Covid-19 pandemic and fertility by geographic area and maternal socioeconomic status. Previous studies have assessed the probable effects of the pandemic on fertility rates and demographic dynamics, mostly in Brazil (Coutinho et al. 2020; Diniz Alvez 2021). Fertility declines were detected in six major cities of Brazil (Lima, Soares, and Monteiro da Silva 2021), but also in some parts of Colombia toward the end of 2020 (Montaño Mendoza et al. 2021). However, these figures are subject to debate, as UNFPA (2021) found that the pandemic had no clear impact on births in Brazil and Colombia. More importantly, these studies did not examine the effects of the pandemic on fertility in a comparative perspective by maternal age and years of schooling.

**Data and methods**

*Baseline and relative measures of births and deaths*

For our dependent variable – the difference between the number of births during the pandemic trimesters in 2020 and 2021 and the expected number of births – we rely on official records of the number of registered live births (2015-2021) published by the Colombian National Bureau of Statistics (DANE) and the Brazilian Departamento de Informática do Sistema Único de Saúde (DATAUS) within the Ministry of Health (DATAUS). The Brazilian data cover births until December 2021, whereas the Colombian data stop in September 2021. The Colombian data are preliminary for the last two years, but reflect about 95% of the final figures[[2]](#footnote-2). Despite the potential underreporting of births in the Brazilian and Colombian data, our level of aggregation (i.e., state and department) makes municipal-level underreporting unlikely to affect our results (Girodo et al. 2015). It is noteworthy that if birth reporting coverage was similar during the pandemic period in both countries, estimates of relative changes would not be affected by underreporting of births, as it would be the case of absolute changes. In total, we use information on 23.5 million births (19.2 million in Brazil, and 4.3 million in Colombia).

We draw on the 2015-2019 information to calculate the expected numbers of births (i.e., baseline births), accounting for time trends and seasonality. Based on these expected numbers of births, we calculate our dependent variable as the ratio between observed and baseline births. These ratios, denoted as *rbc* (i.e., relative birth changes), are analogous to those of excess mortality, as they express the relative change in the number of births with respect to a pandemic-free scenario. These calculations are disaggregated by maternal age (10-19, 20-24, 25-29, 30-34, 35-39, 40-54) and years of schooling groups (zero to three y.s., four to seven y.s., eight to 11 y.s., and 12 or more y.s.)[[3]](#footnote-3). Disaggregation by maternal age groups allows us to account for the age pattern of fertility, and the years of schooling groups serve as a proxy for women’s socioeconomic positions. Given the nature of the educational systems and the characteristics of the labor markets in these two countries, particularly for women, the years of schooling groups are a good proxy not only for women’s human capital accumulation, but also for their socioeconomic status (Sánchez-Ancochea 2021; De Ferranti et al. 2004).

We supplement our data on relative birth changes (*rbc*) with subnational estimates of excess mortality in 2020 and 2021. We define excess mortality as the difference between all-cause observed mortality and all-cause expected mortality in the absence of the pandemic, also denoted as baseline mortality. We estimate weekly 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. Following recent developments in and good practices on excess mortality measurement, 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 and Queiroz 2022). The use of p-scores allows us to compare mortality excess across different populations, regardless of differences in pre-pandemic mortality levels and population sizes. We are not able to account for differences in population age structures, as the weekly mortality series in Colombia have no information on age.

Using multivariate linear models, we correlate subnational p-score excess mortality with the *rbc* in each trimester from the beginning of the pandemic (i.e., the second trimester of 2020) to the third trimester of 2021. We weight each observation (combination of subnational area, trimester, maternal age and years of schooling groups) by the number of births in each cell relative to the total number of births in the country. This weighting strategy improves the representativeness of our results by giving more weight to the age groups in which fertility is concentrated, the subnational areas with larger populations, and the years of schooling groups that account for the largest shares of births.

In a multivariate model, we use two versions of the p-scores as a predictor: one for the current trimester (current excess mortality) and a two-trimester lagged p-score (lagged excess mortality). We use the current excess mortality p-score as a test for the potential short-term influences of the pandemic on fertility (e.g., due to the worsening of reproductive health-related services, and increases or decreases in the number of pregnancy interruptions or fetal deaths). We account for the nine months of pregnancy using the lagged excess mortality p-score, which enables us to test the potential influence of the pandemic on fertility decisions (e.g., as couples may have postponed or abandoned their fertility plans) and opportunities for conception (e.g. as non-cohabitating couples may have reduced their encounters due to lockdown measures). Because deaths (including excess deaths) are the result of individual processes of varying duration (e.g., long-lasting chronic diseases, failed medical procedures or treatments, accidents), there are lags in the excess mortality measures for a given period. In the context of a health crisis, excess mortality in a given month or trimester may reflect the worsening of health services over the preceding months. Therefore, our two measures of excess mortality (current and nine-month lagged) offer a parsimonious overview of how the unfolding crisis may be related differently to ongoing pregnancies and to conceptions that may have occurred (planned or unplanned) right after the consequences of the Covid-19 pandemic began to spread. While these are not perfect measures, the differences in their timing allow us to capture distinct aspects of ongoing mortality and fertility in a sensible manner.

We estimate four multivariate specifications and compare their goodness of fit using the Akaike information criterion (AIC), with lower AIC implying a better fit. The first specification (M.S.1) predicts the *rbc* based on the p-score of excess mortality and dummy variables for the maternal age and years of schooling groups. This specification is our benchmark for: (i) the association between excess mortality and fertility and (ii) the models’ goodness of fit. Our second specification (M.S.2) accounts for pre-existing subnational differences in the populations’ socioeconomic capacity to respond to the pandemic. We use the 2019 subnational Human Development Index (HDI) for this purpose (Smits and Permanyer 2019). Our third specification (M.S.3) includes dummy variables for each subnational level. Finally, our last specification (M.S.4) tests the potential existence of an interaction between excess mortality and maternal years of schooling; i.e., a potential differential association between the pandemic and the fertility of women with different levels of educational attainment. This specification includes dummies for subnational areas.

**Results**

According to Figure 1, the time trends suggest that there was a negative association between the pandemic and the number of births. In Figure 1, all series of observed births in 2020 and 2021 (black lines) are below the series for the expected number of births (red dotted lines).

\*\*\* Figure 1 \*\*\*

Figure 1 indicates that the total number of births to women with eight to 11 and 12 or more y.s. were relatively stable, while the trends in the total number of births for the other two y.s. groups were slightly negative. These diverging trends by years of schooling conflate differences in fertility and fertility timing by educational attainment and changes in the educational composition of the population. Moreover, these trends imply that the predicted number of births (red dotted line) is a conservative baseline for measuring pandemic-related changes. If we were to use the average number of births from 2015 to 2019 (blue lines in Fig. A1) as a baseline, we would overestimate the potential effects of the Covid-19 pandemic on fertility, particularly among groups with declining trends in the number of births (e.g., women with four to seven years of schooling).

Despite the educational expansion and the associated negative trends in the number of births to mothers with less than eight years of schooling (which corresponds to the middle years of education), the number of births to mothers with less than four years of schooling – who are arguably at the very bottom of LATAM stratification systems – was nonetheless substantial. This pattern has been recognized as a feature of fertility in Brazil and Colombia, and can likely be observed in other countries and populations in the Global South as well. In 2019, the mothers with zero to three and four to seven years of schooling combined gave birth to more than 485,000 babies in Brazil and 108,000 babies in Colombia. It is worth noting that seven years of schooling provide basic numeracy and literacy skills, whereas three years of schooling provide just literacy.

Most of the births were to women with eight to 11 years of schooling (1,740,000 in Brazil, and 357,000 in Colombia in 2019). The educational levels associated with these years of schooling are not fully comparable with those of U.S. high schools, but are instead roughly equivalent to those of U.S. middle schools. Although the completion of secondary education is supposed to give young people access to tertiary education (technical, technological, or professional), because of the differences in quality across schools and public educational systems and the wide range of private alternatives to formal training in Brazil and Colombia, the women with eight to 11 years of schooling differ greatly in terms of their socioeconomic backgrounds and their economic prospects (Balan, 2003; Sanchez-Ancochea, 2021). In other words, the women in these groups are more likely to be in the lower or the middle-lower class than in the middle class. Finally, women with more than 12 years of schooling, who are at the top of the social stratification system, also had relatively high numbers of births (603,000 in Brazil and 174,000 in Colombia in 2020).

The subnational heterogeneity in the severity of the pandemic, as measured by the excess mortality p-scores, suggests that the association between the Covid-19 pandemic and fertility varied in magnitude across space and over time. As Figure 2 shows, the timing and the intensity of the pandemic were not the same in Brazil and Colombia. In Brazil, excess mortality was already positive by the second trimester of 2020 in at least 18 of the 26 subnational areas. Indeed, in the state of Amazonas, the observed mortality in April-June 2020 was close to twice the expected level (p-score near 100%). In contrast, by the same trimester, excess mortality in Colombia was high and positive in only four out of the 32 departments, with a maximum of 75% in Atlantico. Notably, high p-scores were first observed in subnational areas with relatively small populations.

\*\*\* Figure 2 \*\*\*

Figure 2 indicates that as the pandemic evolved, excess mortality in Colombia increased and stayed higher than excess mortality in Brazil during the last two trimesters of 2020. This relationship reversed in the first trimester of 2021, when p-scores were positive in all Brazilian subnational areas with a median p-score of 40%. Excess mortality from April 2021 onward remained high in Colombia and decreased in Brazil, which further highlights the changing nature of the pandemic (Nicolelis et al. 2021). Figure 2 also reveals that there was substantial within-country heterogeneity (y-axis range), and that subnational units with relatively small populations had the highest levels of mortality excess. The changes in the two subnational units with the highest excess mortality levels are indicative of the spatial dynamics within the countries.

Figure 3 displays the scatter plot of subnational current excess mortality (x-axis) and the total number of registered births relative to the baseline births by trimester (y-axis). The top panels correspond to Brazil and the bottom panels correspond to Colombia. Both measures are on a logarithmic scale, and the axes are labeled according to the percentage difference to improve readability. Each data point represents a combination of the maternal age (colors) and years of schooling groups (panels), the subnational area, and the trimester (from April-June 2020 to July-September 2021). 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 differences displayed in the association between excess mortality and fertility by years of schooling groups are consistent with our expectations: the association between the severity of the pandemic and the *rbc* was contingent on women’s socioeconomic conditions, proxied by the years of schooling groups. Hence, the main result shown in Figure 3 is that the higher the years of schooling, the less heterogeneous, the weaker, and the more uniformly patterned (flat) the relationship between excess mortality and the *rbc* was. The panels for women with zero to three y.s. display the greatest heterogeneity of all the panels along the y-axis. Moreover, in Brazil, the log-scaled *rbc* among women aged 10 to 29 was above zero, which means that fertility was higher than expected among younger women. Notably, the slope of the lowess lines is more positive for the first age group (10-19) than for the other ages groups, which means that higher excess mortality was associated with higher fertility, particularly among young women with fewer years of schooling; i.e., among women with two sociodemographic characteristics that are typically associated with having disadvantaged living conditions.

In both countries, there was a positive association between excess mortality and the number of births among women with zero to three y.s. The slopes of the lowess lines indicate that places where excess mortality was higher also generally had higher relative numbers of births among women with zero to three y.s. This was found to be the case for values of excess mortality between zero and 100. The greater severity of the pandemic in Colombia than in Brazil (maximum excess mortality = 300) suggests there may have been turning points at which the relationship between excess mortality and the number of births among women with lower educational attainment reversed. In sharp contrast, the number of births to women with more than eight y.s., in both Brazil and Colombia was below or very close to zero, which means that between 2020 and 2021, the number of births was slightly lower than expected for almost all educated women of all ages across subnational areas in Brazil and Colombia. Additionally, the flat pattern in the lowess lines indicates that there was no association between excess mortality and the number of births among educated mothers. If anything, there is a slight negative slope among women with the highest educational attainment (12 or more y.s.), as summarized by the overall line.

When excess mortality was lagged by two trimesters – i.e., when we measured the potential influence of the pandemic on fertility decisions and opportunities by accounting for the average duration of pregnancies – the general pattern among educated women was found to be the same as in Figure 2: i.e., the association between nine-month lagged excess mortality and the number of births appeared to be null (see Figure A2). Instead, among women with less than three years of schooling, this association was negative, which means that higher mortality in a given trimester was associated with fewer births occurring nine months later. The same pattern, albeit with a less negative slope, was found for women with four to seven years of schooling. Again, the greater range of excess mortality in Colombia than in Brazil yielded more erratic associations between the number of births and excess mortality in areas with more than 100% excess deaths.

To test the robustness of the descriptive patterns depicted in Figures 3 and A2, and to assess the degree of uncertainty regarding the slopes of the lowess lines, Table 1 summarizes the regression coefficients for the excess mortality measures (current and lagged) and the number of births according to the four above-mentioned model specifications. To enhance the models’ performance and interpretability, the excess mortality measures and the *rbc* entered the model on the logarithmic scale.

\*\*\* Table 1 \*\*\*

The results presented in Table 1 confirm that the influence of current excess mortality on *rbc* was contingent on women’s socioeconomic status. For Brazil, model specifications 1 to 3 suggest that current excess mortality negatively influenced the number of births. Even after including the subnational HDI (M.S. 2), the coefficient for current excess mortality was -0.07. This coefficient implies that a 10% increase in excess mortality was associated with a 0.7% decrease in the number of births. M.S. 4 reveals that the association between current excess mortality and the number of births was positive for women with zero to three y.s. (slope = 0.35), was virtually null for women with four to seven y.s. (slope = 0.35 - 0.31 = 0.04), and was negative for the remaining groups (0.35 - 0.4 = -0.05, and 0.35 - 0.45 = -0.1, respectively).

For Colombia, the subnational differences in the HDI accounted for the overall negative relationship between current excess mortality and relative fertility: the excess mortality coefficients in M.S. 2 and M.S. 3 were small and statistically non-significant. However, the interaction terms included in M.S. 4 indicated that there were significant associations across years of schooling groups. These associations were similar in direction and slightly larger in magnitude than those observed for Brazil. For example, the association between excess mortality and *rbc* among women with zero to three y.s. was 0.39, which implies that a 10% increase in excess mortality was associated with a 3.9% increase in the number of births. At the other end of the educational attainment spectrum (slope = 0.39 - 0.44 = -0.05), a 10% increase in mortality was associated with a 0.5% decrease in the number of births. The divergence between the signs of the association for less-educated women (i.e., in low social positions) and highly-educated women (i.e., in high social positions) points to the heterogeneous influence of the pandemic.

The results for lagged excess mortality were less consistent across countries. Although M.S. 1 indicated that there was a negative correlation between lagged excess mortality and relative fertility for both countries (-0.03 in Brazil, and -0.07 in Colombia), these associations were not robust to the inclusion of the subnational HDI and the dummy variables for subnational areas. Moreover, the sign of the interaction coefficients also differed by country. For example, the association between lagged excess mortality and the number of births to women with less than three y.s. was negative in Brazil (-0.21) and positive in Colombia (0.23). These two associations imply that there was approximately a 2% decrease and increase, respectively, in the number of births given a 10% increase in lagged excess mortality. These divergent associations could be related to the higher degree of socioeconomic vulnerability of less-educated women in Colombia due to the legacy of the armed conflict, and because Colombia’s public health system is worse than that of Brazil. As the years of schooling increased, the association between lagged excess mortality and the *rbc* became negative in both countries, which suggests that this association was more similar in Brazil and Colombia among women with medium and high educational levels than among women with low educational levels.

All in all, our results underline the importance of accounting for women's socioeconomic conditions when assessing the potential consequences of the Covid-19 pandemic on the number of births. Our finding of diverging associations of current and lagged excess mortality by maternal years of schooling (positive for women with low educational attainment and null or negative for women with high educational attainment) implies that the influence of the Covid-19 pandemic interacted with existing forms of social differentiation regarding access to resources and opportunities to enact reproductive preferences. Despite our data limitations[[4]](#footnote-4) and the simplicity of our models, we feel confident about this interpretation for three reasons. First, the model specifications with interaction terms yielded a better fit than the model specifications without them (refer to AIC rows in Table 1). Second, our results were robust when we excluded the lower and the upper 1% of the distribution of the *rbc* (i.e., outliers in which the relative change was extremely low or high due to the small number of registered or predicted births), and when we used cumulative measures of excess mortality (i.e., cumulative p-scores and lagged cumulative p-scores). This was particularly the case for the coefficients associated with cumulative p-scores. Third, this interpretation is consistent with the extant and the cited literature on the connection between fertility patterns and social stratification in LATAM, and with a very recent review on the unequal consequence of macro-level disruptive events (e.g., economic recession and natural disasters) for individuals and families (Aquino, Brand, and Torche 2022).

**Conclusions**

Based on vital records for the 2015-2021 period, we conducted a thorough examination of the association between the Covid-19 pandemic and the changes in registered births in Brazil and Colombia. We examined the immediate and the lagged influence of excess mortality on the number of births at the subnational level by maternal age and years of schooling (as a measure of socioeconomic status). Our finding that there were heterogeneous associations between these two demographic processes, excess mortality and births, by maternal years of schooling underlines how the negative consequences of the pandemic interacted with pre-existing forms of inequality in women’s living conditions and access to resources. This interaction is fundamental to understanding the long-term effects of the Covid-19 pandemic on demographic patterns, particularly for countries with high or rising levels of socioeconomic inequality and weak or non-existent welfare states; and for population subgroups who, despite residing in rich welfare states, do not fully benefit from welfare policies due to their minority, sexual identity, or migration/citizenship status.

The contribution of this study to the literature on the so-called pandemic babies stems from our materialist perspective (Danna 2021; Lebaron 2003). Previous studies have identified many of the logical mechanisms that could lead to higher or lower fertility during health crises, including higher maternal mortality; miscarriages; restricted access to sexual health-related services, including contraception, family planning, and abortion; and fertility postponement due to financial uncertainty. However, this list of mechanisms does not specify the material conditions under which they become prevalent or effective. From a purely behavioral perspective, any individual may be affected by or susceptible to these mechanisms. However, our results were not consistent with this behaviorist assumption. From a materialistic perspective, assuming that everyone is capable of or susceptible to any logical mechanism confuses the “things of logic” (i.e., deductively-derived logical mechanisms) and the “logic of things” (i.e., the material conditions necessary for mechanisms to operate) (Burawoy 2018). Our findings suggest that the operation of these mechanisms is contingent on women’s access to the material resources for controlling reproduction (e.g., access to contraception, abortion, family planning), which may be particularly scarce or reduced for certain populations during a health crisis.

In other words, by applying a materialist perspective, we were able to identify the subpopulation groups with material living conditions that made them susceptible to the theoretical mechanisms that predicted increases in the number of births, such as a reduction in access to contraception or pregnancy interruption due to the weakening of health systems (especially among vulnerable women); and decreases in the number of births, such as economic uncertainty (especially among non-vulnerable women). Although our measurement of socioeconomic status (i.e., years of schooling) captured only indirectly women’s access to sexual and reproductive health-related services, the consistency of the results for the two countries, and the stronger associations documented among socioeconomically vulnerable women in Colombia (i.e., where women’s vulnerability was likely exacerbated by the country’s legacy of armed conflict and relatively weak health system), suggest this is a sensible, plausible, and informative interpretation.

Because the largest shares of births in Colombia and Brazil are not to women with extremely vulnerable socioeconomic backgrounds, studies that do not disaggregate effectively by socioeconomic status will tend to gloss over the differences in the consequences of the pandemic across subpopulation groups. Indeed, a country-level aggregated analysis will completely neglect the experiences of minorities. Given that one-third of the population in LATAM live in poverty (ECLAC 2022), it is important to highlight the socioeconomic-specific consequences of the pandemic, and such an analysis may extend beyond the group of women with zero to three years of schooling if other dimensions of socioeconomic status are considered (e.g., income, household assets, race/ethnicity).

More generally, these results suggest that ethnic, migration status, and sexual minorities in other contexts, including in high-income countries, may experience the consequences of the Covid-19 pandemic differently than the majority of the population, and especially individuals in socioeconomically privileged positions. Thus, future research that tests the validity of the mechanisms through which a health crisis can affect fertility should distinguish between social groups with varying abilities to avoid negative consequences. For example, during a crisis, some groups may be able to postpone motherhood, while others have more unwanted births because of restricted access to family planning services.

Finally, our results can also inform potential future scenarios of fertility in contexts where the pandemic is ongoing or has ended. Given that socioeconomic inequalities are likely to be exacerbated by the negative consequences 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. For example, if fertility does recover after the pandemic, our results suggest that this recovery will occur first among women with sufficient resources to resume their reproductive schedules while coping with the potential negative legacy of the pandemic period.

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1. https://interactives.lowyinstitute.org/features/covid-performance/ [↑](#footnote-ref-1)
2. The relationship to mortality is presented based on preliminary data from 2019, which were compared to final data for the same year once the final status had been reached. [↑](#footnote-ref-2)
3. The 1.0% and 3.9% of births with missing information on maternal years of schooling were assigned to the zero to three years of schooling groups. [↑](#footnote-ref-3)
4. These data limitations include the potential under-registration of births, particularly in subnational poor areas and among women with few years of schooling (y.s.). Because these under-registration patterns were present before the pandemic, we partially accounted for them when including dummy variables for subnational areas in model specifications 3 and 4. Moreover, the positive association between excess mortality and relative births changed among women with zero to three y.s., which suggests that the under-registration of births is unlikely to have increased during the Covid-19 pandemic, especially among the most vulnerable. [↑](#footnote-ref-4)