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Fertility Responses to the COVID-19 Pandemic: A Perspective of Reproductive Process

Xinguang Fan

The COVID-19 pandemic has potential large-scale impacts on population dynamics. Yet, recent theories and empirical analyses fall short of fully articulating the extent and nature of the pandemic's influence on birth rates at the aggregate level. This study advances the comprehension of fertility dynamics amid the pandemic by focusing on the reproductive process. The effects of the pandemic on conceptions and pregnancy terminations may exhibit considerable variability, which, in turn, could dictate the observed patterns in birth rates during the pandemic. Employing the data from the Performance Monitoring Action survey in Burkina Faso and Kenya, which includes information on conceptions, pregnancy terminations, and births, the research dissects the nuances of fertility behavior in response to the pandemic. Findings indicate an uptick in conception rates around six months following the onset of the pandemic in Kenya, while pregnancy terminations did not significantly shift in either country. Further, the data reveal a pronounced increase in conception rates among disadvantaged groups, whereas a downturn in pregnancy terminations was noted predominantly in urban areas during the early phase of the pandemic. These findings underscore the importance of considering the reproductive process when studying fertility responses to catastrophic events.

Introduction

Since its outbreak, the COVID-19 pandemic has posed a significant public health threat worldwide and has had vast impacts on population dynamics (Banerjee et al. 2020; Wang et al. 2022). Given the time span from conception to childbirth, changes in birth trends become evident later than other demographic consequences, such as migration patterns or mortality rates (Sobotka et al. 2023). In the pandemic's early stages, many researchers anticipated a drop in birth rates due to disruptions in fertility intentions, access

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to reproductive services, and economic stability (Aassve et al. 2020; Berger et al. 2021; Wilde, Chen, and Lohmann 2020). However, as birth data from late 2020 onward became available in various countries, a growing body of research indicated that birth trends during the pandemic diverged from initial forecasts (Aassve et al. 2021). A comprehensive understanding of birth rate changes due to COVID-19 requires more than just aggregate-level analysis, as it might not capture the nuances and complexities of such changes.

Building on the importance of a more nuanced analysis, researchers prioritize individual-level evaluations to better understand and interpret aggregate-level observations. On the supply side, there are serious concerns about the pandemic's potential to disrupt access to contraception and health care services, particularly in less developed regions and among marginalized groups (Emery and Koops 2022; Wood et al. 2021). The rationale aligns with a substantial body of research on the impacts of disaster events, such as hurricanes, on reproductive health, which have consistently shown pronounced effects on health care availability and access (Behrman and Weitzman 2016; Hapsari et al. 2009; Loewen et al. 2022). Recent studies have corroborated these findings, reporting shortages and limited access to reproductive health care services during the pandemic, with disadvantaged groups being disproportionately affected (Aly et al. 2020; Emery and Koops 2022). Moreover, another line of the literature highlighting the demand for children posits that the pandemic shock could shape demand and planning for childbearing through elevating income risk (Blundell et al. 2022; Gummerson et al. 2021), inducing psychological distress (Zhu et al. 2020), restricting movements and social activities (Mooi-Reci et al. 2023), and fostering uncertainty about the future (Dench et al. 2023; Guetto, Bazzani, and Vignoli 2022). Together, these demand-side influences are complex and multifaceted, highlighting the need for a comprehensive approach to fully understand the pandemic's impact on fertility trends.

Building on the intricate interplay between supply-side and demand-side factors discussed earlier, the direction of birth trends during the pandemic continues to be an empirical puzzle. The individual-level factors alone cannot conclusively illuminate the pandemic's overall influence on birth rates. For instance, Bailey et al. (2022) showed that while diminished access to contraception and the 2020 economic downturn led to a slight decline in births among low-income women in the United States in 2021, factoring in reduced access to abortion could conversely lead to a surge in unplanned births, potentially even resulting in an overall birth rate increase for this demographic. Moreover, it is not a given that the pandemic would always lead to delays in childbearing behaviors or alterations in the desired number of children. The environment of heightened uncertainty might suppress fertility intentions, with prospective parents concerned about raising children in a pandemic-stricken world (Dench et al. 2023; Guetto, Bazzani, and Vignoli 2022). But for some social groups with more socially and economically

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insecure situations in developed countries, movement restrictions and the decrease in social activities could make the pandemic a favorable time to accelerate childbearing behaviors (Lappegård et al. 2023). This observation is not limited to developed contexts. Some studies on fertility intentions in developing nations indicate similar trends (Sennott and Yeatman 2012). Zimmerman et al. (2023), for instance, showed that impoverished families in select sub-Saharan African regions appeared less inclined to reduce fertility intentions in response to economic downturns. A potential reason for this is the long-standing argument of children as a form of economic security and potential support in uncertain futures, a sentiment echoed by (Banerjee and Duflo 2011).

This multifaceted situation underscores the need for a holistic approach to understanding birth trends during the pandemic. The previous research has often focused narrowly on fertility intentions and birth outcomes, neglecting the crucial intermediate stages: conception and pregnancy terminations, including conception loss, spontaneous abortion, induced abortions, miscarriages, stillbirths, and so on. Recent findings underscore the significance of these stages, revealing that events like miscarriages and stillbirths were not uncommon, and the pandemic's impact on these pregnancy outcomes could be substantial (Calvert et al. 2023; Kc et al. 2020; Mahajan et al. 2021; Marquez-Padilla and Saavedra 2022). For a holistic comprehension of birth trends, it is essential to consider the entire reproductive process—from conception to birth outcomes. Specifically, if the pandemic-induced changes in conceptions and pregnancy terminations were driven by different factors or showed varied patterns, these elements of the reproductive process merit in-depth exploration within an integrated framework, ensuring we capture the full spectrum of factors influencing birth trends during such disruptive periods.

Amidst the surge in empirical research exploring the pandemic's influence on individual reproductive events, such as conception (Bailey, Bart, and Lang 2022), spontaneous abortion (Kharbanda et al. 2021), stillbirth (Chen et al. 2022), and preterm birth (Torche and Nobles 2022), a significant gap persists in piecing together these distinct events to provide a cohesive understanding of overall birth trends during this period. Unraveling this "black box"—discerning how pandemic-related changes in conception and pregnancy outcomes translate into birth trends—is a critical yet complex endeavor. A comprehensive approach that dynamically connects conceptions and pregnancy terminations to births is essential. Compounding this challenge is the lack of longitudinal data that offer a detailed account of individual pregnancy trajectories.

Addressing the aforementioned challenges, the present study offers insights into fertility responses to the pandemic in two respects. First, in alignment with the established tradition of demographic models concerning the reproductive process, I argue that understanding the fertility responses

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to the pandemic necessitates an integrating framework highlighting the relationship between conception, pregnancy termination and birth. Second, I embarked on a thorough empirical exploration of these reproductive events amidst the pandemic. Leveraging a longitudinal survey targeting women of reproductive age in Burkina Faso and Kenya, I collated a comprehensive, representative dataset spanning person-month records detailing the three key reproductive events. By employing linear probability models, factoring in region-, year-, and month-specific variations while adjusting for individual covariates and potential seasonal biases, I quantified the pandemic's repercussions on conception, pregnancy termination, and birth outcomes over an eighteen-month window post-pandemic onset. Benefiting from the detailed individual information collected by the survey, I investigate to what extent the pandemic impacts vary across social groups. In essence, this study seeks to understand the pandemic's influence on births by meticulously examining the reproductive continuum.

Theoretical consideration

The field of demography has a long research tradition of understanding the reproductive process, tracing the path from union formation to birth outcomes (Ridley and Sheps 1966; Sheps and Menken 1971; Sheps and Perrin 1966). Within this research line, family-building models utilize mathematical and simulation methods to map out the various reproductive stages, beginning with the initiation of a union to the act of childbearing (Sheps, Menken, and Radick 1973). Yet, the prominence of such modeling has waned in contemporary demography. With the advent of extensive census data and granular demographic datasets, there's been a paradigm shift toward "'empirical' work based on general-purpose statistical tools" as they're seen as a more viable analytical approach compared to traditional model building (Ciganda and Todd 2022, 3). Nonetheless, when examining fertility responses to the COVID-19 pandemic, these time-honored demographic models centered on the reproductive process offer invaluable insights.

First, it is essential to understand that conception and birth are distinct events within the reproductive process. Pregnancies might result in miscarriages, induced abortions, stillbirths, or other kinds of terminations not ending with live births. With the availability of reproductive statistics in recent decades, numerous studies posit that pregnancies not ending with live births are among major public health threats worldwide. For instance, a recent study estimates 23 million miscarriages every year worldwide, which translates to 44 pregnancy terminations each minute (Quenby et al. 2021). In light of this, it is crucial to discern conceptions from births when assessing reproductive outcomes. Echoing this sentiment, Ridley and Sheps (1966) emphasized that probing the impact of fluctuating rates of pregnancy

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termination on birth rates holds considerable potential for refining demographic theories.

Second, unraveling the pandemic's effects on birth trends necessitates a comprehensive understanding of the dynamic changes in both conceptions and pregnancy outcomes. The intricate interplay of these two elements is crucial. The pandemic swiftly made its impact on birth patterns evident, with several studies correlating exposure to the pandemic with increased risks of spontaneous or induced abortions and stillbirths in specific demographic groups (Bayefsky, Bartz, and Watson 2020; Calvert et al. 2023; Polis et al. 2022). Approximately a full gestational cycle after the pandemic's onset, its repercussions on births became apparent, directly mediated through shifts in conception rates and pregnancy outcomes. This timeline underscores the importance of dissecting the reproductive process to understand the pandemic's comprehensive impact on birth trends.

Finally, factoring in the reproductive process provides additional depth to existing explanations emphasizing the socioeconomic disparities of the pandemic's repercussions on reproductive health and actions. Research from developed countries reveals that individuals in lower socioeconomic brackets or precarious economic circumstances face heightened risks of induced abortions and spontaneous terminations and increased stillbirth occurrences (Norsker et al. 2012) and stillbirth risk (Luque-Fernández et al. 2012). Furthermore, challenges like unintended pregnancies, stillbirths, and unsafe abortions are exacerbated in developing countries where health care resources are constrained and less available to marginalized communities (Ganatra et al. 2017; Hubacher, Mavranezouli, and McGinn 2008; McClure, Nalubamba-Phiri, and Goldenberg 2006). A granular examination of the pandemic's influence on distinct reproductive milestones—encompassing conceptions, pregnancy terminations, and births across various social strata—illuminates a fuller picture of the pandemic's impacts on birth rates.

To thoroughly analyze the pandemic's impact on birth trends through a reproductive process perspective, a comprehensive and rigorous methodological framework is indispensable. First, high-frequency data pertaining to stages of the reproductive process are required and allow for a nuanced understanding of the pandemic's effects on fertility. Second, attention should be given to mitigating seasonality bias, as recent studies focusing on birth trends posited (Kearney and Levine 2023; Sobotka et al. 2023). Third, subgroup analysis is necessary to assess the unequal impacts of the pandemic on reproductive trajectories depending on socioeconomic and demographic characteristics. This approach not only illuminates disparities but also facilitates the identification of groups that are particularly vulnerable. Addressing their unique challenges through targeted interventions and policy initiatives can contribute to achieving health equity in the context of the pandemic's repercussions on reproductive health.

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The context of Burkina Faso and Kenya

The present study centers on Burkina Faso and Kenya, two countries in sub-Saharan Africa. Categorized as global south countries (World Population Review 2023), Burkina Faso and Kenya display different developmental trajectories. Burkina Faso has been listed among the least developed countries (LDCs) since 1971 (United Nations 2023) while Kenya has made significant social and economic development over the past decades (World Bank 2023).

In terms of fertility, Burkina Faso is among the countries with the highest fertility rates. In 2021, the total fertility rate was 4.8. Beyond fertility figures, Burkina Faso grapples with significant disparities in health care access and provisions, both regionally and among social groups. Less than 10 percent of the population was covered by some form of health insurance in Burkina Faso by 2018 (Yaya Bocoum, Grimm, and Hartwig 2018). A mere 10 percent of its population benefited from some form of health insurance as of 2018, with the majority of these beneficiaries residing in urban locales. Moreover, a recent study based on rural Burkina Faso also posited that women's decision-making power in utilizing reproductive care and family planning was low due to social norms and gender inequality (Beaujoin et al. 2021). Compared with Burkina Faso, Kenya has a relatively lower total fertility rate, which was reported as 3.3 in 2021, and has achieved a significant improvement in building the health care system (Masaba et al. 2020). Particularly, since 2006, Kenya has established a reproductive health voucher program, which significantly increased health facility deliveries and improved access to appropriate health services for poor women (Obare et al. 2013).

The 2020 pandemic onset strained health care infrastructures, including in less-developed regions (Amos et al. 2021). The first reported case appeared nearly at the same time in Burkina Faso and Kenya, at the second week of 2020 March. In the aftermath of the initial COVID-19 diagnosis, both countries implemented movement restrictions (Hale et al. 2021). However, their respective governmental capacities to navigate this health emergency differed significantly. Kenya soon established the most comprehensive response by deploying surveillance systems and diagnostic protocols (Zimmerman et al. 2023). The response of Burkina Faso is another story. According to the Financial Tracking Service (2023), Burkina Faso received about 50 million dollars under the COVID-19 Global Humanitarian Response plan, which was far less the required 105.9 million dollars. Due to the financial constraint, limited health services, and shortage of protective equipment, Burkina Faso responded to the crisis insufficiently. By March 10, 2023, the reported cases and deaths in Burkina Faso were only 22,056 and 396, far lower than 342,937 cases and 5,688 deaths reported in Kenya (The Johns Hopkins Coronavirus Resource Center 2023). Given the fact that

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the population size of Kenya was about 2.5 times in Burkina Faso, it would be expected that the reported COVID-19 statistics were severely underestimated in Burkina Faso due to the capacity of surveillance system (Struck et al. 2022).

Economic stability critically shapes individual responses to COVID-19 (Cavalhieri 2021). Recent studies indicate that income loss and food security were widespread at the early stage of the pandemic in Burkina Faso (Gummerson et al. 2021; Zidouemba, Kinda, and Ouedraogo 2020). Kenya families experienced less severe economic insecurity because of the efficient government responses to the crisis (Nechifor et al. 2021). Given this backdrop, it is plausible to infer that Burkina Faso and Kenya exemplify distinct subcategories within the developing world.

The pandemic's overarching implications on conceptions, pregnancy terminations, and births have garnered limited attention. Recent studies evaluating the impacts of COVID-19 shock on reproductive health in SSA areas show mixed findings. Access to health care is negatively influenced by movement restrictions and clinic closure (Amewu et al. 2020; Gummerson et al. 2021). However, studies show that contraceptive use and unmet needs did not change significantly overall (Moreau et al. 2023; Wood et al. 2021). Given the proportion of abortions, especially unsafe abortions, exceptionally high among SSA areas (Ganatra et al. 2017), understanding the pandemic's influence on births requires a comprehensive look into the reproductive process.

Data and measures

The analysis uses data from three waves of the Household and Female Survey (HQFQ) dataset, curated by the Performance Monitoring Action (PMA) survey[1]. The PMA survey employs a multistage cluster design for household selection, stratifying by urban or rural areas and, when applicable, by subregions. Initially, the survey covered 28 regions across four sub-Saharan African countries: Burkina Faso, the Democratic Republic of the Congo (DRC), Kenya, and Nigeria. It later expanded to encompass four additional FP2020 countries. Phase 1 wave was launched in late 2019 and early 2020, around the date of reporting the first coronavirus case worldwide. Phase 2 and 3 waves were fielded around one and two years later than Phase 1. In mid-2020, PMA carried out a phone-based survey targeting women aged 15–49 from the four initial participating countries, provided they owned or could access a telephone.

Eligible females, aged 15–49 and typical household members, were given consent forms to participate in the survey. PMA enrolled new eligible women turning 15 at annual follow-up and excluded those aged 49 from earlier rounds. This open panel approach guarantees an annually representative sample of women aged between 15 and 49. The female-centric

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survey collects data on participants' backgrounds, birth histories, family planning practices, and other details pertinent to health and family planning enhancement.

This study narrows its focus to Burkina Faso and Kenya exclusively. It excludes DRC and Nigeria from the analysis because, for both countries, only two subnational regions were included in the survey. The DRC survey does not contain information on rural and urban residences, which is an essential indicator for social and demographic groups. PMA surveys Lagos and Kano in Nigeria with a relatively small sample size. Additionally, countries that joined the survey post-pandemic are not suitable for contrasting female reproductive trajectories from pre-pandemic to during the pandemic periods. Figure 1 illustrates region-specific cases, deaths, and respondent distribution based on interview dates for Burkina Faso and Kenya.

Constructing the analytical sample

This research utilizes the contraceptive calendar from the survey's three phases to create a person-month sample, capturing reproductive status transitions over time. Typically, a contraceptive calendar allows female respondents to detail their contraceptive use, pregnancies, pregnancy terminations, and births on a monthly basis. Hence, depending on the module's design, it provides retrospective data on high-frequency measures related to reproductive health and behaviors over several years. One of the calendar's strengths lies in its ability to trace a woman's transitions in reproductive stages, thus presenting a comprehensive view of individual reproductive trajectories.

In the initial wave, the calendar encompasses data from 2018 up to the interview month. When constructing the person-month sample for the Phase 1 wave, I set the starting date as October 2018 and end date as September 2019. From October 2019 (2020) to September 2020 (2021), I took the person-month observations from the Phase 2 (3) wave. The descriptive and regression analysis is based on the 36-month individual-level representative sample.

The reliability of contraceptive calendar data can decrease when faced with larger recall periods or increasing complexity (Anglewicz et al. 2023; Bradley et al. 2019; Callahan and Becker 2012; Strickler et al. 1997; Tumlinson and Curtis 2021). To increase the data reliability and accuracy, I employed the following steps. First, I only focus on the calendar data of, on average, 12 months from the interview date for each wave to reduce the recall bias in the analytical sample.

Furthermore, I have conducted a data consistency check using PMA's survey design. Many public health surveys grapple with underreporting biases related to pregnancy terminations, which can be influenced by factors like recall bias, the desire for social acceptance, and the interviewer's

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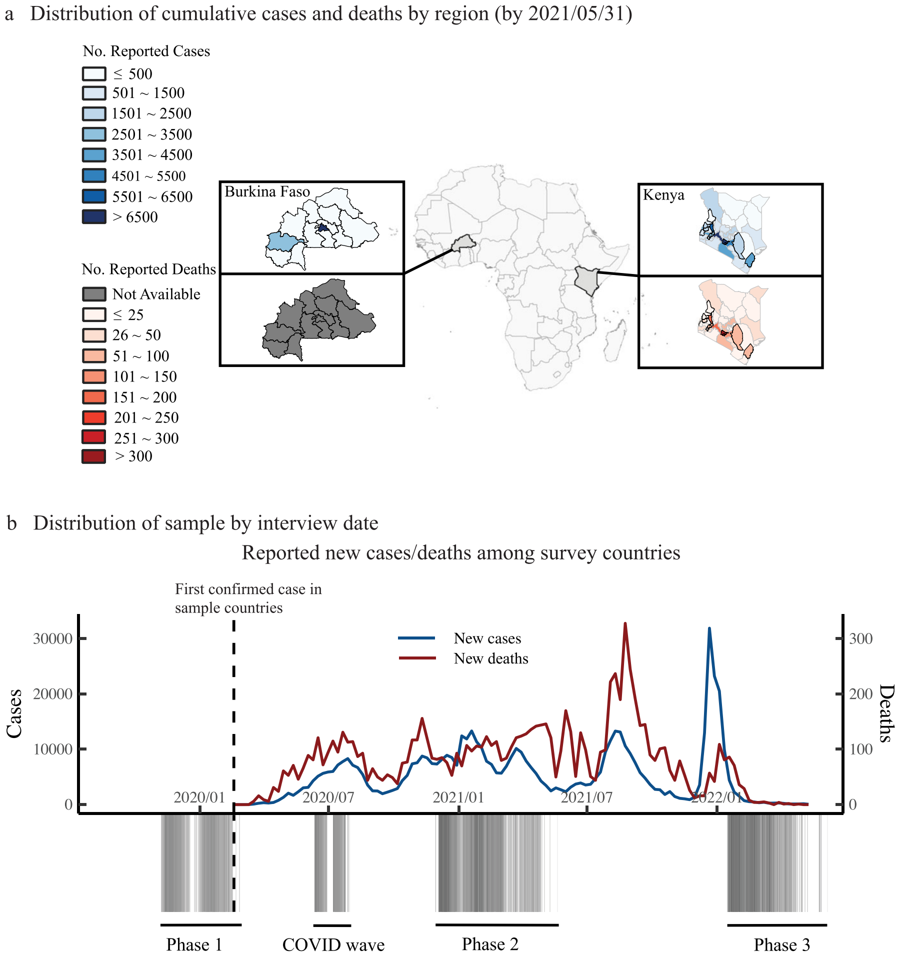
FIGURE 1 COVID-19 situation and PMA survey timeline in Burkina Faso and Kenya



NOTE: Available cumulative cases and deaths at the subnational level in Panel A are aggregated from the Humanitarian Data Exchange and official COVID-19 reports by the Ministry of Health of Burkina Faso and Kenya. The new cases and deaths in Panel B are obtained from the WHO Coronavirus (COVID-19) Dashboard.

influence (Callahan and Becker 2012), social desirability bias (Maddow-Zimet, Lindberg, and Castle 2021), and interviewer effects (Leone, Sochas, and Coast 2021). Phase 2 of PMA adopted a confidante approach based on social network-based measurement to address some abortion-related data deficiencies for the female survey. While respondents did not specify the exact month of incidents, my robustness check aligned the reported years of calendar data's recent pregnancy termination experience with the respective section's pregnancy termination experience. I found that the dates reported in the calendar and in this section are consistent. However, the survey does not allow for distinguishing types of pregnancy terminations[2],

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such as conception loss, spontaneous abortion, induced abortions, miscarriages, stillbirths, and so on.

Finally, to account for the underreporting issue of conceptions, I designated September as the final month for person-month observations for each phase. Given that interviews for each phase in both Burkina Faso and Kenya started no earlier than November[3], conceptions occurring roughly a month before the interview might remain unreported, as pregnancy symptoms typically become noticeable after five weeks (Hibbard 1971).

Variables

The primary outcomes focus on three facets of the reproductive process: conception, pregnancy termination, and childbirth. Each of the indicators is measured in the person-month unit. Conception corresponds to the initial month of pregnancy as logged in the calendar, while childbirth and pregnancy termination are recognized as distinct outcomes of pregnancy.

Previous literature suggests various methods to characterize the pandemic exposure. A convenient measure could be the date of implementing nation-level lockdown polices or the date the COVID-19 case was reported. However, one limitation is the variability across regions in the enforcement and timing of lockdown policies, as well as in the reporting of the inaugural COVID-19 cases. In addition, using the national lockdown policy as an indicator of exposure to the pandemic can neglect the impacts of the local policies and other channels of the impacts of the pandemic, except for the policy. I gathered data on when each region in our sample reported its initial case. For Burkina Faso, I extracted the date of reporting the first case by subnational region from the COVID-19 cases and deaths statistics published by the Humanitarian Data Exchange. For Kenya, I manually identified the date of the first subnational case by region from the official website of the Ministry of Health in Kenya. The dates of the COVID-19 shock by region are shown in Table 1. Compared with relying on the number of cases or deaths as the exposure indicator, relying on the date of the first case has two advantages. First, as stated in the prior section, the accuracy issue of reported cases and deaths existed, particularly in Burkina Faso, and leads to conclusions based on reported statistics on infections not comparable and convincing. Second, the date of the first reported case is closely related to government responses, including movement restrictions, and thus could be an appropriate indicator of individual perceptions of and responses to the pandemic.

I set the baseline to encompass person-month observations from the 12-month period following the reporting of a region's first COVID-19 case. To account for significant noise brought by month-to-month analysis, I group the person-month observations exposed to the pandemic into trimester categories of treatment groups: "0–2 months," "3–5 months,"

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TABLE 1 Dates of the first reported COVID-19 case by region

Country	Region	Date of reporting first case
Burkina Faso	Boucle du Mouhoun	March 20, 2020
	Cascades	March 22, 2020
	Centre	March 9, 2020
	Centre-Est	August 23, 2020
	Centre-Nord	April 6, 2020
	Centre-Ouest	October 12, 2020
	Centre-Sud	March 23, 2020
	Est	July 9, 2020
	Hauts-Bassins	March 14, 2020
	Nord	August 23, 2020
	Plateau-Central	March 25, 2020
	Sahel	April 8, 2020
	Sud-Ouest	March 29, 2020
Kenya	Bungoma	April 8, 2020
	Kakamega	March 24, 2020
	Kericho	May 28, 2020
	Kiambu	April 19, 2020
	Kilifi	March 19, 2020
	Kitui	March 29, 2020
	Nairobi	March 13, 2020
	Nandi	May 30, 2020
	Nyamira	June 13, 2020
	Siaya	April 10, 2020
	West-Pokot	July 28, 2020

SOURCE: Humanitarian Emergency Response Africa (2022); Ministry of Health, Republic of Kenya.

"6–8 months," "9–11 months," "12–14 months," and "15–18 months". In the regression analysis, I set the period for the analytical sample ranging from 12 months before to 18 months after the month of the pandemic outbreak.

In the statistical models, I incorporated individual covariates sourced from the survey's three phases. Educational level is the highest level of school as of the interview date and coded using four categories: never attended any school, primary school, secondary school, and tertiary, college or above. Marital status is coded as five categories: currently married, living with a partner, divorced or separated, widowed, and never married. Age is segmented into seven groups, each spanning five years, ranging from 15–19 up to 45–49. I also identified those women having any birth before the interview date and generated a dummy variable indicating the childbearing experience. In addition, I also included the covariate indicating whether the respondent had done any work aside from her own housework in the last seven days.

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After dropping the missing values of key variables, I constructed a representative sample of 8,555 and 13,367 respondents aged 15–49 for Burkina Faso and Kenya separately, corresponding to 172,257 and 255,697 person-month observations. Table A1 of the Supporting Information presents the summary statistics.

Modeling strategy

Each type of reproductive events is modeled using a linear probability regression with a region-fixed effect as follows:

$$y_{ijkt} = \boldsymbol{\beta} \boldsymbol{E}_{ijkt} + \boldsymbol{\sigma} \boldsymbol{X} + \pi_k + \lambda_t + \theta_j,$$

where y_{ijkt} is the outcome measure for individual i in region j at year t and month k. $\boldsymbol{E}_{ijkt}$ represents a vector of exposure to the pandemic defined as in the section of key variables. By incorporating the region-fixed effect (θ_j), I isolate region-level, time-invariant confounders from the pandemic's impact estimates. Moreover, I include the year-fixed effect (π_k) for controlling the temporal trends of outcome indicators and the month-fixed effect (λ_t) for controlling seasonal bias. In addition to these baseline model settings, I include a series of individual-level covariates ($\boldsymbol{X}$), including educational level, age group, work status last seven days, and marital status. Table A1 of the Supporting Information presents the summary statistics of variables used in the analysis.

The coefficient estimates of interest are $\boldsymbol{\beta}$, representing the effects of exposure to the pandemic roughly every three more months relative to the pre-pandemic reference group. This modeling approach substantially improves upon recent studies that utilized similar data but overlooked the seasonality bias (Backhaus 2022). Through the analysis of person-month data, this study incorporates multiple fixed effects, yielding more reliable estimates over the exposure months.

Furthermore, I also performed a subgroup analysis to assess the heterogeneity of the pandemic's effects. To account for social and demographic characteristics, I identify four indicators: age group (15–29/30–49), residence type (rural/urban), educational level (primary or below/secondary or above), and household wealth level (below region-level mean wealth/above region-level mean wealth). I ran the regression model above for each subgroup and obtained the coefficient estimates for the specific group.

For the primary analysis, I showcase the model's estimates using the full sample of women aged 15–49. Additionally, I undertook a sensitivity analysis for conceptions and pregnancy terminations using distinct subsamples: fecund women and those in their gestational period, given that these reproductive events are specific to certain groups. The sample of fecund women was defined as the person-month observations of women who were

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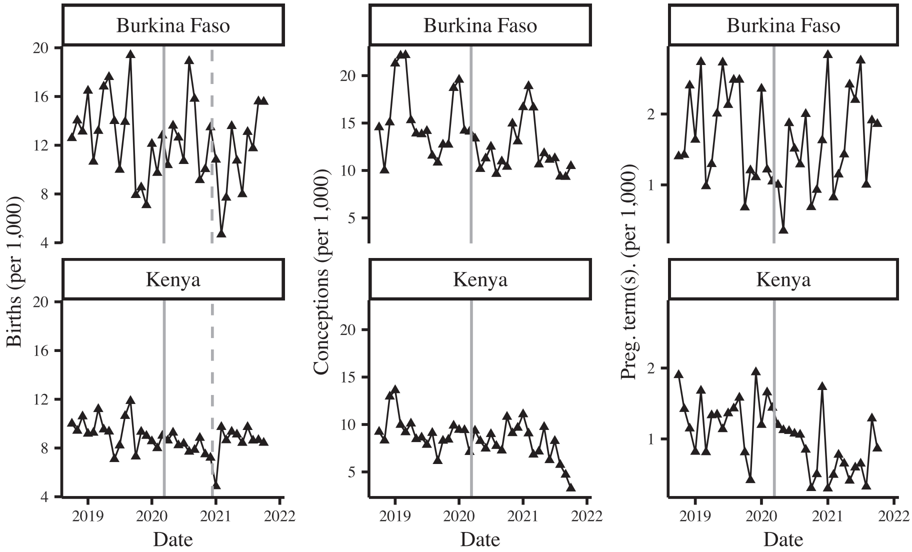
FIGURE 2 Aggregate-level trends of reproductive events by country



NOTE: Solid(dashed) vertical line indicates the date of the country's first reported COVID-19 case (+9 months).

either married or in a union and had neither undergone sterilization nor used long-acting reversible contraceptives, such as IUDs or implants (on the classification, refer to Tibaijuka et al. 2017). The sample of women in the gestational period pertained to person-month observations that highlighted statuses like pregnancy, termination, or birth. All regression analyses employed sampling weights and considered individual-level clustered standard errors[4].

Results

Descriptive trends

I begin with the analysis of aggregate trends of conceptions, pregnancy terminations, and births before and during the pandemic. Country-specific results are depicted in Figure 2. The denominator is the number of women aged 15–49. The solid gray lines indicate the dates of reporting the first COVID-19 case in the country, and the solid, dashed lines indicate nine months after the date of reporting the first COVID-19 case in the country, which could be regarded as the approximate date of conceptions turning into births. For the TFRs, there is a noticeable decline approximately nine months after the onset of the COVID-19 shock. Burkina Faso exhibits a more pronounced drop. Conception trends in the second column remain relatively stable around the outbreak's onset for both countries, though they decline as time progresses. Regarding pregnancy terminations, both

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countries experienced slight decreases at the beginning of the pandemic and rebounded in the short run. The excessive volatility could be attributed to the small number of pregnancy terminations in the sample because overall the monthly pregnancy termination rate was 1–2 per 1,000 women aged 15–49 years before and during the pandemic.

While basing results on the count of women aged 15–49 is direct, it does not clarify if the pandemic-induced shifts in conceptions and pregnancy terminations arose from reproductive behaviors or population compositions. I present the trends of conceptions and pregnancy terminations based on alternative denominators in Figure A1 (Supporting Information). The trend of conceptions using the number of fecund women as the denominator is very similar to that in Figure 2. This implies a minimal change in the composition of fecund status during the pandemic. For trends of pregnancy terminations, I use the number of pregnant women as the denominator. The result shows a lower level of decrease compared with Figure 2. Given the drop in conceptions during the pandemic's early phase, the noted decline in pregnancy terminations in Figure 2 might partly stem from the choice of denominator.

On an aggregate level, there are minor variations in the three reproductive events throughout the pandemic. However, there could be multiple factors that account for the difference. For instance, the short-term fluctuations could be attributed to seasonability bias. For trends in births, the downturn at the close of 2020 might be attributed to birth seasonality, as Panel B of Figure 2 similarly indicates a drop at 2019's end. Additionally, without accounting for the regional differences in pandemic onset dates and individual attributes, drawing persuasive conclusions on the pandemic's implications across various social groups becomes challenging.

Multivariate analysis

Table 2 presents the regression results for the full sample. I conducted regression analysis for Burkina Faso and Kenya separately with the consideration of context differences. I evaluated the sensitivity of the pandemic effects on each indicator, including fixed effects and covariates at the individual level. For birth (Panel A), the baseline model's coefficient estimates (Models a1 and b1) mirror the findings of the aggregate-level analysis. For Burkina Faso, the probability of birth decreased from 6 to 11 months since the pandemic outbreak, while the decrease is statistically significant from 6 to 8 months since the attack in Kenya. After adding individual controls and the region-fixed effect (Models a2 and b2), the coefficient estimates are nearly the same as those in the baseline model, and R^2s increase substantially. This indicates that the impacts of the pandemic exposure do not vary with individual characteristics.

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TABLE 2 Estimated effects of exposure to the pandemic on births, conceptions, and pregnancy terminations, by country

a. Birth	Burkina Faso				Kenya			
Variables	**(a1)**	**(a2)**	**(a3)**	**(a4)**	**(b1)**	**(b2)**	**(b3)**	**(b4)**
Exposure to the pandemic								
(Ref: 12 months before exposure)								
0–2 months	0.003*	0.003*	0.004*	0.004***	−0.001	−0.001	0.001	0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
3–5 months	−0.001	−0.001	0.001	0.003	−0.001	−0.001	0.000	0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
6–8 months	−0.001	−0.002	0.001	0.004	−0.001	−0.002*	−0.000	0.002
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)
9–11 months	−0.001	−0.002	0.002	0.006***	−0.000	−0.001***	0.000	0.003
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)
12–14 months	0.001	−0.000	0.004***	0.007***	0.001	−0.000	0.002	0.006*
	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)	(0.001)	(0.002)	(0.003)
15–18 months	0.001	−0.000	0.004***	0.009***	0.001	−0.001	0.001	0.006***
	(0.001)	(0.001)	(0.003)	(0.005)	(0.001)	(0.001)	(0.002)	(0.003)
Individual controls[a]	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Region fixed effect	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Year fixed effect	No	No	Yes	Yes	No	No	Yes	Yes
Month fixed effect	No	No	No	Yes	No	No	No	Yes
R^2	0.000	0.008	0.009	0.009	0.000	0.011	0.011	0.011
Observations	172,257	172,257	172,257	172,257	255,697	255,697	255,697	255,697

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TABLE 2 (Continued)

b. Conception	Burkina Faso				Kenya			
Variables	**(c1)**	**(c2)**	**(c3)**	**(c4)**	**(d1)**	**(d2)**	**(d3)**	**(d4)**
Exposure to the pandemic								
(Ref: 12 months before exposure)								
0–2 months	−0.003*	−0.003***	−0.003	0.001	−0.000	−0.000	−0.000	0.000
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
3–5 months	−0.001	−0.001	−0.001	0.002	0.000	0.000	0.000	0.002
	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
6–8 months	0.001	0.001	−0.001	0.004	0.003**	0.003**	0.003**	0.004**
	(0.001)	(0.001)	(0.002)	(0.003)	(0.001)	(0.001)	(0.001)	(0.002)
9–11 months	−0.000	−0.000	−0.004***	0.001	0.001***	0.002*	0.001	0.002
	(0.001)	(0.001)	(0.002)	(0.004)	(0.001)	(0.001)	(0.001)	(0.002)
12–14 months	−0.001	−0.001	−0.006*	0.002	0.000	0.001	−0.001	0.001
	(0.001)	(0.001)	(0.003)	(0.004)	(0.001)	(0.001)	(0.001)	(0.003)
15–18 months	−0.004**	−0.004**	−0.009**	−0.000	−0.002**	−0.002**	−0.003*	−0.000
	(0.001)	(0.001)	(0.003)	(0.005)	(0.001)	(0.001)	(0.001)	(0.003)
Individual controls[a]	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Region fixed effect	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Year fixed effect	No	No	Yes	Yes	No	No	Yes	Yes
Month fixed effect	No	No	No	Yes	No	No	No	Yes
R^2	0.000	0.008	0.008	0.008	0.000	0.007	0.007	0.008
Observations	172,257	172,257	172,257	172,257	255,697	255,697	255,697	255,697

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TABLE 2 (Continued)

c. Pregnancy termination	**Burkina Faso**				**Kenya**			
Variables	**(e1)**	**(e2)**	**(e3)**	**(e4)**	**(f1)**	**(f2)**	**(f3)**	**(f4)**
Exposure to the pandemic								
(Ref: 12 months before exposure)								
0–2 months	−0.001**	−0.001**	−0.001**	−0.001	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)
3–5 months	0.000	0.000	0.000	0.000	−0.000	−0.000	−0.000	−0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
6–8 months	−0.000	−0.000	−0.001	0.000	−0.000***	−0.000***	−0.000	−0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.000)	(0.001)
9–11 months	0.000	0.000	−0.001	0.000	−0.000***	−0.000	0.000	0.000
	(0.000)	(0.000)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
12–14 months	0.001	0.001	−0.000	0.001	−0.001**	−0.001*	0.000	0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)
15–18 months	0.001	0.001	−0.000	0.001	−0.000	−0.000	0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.002)	(0.000)	(0.000)	(0.001)	(0.001)
Individual controls[a]	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Region fixed effect	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Year fixed effect	No	No	Yes	Yes	No	No	Yes	Yes
Month fixed effect	No	No	No	Yes	No	No	No	Yes
R^2	0.000	0.001	0.001	0.001	0.000	0.001	0.001	0.001
Observations	172,257	172,257	172,257	172,257	255,697	255,697	255,697	255,697

***$p < 0.1$, **$p < 0.01$, *$p < 0.05$.
[a] See the description in the text.
NOTE: Numbers in parentheses are standard errors clustered at the individual level. Data are from the author's calculation.

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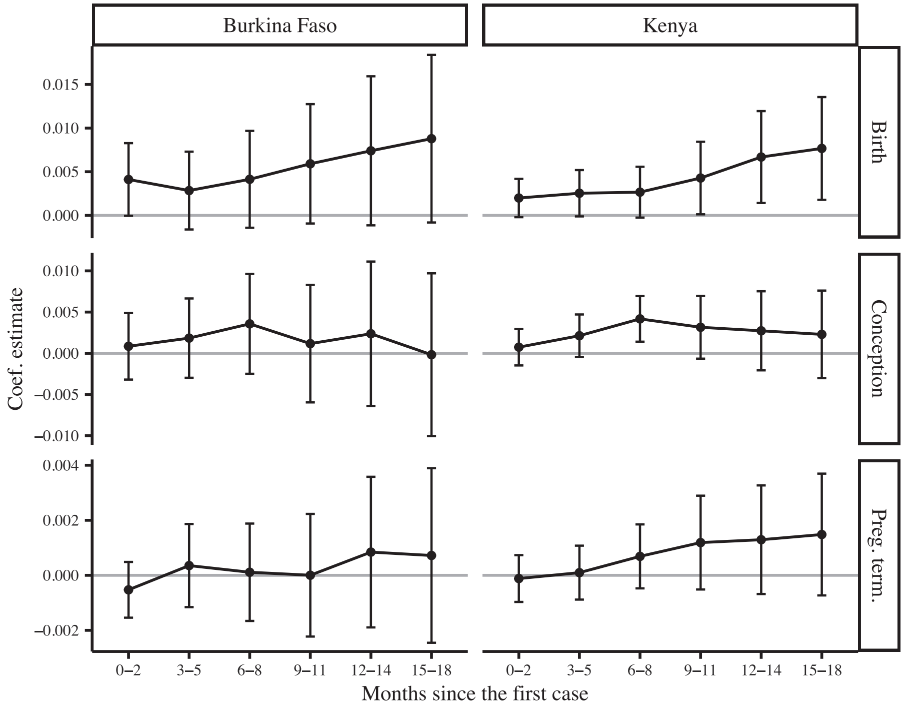
FIGURE 3 Effects of pandemic exposure on individual reproductive events



NOTE: Error bars represent 95 percent confidence intervals. Only error bars of coefficients that are statistically significant at 0.05 are presented.

The coefficient estimates changed substantively as I included the year-fixed effect (Models a3 and b3). Especially for Burkina Faso, the directions of most coefficient estimates change from negative to positive. For Kenya, there is no single coefficient estimate that is statistically significant.

The final model incorporates a month-fixed effect (Models a4 and b4) to adjust for seasonal bias. For Burkina Faso, the coefficient estimates are no longer statistically significant. In contrast, the coefficient estimates for Kenya are positive and became statistically substantial six to eight months after the pandemic outbreak. These results suggest that a considerable part of observed changes in the probability of birth is attributed to the macro-level decline of the fertility rate and seasonability of births. Similarly, including year- and month-fixed effects also changes the magnitudes and even directions of the coefficient estimates for conception and pregnancy termination.

Figure 3 graphically represents the coefficient estimates, drawing from full models that control for individual covariates and all fixed effects. The results show no statistically significant impact of the pandemic on the probabilities of birth, conception, and pregnancy termination in Burkina Faso. For Kenya, the results posit positive effects of pandemic exposure on births

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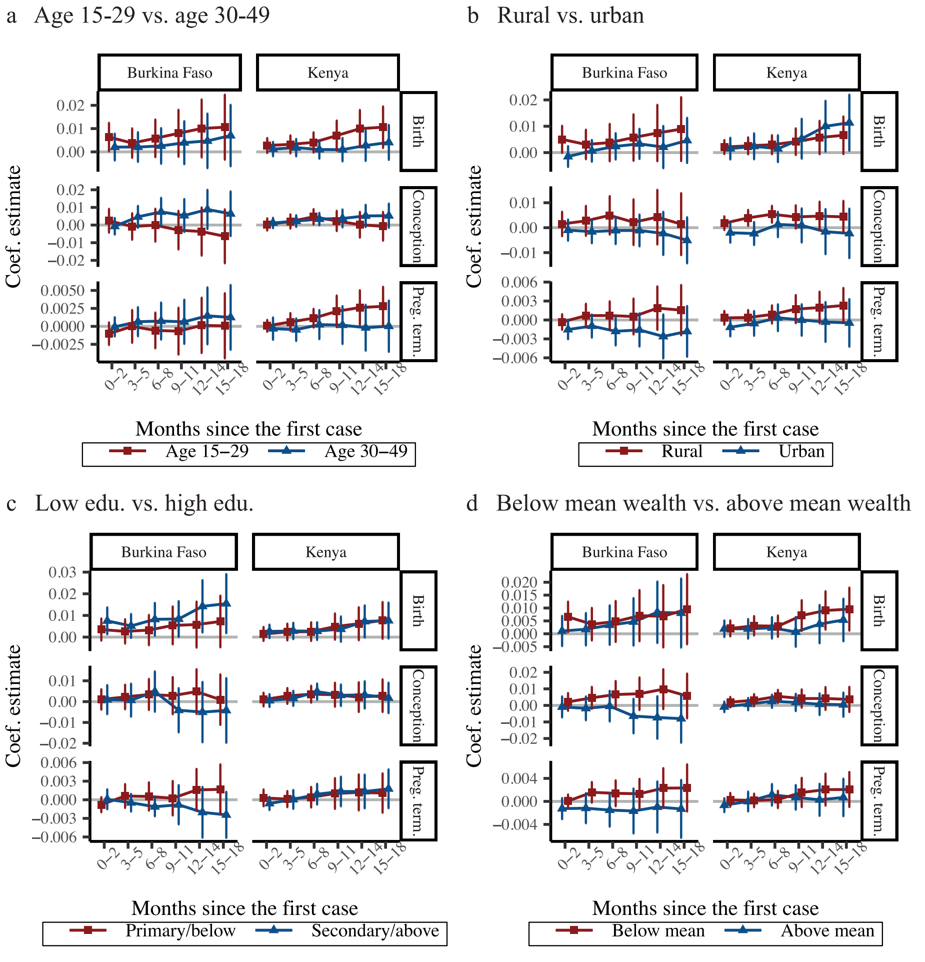
FIGURE 4 Effects of pandemic exposure on individual reproductive events by subgroup



NOTE: Error bars represent 95 percent confidence intervals. Only error bars of coefficients that are statistically significant at 0.05 are presented.

for 6–18 months and a short-term positive impact on conception for six to eight months after the pandemic outbreak.

To explore the heterogeneity of impacts of the pandemic among social and demographic groups, Figure 4 presents coefficient estimates by running the full models with all controls and fixed effects separately for each subgroup. Subgroup analysis by age reveals no notable pandemic impact on all outcomes for both the younger (15–29) and older (30–49) groups in Burkina Faso, except that the young group experienced a significant increase in births during the first trimester of the pandemic. For Kenya, the increases in the probability of birth for the young group were substantial and consistent with the findings in the full sample while the impacts on the elder group are not noticeable. Regarding conception, both young and elderly groups

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experienced a statistically significant increase only six to eight months after the pandemic outbreak, consistent with the findings of the full sample. In terms of pregnancy termination, although the magnitudes of coefficient estimates are small, we still observe a significant increase in probability of pregnancy terminations among the young group about one year after the pandemic outbreak.

Because urban areas generally offer better health care services than rural areas (Yaya Bocoum, Grimm, and Hartwig 2018), analysis by residence may provide meaningful results on the heterogeneity of the impacts of the pandemic. For Burkina Faso, although there are still no statistically significant impacts on birth and conception, there was a decrease in the probability of pregnancy termination in urban areas soon after the pandemic outbreak. In Kenya, the probability of conceptions among the rural group increased substantively from three to eight months since the pandemic outbreak, while there is no significant change among urban women. As for pregnancy termination, I observed a similar trend in urban areas like in Burkina Faso although it was only statistically significant at the level of 0.1. When it turned to births, I observed that the trends for rural and urban women were very similar and showed an increase about one year after the pandemic. The results in Kenya may imply that simultaneous shifts in conceptions and pregnancy terminations might result in less pronounced changes in birth rates.

Because education and family wealth are essential indicators of social status, I discuss the results of two subgroup analyses together. For Burkina Faso, there is a statistically significant increase in the probability of birth for the highly educated group for several periods after the pandemic outbreak. Although there are no statistically significant changes in conceptions and pregnancy terminations during the pandemic, we could see a decrease in pregnancy terminations among the high-education group. The subgroup analysis by wealth status does not indicate any statistically significant findings, except the increase in births among the poor group (below mean wealth) in the first three months of the pandemic. For Kenya, differences in the pandemic effects by educational level are ignorable. The results based on wealth shows a significant divide in birth trends after nine months of the pandemic outbreak. Namely, I observed a substantive increase in conceptions among the poor group, while there is nearly no change among the wealthy group.

Robustness check

I conducted a robustness check for conceptions and pregnancy terminations using alternative samples, as described in the previous section, with results displayed in Figures A2 and A3 (Supporting Information). In terms of conceptions, the results based on the person-year sample of fecund women are consistent with the main findings. These results indicate that the pandemic's

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effect on conceptions primarily arose from a change in the probability of individual conception, not from shifts in the female composition of fecundity. In alignment with our main results, the findings for pregnancy terminations, based on the person-month sample of women in their gestational periods, also reveal no statistically significant differences. It is noteworthy that the upward trend observed in Kenya vanished when applying the sample restriction in the analysis. Intriguingly, the subgroup analysis still reveals slight declines in the probability of pregnancy terminations in urban areas of both Burkina Faso and Kenya during the pandemic's early stages. This suggests that this specific coefficient estimate might stem from the pandemic's direct impact on experiences of pregnancy terminations rather than its indirect influence on conceptions.

Further analysis

Despite the complexities in presenting a comprehensive overview of the primary findings, an exploratory analysis was undertaken to reconcile and consolidate the results in two specific areas.

First, I conducted the regression analysis on a series of fertility-related outcomes, including contraceptive use, health service access, and subjective feelings of pregnancy. For each wave of the PMA survey, it includes consistent measures of whether the respondents were currently using contraceptive methods and multiple subjective questions related to fertility. I pool three waves of data and the COVID-19 (2020) wave together to conduct the analysis. The baseline wave serves as the reference group (pre-pandemic group) because it was surveyed just before the pandemic outbreak. The COVID-19 (2020) wave was surveyed around three months later after the first reported case in both countries and defined as the first treatment group (early stage of the pandemic). In a similar vein, the second and third waves correspond to the second and third treatment groups (representing the middle and late stages of the pandemic, respectively). The analysis included the same set of covariates as in the main analysis.

Drawing from the supply-side perspective, which emphasizes the pandemic's disruption to health service access, I employed dummy variables for contraceptive use and health facility visits in the past 12 months. I then conducted an analysis for both the full sample (Figure A4 of the Supporting Information) and specific subgroups (Figure A5 of the Supporting Information). The results indicate that there was little disruption in contraceptive use during the pandemic but a dramatic decrease in health facility visits in the early stage of the pandemic. The subgroup analysis further shows that the early disruption on facility visits was more severe in urban areas of both countries. Notably, in Kenya, the likelihood of health service visits remained lower in Phase 2 compared to the pre-pandemic period. Phase 2 was surveyed between the end of 2020 and early 2021.

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In terms of the demand-side explanation, I used the dummy variables of wanting more children and feeling happy if pregnant as dependent variables and conducted the analysis for the full sample (Figure A6 of the Supporting Information) and subgroup samples (Figure A7 of the Supporting Information). I did not find any evidence that the pandemic led to the decline of fertility intention. On the contrary, the results indicate substantive increases in fertility intention or positive feelings on pregnancy in the early stage of the pandemic. Particularly for the poor and rural groups in Kenya, the magnitudes of increases were higher. Considering little evidence on the pandemic's disruption on contraceptive use, the increase in conceptions among disadvantaged groups of Kenya could be driven by the increase in fertility intention, as shown in Figure A7 of the Supporting Information. Moreover, more positive feelings for pregnancy at the early stage of the pandemic may indicate a lower preference for induced abortions. Due to the lack of information on induced abortion services, I cannot claim that the decline of pregnancy terminations at the early stage of the pandemic in urban areas was explained by feelings for pregnancy, but the results indeed suggest that the pandemic might not lead to the increase in induced abortions.

Second, I integrated conception, pregnancy termination, and birth into one framework and conducted a simulation practice by offering a dynamic model of the reproductive process under the pandemic shock. The details are included in Section B of the Appendix (Supporting Information). The simulation results are visualized in Figure A8 (Supporting Information), and the numerical results can be found in Table A3 (Supporting Information). From a theoretical perspective, it is difficult to interpret the impact of the pandemic on births directly through the impacts on conceptions and pregnancy terminations. On the one hand, both changes in conceptions and pregnancy terminations attributed to the pandemic cannot be reflected in changes in births intuitively but should take a dynamic process into account. On the other hand, the direction and magnitude of changes in birth trends could be more explainable by investigating the pandemic's impact on conception and pregnancy separately (Figure A8 of the Supporting Information). Particularly, when the pandemic's impacts on conception and pregnancy termination are in the same direction, we could expect the possibility of insignificant birth changes. To put it differently, instead of solely examining the pandemic's influence on birth outcomes, considering the reproductive process as a whole offers valuable theoretical insight.

Conclusion

Demographic studies often explore how human reproductive behaviors adjust to rapid environmental and societal changes. Historically, researchers have studied fertility reactions to significant events, such as natural and

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human-made disasters. The coronavirus pandemic, however, presents a nuanced effect on human reproduction. Unlike past events that drastically impacted child mortality, COVID-19's influence is more through social and economic upheavals caused by the global health care crisis and economic slowdowns. In the absence of a channel of fertility replacement due to the mortality of children, fertility responses to the COVID-19 pandemic could be explained by social and economic channels, given the disruptions of the pandemic on the public health system and economy worldwide.

This research adopts a reproductive process perspective, seeking to bridge the gap between theoretical predictions and actual birth rate fluctuations during the pandemic. By connecting conceptions and pregnancy outcomes to births, I unveil diverse pandemic effects across different countries and social strata. The patterns of how the pandemic shapes conceptions and pregnancy terminations may vary across countries and social groups.

The study focuses on two less-developed countries, using an extensive representative sample to ascertain the pandemic's effect on conceptions, pregnancy terminations, and births. This enables me to distinguish how conceptions and pregnancy terminations respond to the pandemic differentially. The analysis highlights the varying impacts of the pandemic on reproductive events across different countries and social groups. Three key findings emerge. First, there is no substantive impact of the pandemic on conceptions and pregnancy terminations for the whole group of women aged 15–49 but we indeed observed an increase in births since about one year after the pandemic outbreak in Kenya. Second, aggregate-level changes in births, conceptions, and pregnancy terminations may not reflect the impacts of the pandemic due to the existence of temporal and seasonability effects. This observation is in line with recent studies on fertility responses to the pandemic, which consider these confounding factors (Lima, Soares, and Silva 2022; Silverio-Murillo et al. 2023). Unlike previous studies that primarily concentrate on aggregate-level analysis, this study leverages individual-level covariates using available micro-level information. Third, there is heterogeneity in the pandemic's impact on conceptions and pregnancy terminations by some social groups. Pregnancy terminations might have increased in urban areas at the early beginning of the pandemic in both countries while the increase in conceptions was more likely to occur among the disadvantaged groups, such as poor or rural women in Kenya.

This research underscores the nuanced relationship between pandemic impacts on conception and pregnancy terminations and their eventual effect on birth rates. Insignificant birth changes during the pandemic could exist even if there are significant pandemic effects on conceptions and pregnancy terminations. This finding is not surprising because many studies have mentioned this point. Though many past studies have hinted at this connection, this work emphasizes the crucial role that both conception and pregnancy play in determining birth rates. The perspective of the

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reproductive process may provide implications for explaining mixed findings on birth changes during the pandemic. That is, without distinguishing the pandemic effects on conceptions and pregnancy terminations, the existing explanations may not predict the magnitude and even direction of the impact of the pandemic on the birth rate.

There are several limitations in this study. First, the large representative sample of person-month data allows for examining the fertility responses to the pandemic, but the data are far from perfect. Throughout the empirical analysis, I do not consider migration and assume that the respondent does not move across the whole observation period. This assumption could be problematic if the rapid coronavirus spread in a region leads to a sizable migrant flow of fecund or pregnant women across areas. However, during the pandemic, movement restrictions and fear of infections significantly reduced the probability of migration. Hence, it is reasonable to expect that taking migration into account does not change the main findings. Moreover, the person-month data are constructed based on retrospective information on reproductive events. As many studies suggest, reporting errors in the contraceptive calendar has been an important issue (Anglewicz et al. 2023; Becker and Sosa 1992; Callahan and Becker 2012). To reduce the risk, this study only focuses on the reported events around one year before the interview date. However, it should be admitted that the date of reproductive events, particularly pregnancy, could be inaccurate for some observations.

Second, this study does not take preterm birth into account. Recent studies show that the risk of preterm birth could increase during the pandemic (Calvert et al. 2023; Hedley et al. 2022; Khalil et al. 2020; Kingston 2020; Torche and Nobles 2022). In the fertility model that this study proposes, preterm birth impacts the probability distribution of delivering births conditional on conceptions and pregnancy terminations. Due to the sample size and information availability, this study cannot accurately identify preterm births.

Third, this study does not distinguish different types of pregnancy terminations and hence cannot provide mechanism explanations for the findings. As an alternative, I conducted a series of exploratory analyses building on the supply-side and demand-side explanations. Future research should rely on micro-level data accurately distinguishing various types of pregnancy terminations and may advance our understanding of channels through which the pandemic affects pregnancy outcomes.

Finally, the results should be explained with caution due to the potential underreporting issue of conceptions or abortions. To increase the accuracy of the analysis, this study takes multiple strategies to increase data reliability. PMA has implemented the social network-based measure in the Phase 2 survey and to some extent provides more reliable information on pregnancy terminations. However, the underreporting issue of both

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conceptions and pregnancy terminations could exist. Particularly for pregnancy terminations, if the majority of underreported pregnancy terminations were safe abortions, the finding that urban females experienced a decline in pregnancy terminations at the early stage of the pandemic could have been attributed to the underreporting issue because induced abortion services were more accessible in urban areas in both countries (Bankole et al. 2014; Ushie et al. 2019). Unsafe abortions could occur more frequently among disadvantaged groups (Grimes et al. 2006). Similarly, if the majority of underreported pregnancy terminations were unsafe abortions, the study might underestimate the positive effect of the pandemic on pregnancy terminations because the analysis did not find significant changes in pregnancy terminations among all disadvantaged groups.

Acknowledgments

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Notes

1 PMA data are publicly available from the official website of Performance Monitoring for Action: https://www.pmadata.org/data/available-datasets.

2 Due to the lack of information on the types of pregnancy terminations, this study focuses on the general meaning of pregnancy terminations. It should be acknowledged that the pandemic's influence on pregnancy terminations could vary across types.

3 Phase 1 was conducted from November to December 2019 at Kenya and from December 2019 to February 2020 at Burkina Faso. Phase 2 was conducted from November to December 2020 at Kenya and December 2020 to March 2021. Phase 3 was conducted from November 2021 to January 2022 at Kenya and December 2021 to March 2022.

4 The analytical sample uses person-month observation as the unit and is constructed based on retrospective reproductive calendars. The analytical sample could be seen as a panel of monthly data at the individual level for each wave of the survey with individuals as clusters. Following Abadie et al. (2023), I reported the clustered standard error at the individual level.

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