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Trude Lappegård, Tom Kornstad, Lars Dommermuth and Axel Peter Kristensen

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Trude Lappegård, Tom Kornstad,
Lars Dommermuth and Axel Peter Kristensen

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Abstract:
This study examines the effect of the COVID-19 pandemic on fertility in Norway at the individual level. Studies using data at the macro level have found a positive short-term effect of the pandemic on fertility level in Norway, but women's fertility response to the pandemic may differ depending on their life situation. We use the first lockdown on March 12, 2020 as a marker of the pandemic and apply a regression discontinuity design to compare births of women that were conceived before the pandemic started with those conceived during the first eight months of the pandemic. The positive effect on women's fertility in Norway was mainly driven by women in life phases that have generally high fertility rates (women aged 28–35 years and women who already have children). These groups are likely to be in an economic and socially secure and stable situation in which the restrictions due to the pandemic had limited influence. Besides two exceptions, we do not find differences in the effect of the pandemic on childbearing by women's work situation. This is most likely related to the strong welfare state and the generous additional pandemic-related measures taken by the Norwegian government.

Keywords: fertility, demography, COVID-19, regression discontinuity design

JEL classification: J13, J11, I24

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Address: Trude Lappegård, University of Oslo, Department of Sociology and Human Geography, E-Mail: trude.lappegard@sosgeo.uio.no
Tom Kornstad, Statistics Norway, Research Department, E-mail: tko@ssb.no
Lars Dommermut, Statistics Norway, Research Department, E-mail: ldo@ssb.no
Axel Peter Kristensen, University of Oslo, Department of Sociology and Human Geography, E-Mail: a.p.kristensen@sosgeo.uio.no

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Sammendrag

Covid-19 pandemien førte til de sterkeste og mest inngripende tiltakene vi har hatt i Norge i fredstid ifølge daværende statsminister Erna Solberg. Denne studien ser på effekter av covid-19 pandemien på fruktbarheten til ulike grupper av kvinner i Norge. Det er tidligere vist at pandemien har hatt en positiv effekt på fruktbarhetsnivået i Norge, men studiene har ikke vist hvorvidt kvinner vil kunne respondere forskjellig på pandemien avhengig av hvilken arbeids- og livssituasjon de er i. Vi bruker den første nedstengingen 12. mars 2020 som en markør på pandemien og bruker metoden regresjon diskontinuitet design (RDD) på administrative registerdata for å sammenligne antall fødsler knyttet til barn som ble unnfanget før pandemien startet og fødsler av barn som ble unnfanget de første åtte månedene av pandemien. Resultatene fra studien viser at den positive effekten av pandemien på fruktbarheten i Norge var drevet av kvinner i livsfaser hvor fruktbarheten generelt er høy (kvinner i alderen 28-35 år og kvinner som allerede har barn). Dette er grupper som ofte er i en stabil økonomisk og sosial situasjon og hvor restriksjonene på grunn av pandemien har hatt mindre betydning for deres livssituasjon. Med unntak av for kvinner i servicesektoren og offentlig administrasjon, har kvinnenes arbeidssituasjon – målt ved hvilken næring de arbeidet i rett før nedstengingen – liten betydning for effekten av pandemien på fruktbarheten. Dette kan forklares med de gode velferdsordningene i Norge og de generøse økonomiske tiltakene fra myndighetene i forbindelse med pandemien.

1. Introduction

People in most countries have experienced national and/or local lockdowns and social restrictions to control the spread of the COVID-19 virus. For many, the pandemic has had severe consequences for their economic and social situation that may influence various aspects of their lives. There is great interest in whether fertility was affected by the pandemic and several studies have shown differences in the development of the short-term birth rates across countries due to the pandemic (Aassve et al. 2021; Sobotka et al. 2021). Besides differences between countries, there might also be variation between individuals in their fertility response to the pandemic. In this study, we investigate the effect of the COVID-19 pandemic in Norway at the individual level among groups of women depending on their life situation, that is, age, number of children, educational attainment, and work situation.

In contrast to most other high-income countries, in Norway there was no negative short-term effect of the pandemic on fertility level, but an increase in the number of births and birth rate has been observed (Aassve et al. 2021; Sobotka et al. 2021; Statistics Norway 2022). One explanation for this development is related to the implementation of the extensive governmental economic compensation during the pandemic in Norway, which attenuated possible negative economic and social consequences of the pandemic (Ursin, Skjesol, and Tritter 2020). The reasoning behind this argument is that the economic and social consequences of the pandemic in a country are likely to influence the effect of the pandemic on the fertility level. For instance, a study examining fertility plans of young adults during the first lockdown in Italy, France, Germany, Spain, and the UK found a smaller proportion postponing or abandoning their fertility plans in countries with a stable economic and labor market situation before the pandemic—France and Germany—than in the other countries (Luppi, Arpino, and Rosina 2020). We can see a parallel in the economic consequences of the pandemic on fertility and the Great Recession in 2008, where country differences in the fertility development in the aftermath of the recession were explained by the policies introduced to tackle economic turmoil (Comolli et al. 2021). Thus, a plausible argument is that the governmental economic crisis management of the pandemic had a moderating effect on the economic consequences of the pandemic. However, it does not explain the slight increase of the fertility level in Norway.

In the same way as for cross-country differences in the impact of the pandemic on fertility rates, it is likely that there are variations across groups of women within a country. This means, women's fertility response to the pandemic may depend on their life situation. To explore this, using information from administrative register data covering the full population in Norway, we identify the causal effect of the pandemic on fertility behavior among subgroups of women in Norway. More specifically differences by age, number of children, educational attainment, and women's work situation (business sector classification). We use the first lockdown on March 12, 2020 as a marker of the pandemic and apply a regression discontinuity design, where we compare births that were conceived in the months before the pandemic started versus those that were conceived during the first eight months of the pandemic.

This study contributes to the literature in three ways. First, the methodological design provides us with strong external validity to causal claim on the impact of the pandemic on fertility. Second, studying the effect of the pandemic on fertility for different subgroups of women advances our knowledge on women's responses to the economic and social consequences of the pandemic. Third, examining the effects of the pandemic in Norway provides insights on its effects in a country offering extensive governmental economic compensation to employers and employees.

2. The Norwegian context

One day after the WHO declared COVID-19 a pandemic (March 12, 2020), the Norwegian government implemented extensive measures to prevent the spread of the disease, including closing all kindergartens, schools, colleges, and universities as well as shutting down all cultural and sport activities and businesses in the service industry. In addition, general advice for social distancing and hygiene measures was given, and all persons traveling to Norway from abroad were placed in a two-week quarantine. These were the most intrusive measures implemented in peacetime in Norway and can be described as an immediate lockdown of large parts of society (Ursin, Skjesol, and Tritter 2020). When the number of infected persons started to decline in April 2020 and in the following months, society gradually reopened, starting with the kindergartens and primary and lower secondary schools. At the same time, it was made clear by the Norwegian government that new restrictions could be implemented at a later date as the pandemic was not over. Specific services (including hairdressers) could reopen while others remained closed (restaurants and bars, fitness centers and swimming pools, tattoo studios, etc.). However, nursing homes and institutions for vulnerable groups could still not be visited, several public services remained closed (passport offices, libraries, etc.), stricter border controls were retained, and foreign nationals without a residence permit were still refused entry to the country. Thereafter, all schools reopened together with the universities, indoor and outdoor sports for young people were allowed, and bars and restaurants reopened (for the complete timeline of measures taken by the Norwegian government, see Ministry of Health and Services 2022).

One consequence of the lockdown was a dramatic increase in unemployment. Before the lockdown, the unemployment rate in Norway was below 4%. In the month of the lockdown, the unemployment rate quadrupled. While the monthly number of temporarily laid-off employees for February 2020 was about 5,300, the total for March exceeded 250,000 and increased to over 272,000 in April, dropping to 217,000 in May and 144,000 in June 2020 (Ursin, Skjesol, and Tritter 2020). As an oil and gas exporting country, Norway has built one of the largest funds in the world, namely the Government Pension Fund of Norway. The revenues from this fund are an important contribution to the national budget and the guidelines for the fund allow the government to allocate more money from this source in times of crisis, such as during a pandemic (Ursin, Skjesol, and Tritter 2020). Thus, from an international comparative perspective, the Norwegian government was in a unique position allowing them to implement costly measures at short notice. Several measures were taken directed at both employees and employers to reduce the economic burden of the pandemic. Those unemployed would normally receive an economic benefit covering 62% of their previous income up to a high fixed ceiling. During the pandemic, this benefit was increased to 80%. For employers forced to temporarily lay off their employees, the state paid unemployment benefits from day one rather than after two weeks, which would be the standard course of action, to reduce employer costs. In addition, loan guarantees to businesses in the private sector were implemented to prevent bankruptcy of firms and enterprises due to the lockdown or the restrictions. These measures were prolonged, enlarged, and adjusted in the following months, and by the end of May 2020, the economic measures were revised to increase economic activity and employment rates again (Ministry of Health and Services 2022).

In addition, existing generous welfare benefits to families with young children were sustained during the pandemic, including one year of paid parental leave when a child is born and affordable high-quality childcare facilities. The paid parental leave is either 49 weeks with 100% income compensation or 59 weeks with 80% income compensation to be shared between the parents. The leave includes a mother’s quota (1/3 of the weeks + 3 weeks before birth), a father’s quota (1/3 of the weeks), and a part to be shared of the parents’ choosing (1/3 of the weeks). The income compensation is calculated based on the average income during the last three months before the leave starts or the average income for the last 12 months if there is a large gap between the two. In addition, unemployed individuals have the right to receive parental leave benefits. This means that the income compensation during the parental leave would not necessarily be that different whether one was laid off due to the lockdown or not (Norwegian Labour and Welfare Service 2022).

When the pandemic started, the overall fertility level in Norway was at a historical low. The total fertility rates in Norway dropped yearly from 1.98 in 2010 to 1.48 children per woman in 2020, after being stable and comparatively high in Europe during the 1990s and 2000s (Statistics Norway 2022). The decline was particularly a result of higher age at first birth and postponement of transition to motherhood (Hellstrand et al. 2021). In 2021, the total fertility rate increased to 1.55.

3. Theoretical considerations

In the following, we discuss several mechanisms through which the pandemic and measures taken to prevent the spread of the disease may affect fertility in general, and for specific subgroups of women. It is likely that for many, the pandemic has created uncertainty about the future. An individual's perception of the future is a primary element of the narrative framework (Vignoli, Bazzani, et al. 2020; Vignoli, Guetto, et al. 2020). This framework takes into account that people do not only consider their current situation when contemplating childbearing but also their own subjective narrative of what the future will be like. Perceiving the future as uncertain can lead to postponed or abandoned fertility intentions. A sudden reinforcement of uncertain perceptions of the future, in our case related to the pandemic and the first lockdown that was introduced at short notice, may lead to a decline in fertility. Support for such a perspective is found in a study from Italy conducted during the lockdown in spring 2020 (Guetto, Bazzani, and Vignoli 2020). Subjective perceptions and personal narratives of the future (especially negative) were found to have more influence on people's fertility intentions than their current economic situation in Italy at this stage. Compared with Italy, the consequences of the pandemic in Norway were less severe, with comparatively low numbers of hospitalized persons and deaths due to COVID-19. Nine months after the COVID-19 outbreak, Norwegian participants in a cross-national study expressed high levels of trust regarding the response of the public authorities to the disease (Price et al. 2021). Thus, if the perception of uncertainty of the future due to the pandemic is not severe, other narratives of the future may play a more significant role for decisions about childbearing.

In addition to possible perceptions of uncertainty of the future due to the pandemic, the pandemic also caused direct changes in individuals' employment and economic situation. Economic theory suggests that people's fertility behavior depends on whether they can afford to have children and whether they are experiencing uncertainty in the labor market (Kreyenfeld 2016; Kreyenfeld, Andersson, and Pailhé 2012; Vignoli, Guetto, et al. 2020). Following such an argument, people who are laid off or experience a drastic cut in income would be less likely to have children. Focusing on fertility intentions among Italian young adults, a negative effect of the first lockdown was found among those affected most economically (Arpino, Luppi, and Rosina 2021). As noted, unemployment rates also increased in Norway immediately after the lockdown, and in addition, many employees were temporarily laid off (Ursin et al., 2020). Specific business sectors, such as the service sector, were hit particularly hard by the restrictions, while others could continue more normally. Thus, one would expect that the impact of the pandemic on childbearing behavior would vary across business sectors. However, it is likely that the generous governmental economic crisis management of the pandemic in Norway had a moderating effect on the impact of the pandemic, potentially lowering the variation in childbearing behavior between women in different business sectors.

Although the main argument in economic theory is that an income loss or unemployment should decrease fertility, there are alternative arguments predicting the opposite. Following the uncertainty reduction theory (Friedman et al. 1994), having a child could be a response to uncertainty, given that committing to a child will last for a long time and create a more predictable situation and thereby reduce uncertainty. As found among mothers in a recent study in Norway (Kristensen 2019), some may also consider childbearing as an alternative to unemployment as it provides a convenient time slot for childrearing and providing care (see also Busetta, Mendola, and Vignoli 2019; Adserà 2011). During the pandemic, the Norwegian government increased the unemployment benefits, meaning that the negative economic consequences of being laid off were less severe than otherwise. In line with the uncertainty reduction theory, major crises may activate an individual's or a couple's attachment behavior as a response to strong distress, resulting in increased fertility. Such findings were reported following Hurricane Hugo in the US in 1989 (Cohan and Cole 2002). These latter mechanisms suggest that some individuals realize their existing fertility intentions despite the pandemic or accelerate and have a(nother) child earlier than initially planned.

The direction of these more general mechanisms may vary across different subgroups, for example, depending on their work situation. In addition, in business sectors that were not directly hit by the lockdown and where employees were not laid off, the pandemic led to various changes in the work situation. For instance, within the health sector, the restrictions were severe and the concern for spread of the disease was especially high. In many ways, employees in the health sector were at the frontline of the pandemic, and experienced much illness and the possible fatal consequences of the disease. In contrast, employees in many other business sectors were forced to work from home. While typical office work could be transferred to a home office relatively easily, the work situation changed significantly in other sectors and professions. For example, teachers and professors had to relocate their workspace from physical classrooms to digital platforms overnight.

The work situation of employees also varies according to their educational background and age. Descriptive analyses of temporary employment in Norway indicate that young age and having an education at the primary level substantially increase the probability of having a fixed-term or temporary contract compared with other age groups or employees with higher education (Nergaard 2019). Higher educated employees more often have the possibility to work from home (Sarbu 2015) and this difference has most likely increased during the pandemic. In Norway, higher educated employees in particular reported during the pandemic that their work situation had changed and that they worked mostly from home. This was also the case for employees in the educational sector, while employees in the production industries reported fewer changes in their work situation (Nergaard 2020). Taken together, one can expect that the impact of the pandemic on childbearing behavior would vary according to an individual's employment situation and their educational background.

Overall, for many women, the pandemic has resulted in more time spent at home, either alone or together with their partner and family, with varying consequences for their childbearing plans depending on their life situation. For single persons, limited social interactions may have put their dating life on hold with fewer possibilities to meet new people and a potential partner. It can be assumed that this group will not have a strong influence on short-term fertility, as most people live together with a partner for some time before they have a child. However, if the pool of coresidential couples in childbearing ages decreases over a longer period, this could have a negative impact on fertility in the future.

For childless couples, being forced to spend more time at home together may trigger questions about what matters in life and how they want to spend their time. This may result in more people considering starting a family. Such a mechanism might be especially relevant in the case of Norway, as the fertility decline in the past decade was mainly driven by lower first-birth rates (Hellstrand et al. 2021). Assuming that this is at least partly due to postponement of first births, one may argue that the pandemic can serve as an external shock, pushing people to realize their latent childbearing plans.

Similarly, this may also be the case for parents with young children. Working from home and/or having fewer other social activities may provide a more balanced and less stressful family life and strengthen family-related values. If parents also still feel economically secure, this may be considered as a favorable time for having another child (Berrington et al. 2022). In Norway, there is a strong two-child norm (Lappegård and Kornstad 2020), that is, most one-child parents also have a second child. From this perspective, the pandemic may enhance an increase in second births. However, the lockdown may also have resulted in more intense family interactions and crowded homes. For instance, at the beginning of the pandemic, when kindergartens and schools were closed, parents with young children were forced either to resort to full-time childcare for the youngest children, or to supervise homeschooling for school-aged children. If parents in addition had to work at home or experienced a more stressful work situation, this is unlikely to have resulted in new or enhanced childbearing plans.

The burden for family members due to the pandemic depends also on the level of gender equality they practice. There are already several examples from Australia, the UK, and the US that the pandemic has led to a setback in gender equality (Craig and Churchill 2021; Collins et al. 2021; Anders et al. 2020), and it is argued that the work–family balance has placed greater strain on women and especially on mothers (Settersten et al. 2020). To our knowledge, there are to date no similar studies for Norway, although gender equality is considered high in Norway (Ellingsæter and Jensen 2019). This could imply that the burden due to the pandemic could be more equally distributed than what is observed in other countries. Some studies that investigated the link between gender equality and childbearing before the pandemic suggest a positive impact of gender equality and equity on childbearing (Dommermuth, Hohmann-Marriott, and Lappegård 2017; Miettinen, Lainiala, and Rotkirch 2015). Thus, a gender-equal division of household labor and child-rearing tasks during the pandemic may have a positive impact on fertility in such a setting.

4. Data and method

For this study, we use administrative register data covering the total Norwegian population. In Norway, all administrative registers include a personal identification number, which means it is possible to link information from different registers. Here, we use information from the population registries, the National Database on Education, birth registries, and labor market registries for 2017–2021.

To investigate whether the pandemic in Norway affected women's fertility, we use a modified regression discontinuity design, which is a quasi-experimental method (Angrist and Pischke 2014) that allows us to compare similar women before the pandemic started and during the pandemic. We use the first national lockdown (March 12, 2020) as the marker of the pandemic. In the weeks leading up to the lockdown, although the spread of COVID-19 in the world was highlighted in the national media, no significant measures were taken in Norway. When the national lockdown was announced by the

Norwegian government one day after the WHO declared COVID-19 a pandemic, the measures taken by the government were drastic and started immediately.

The cutoff point for our analysis is March 12, 2020 and we compare the proportion of women that conceived a child before and after this date. As a pregnancy usually lasts nine months, this means that we compare the proportion of women giving births before and after December 17, 2020. To identify the observations before and after the cutoff point, regression discontinuity analysis requires a running variable. Here, we use weeks and the observation window for our analysis is 19 weeks before and 32 weeks after the cutoff point, which gives us an observation window of 51 weeks in total. We do not want to exceed one year to avoid overlap between the study population and comparison population (described below). Thus, we follow women during the first 32 weeks of the pandemic and children conceived during this period. We do not follow them longer because in November 2020 the pandemic went into a new phase in Norway, with substantial regional differences in the measures that were taken to avoid the spread of the disease. We use week over day because there is variation in births during a week, for example, there are few planned births during the weekend due to reduced staff in the hospitals. We exclude observations one week before and after December 17 from our dataset to avoid bias with the estimated effect of the pandemic on fertility. That is, because pregnancies do not always last exactly nine months, it can be difficult to know if a child was conceived before or after the lockdown.

Our main study population comprises all women aged 20–45 years living in Norway at the end of 2020. This age range was chosen because only few newborns in Norway have mothers aged younger than 20 or older than 45 years. As we are interested in the decision to have a(nother) child and not the number of newborn children, multiple births are counted as one birth event. We also include a comparison population because there are seasonal differences in childbirth, which might lead to bias in the estimated effects if not accounted for. The dataset for the comparison population is constructed in the same way as the dataset for the main study population, but for the years 2017, 2018, and 2019. We use the three preceding years to ensure that the comparison population is as robust as possible.

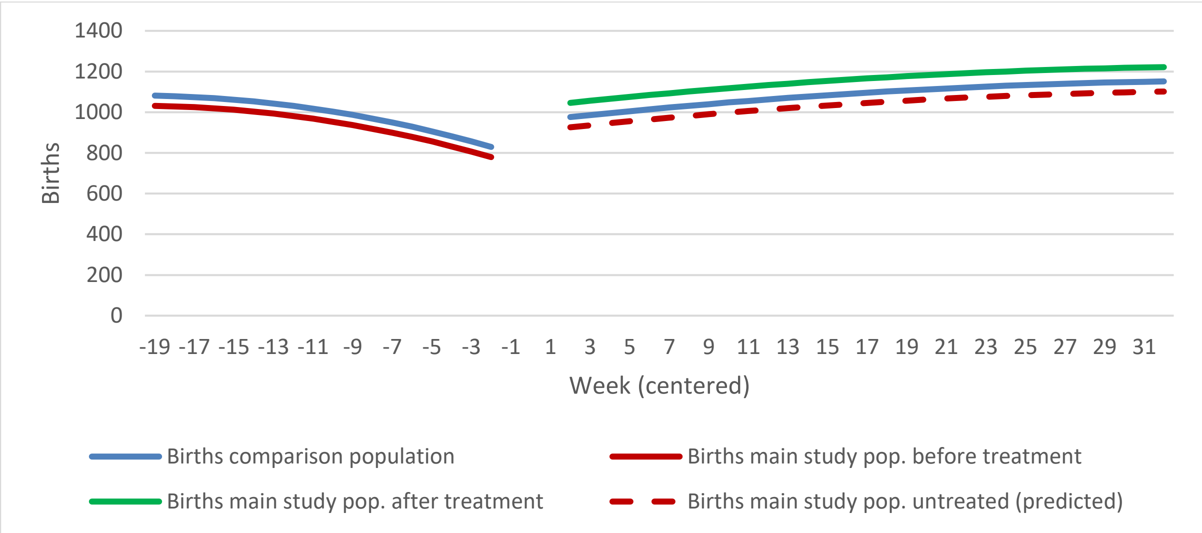
Table 1. Descriptive statistics for women (in % of person-weeks) and number of births in the comparison and study population

	Comparison population			Study population
	2017	2018	2019	2020
Age groups				
20-27 years	29.9	29.7	29.5	29.2
28-35 years	31.9	32.3	32.7	32.8
36-45 years	38.2	38.0	37.9	38.0
Parity				
Childless	49.1	49.8	50.7	51.4
1 child	16.1	15.9	15.6	15.3
2+ children	34.8	34.3	33.7	33.3
Educational attainment				
Compulsory	25.5	25.5	25.7	25.6
Secondary	29.9	29.2	28.6	28.4
University, short	32.7	32.9	33.0	33.0
University, long	11.9	12.3	12.7	13.0
Work situation				
Public administration	4.0	4.0	4.0	4.1
Health and teaching	32.3	32.6	32.8	33.1
Service sector	15.1	15.1	14.9	14.8
Industry	7.9	7.9	8.0	8.2
Other sectors	11.3	11.6	11.9	12.2
Not working (students, unemployed, etc.)	29.5	28.8	28.3	27.6
Number of births				
Births conceived before cut-off point	18,369	18,182	18,048	17,455
Births conceived after cut-off point	32,747	32,390	31,491	33,158
Total number of births	51,116	50,572	49,539	50,613
Total number of women	895,374	898,372	902,600	902,363
Number of observations (person-weeks)	43,873,326	44,020,228	44,227,400	44,215,787

As we are especially interested in whether the pandemic affects fertility differently for subgroups of women, age, parity, educational attainment, and work situation are linked to the dataset. *Age* (measured at the beginning of the year) is divided into three groups, 20–27 years, 28–35 years, and 36–45 years, which capture young mothers, the main ages of having children, and older mothers, respectively. *Parity* (measured on March 1 each year) is divided between childless, one-child, and two+-child mothers. *Educational attainment* (measured the year before) is divided between compulsory education, secondary education, short university education (BA), and long university education (MA, PhD). *Work situation* (measured at the beginning of the year) is divided into five groups: working in the health and education sectors, in public administration, in the service sector, in the industry sector, in other sectors (e.g., media and communication, and real estate), and not working (including unemployed, students, homemakers, and people on welfare benefits). Table 1 provides the summary statistics for the women included in the estimation and the actual number of births covered in our models.

The model specification for our analysis is motivated by Figure 1, which shows a stylized picture of our data. The blue line indicates the (average) number of weekly births for the comparison population. The shape of the line (not the level) represents the birth pattern we would expect for women in the main study population without the pandemic. The red solid line indicates the births for the main study population prior to the cutoff point, the red dotted line indicates the predicted births for this group without the pandemic (counterfactual predictions) while the green line indicates the actual births during the COVID-19 pandemic.

Figure 1. Weekly number of births conceived before and during the COVID-19 pandemic. Stylized picture of the data used in the models.



Note: Cutoff point is week 0.

We use linear regression models to estimate the probability of giving birth to a child in a week due to the pandemic. Since the dependent variable is binary, and the error term is not white noise, the models are estimated in Stata using OLS with robust standard errors. We estimate the following model:

$$Birth_{it} = a_0 + a_1Year_{it} + a_2Treatment_{it} + a_3Week_{it} + a_4Weeksq_{it} + a_5Mod_{it} + a_6Mod\_week_{it} + a_7Mod\_weeksq_{it} + X_{it}\beta + u_{it},$$

where t is time (week), i is woman, a_0–a_7 are parameters, β is a vector of parameters, and u_{it} is a stochastic error term. $Birth_{it}$ is a dummy variable that equals one if woman i gives birth to a child at week t, and zero otherwise. $Year_{it}$ is a dummy variable that equals one for all observations for the main study population and zero for the comparison population. The variable captures the general trend in births between the main study population and the comparison population (i.e., the vertical shift between the blue line and the two red lines in Figure 1). $Treatment_{it}$ is a dummy variable that equals one for all observations collected after the cutoff point, and zero otherwise. This is the main parameter of interest in this study, as it measures the effect of the pandemic in the models with no interaction terms (In Figure 1 this is vertical distance between the red dotted line and the green line). The variable X_{it} includes person-specific characteristics of the woman, that is, dummy variables for age, parity, educational attainment, and work situation. In some of the models, X_{it} also includes interaction terms between these variables and $Treatment_{it}$ to capture that the effect of the pandemic might differ with person characteristics. $Week_{it}$ is week number, where week is in the interval [–19,…. –1, 1,….32], and $Weeksq_{it}$ is week squared . By introducing $Weeksq_{it}$ in model specifications, we capture that the relationship between *Birth* and *Week* might be nonlinear. The parameters related to $Week_{it}$ and $Weeksq_{it}$ are identified from the data for the comparison population as well as the main study population prior to the cutoff point.

There is an overall significant shift in births around the turn of the year. That is, the number of births is substantially lower at the end of the year than at the beginning of the year (e.g., on average, 550 more children were born in January than in the previous month December in 2014–2018). To capture this shift, we include the variables Mod_{it} and Mod_week_{it} and Mod_weeksq_{it}. Mod_{it} is a dummy variable that equals 1 if $Week_{it} \geq 2$, and zero otherwise. The variable Mod_week_{it} is the number of weeks in excess of 2, that is, $Mod\_week_{it} = (Week_{it} - 2)$ if $Week_{it} \geq 2$, and zero otherwise. Mod_weeksq_{it} is a quadratic term of Mod_week_{it}, that is, $Mod\_weeksq_{it} = (Week_{it} - 2) \times (Week_{it} - 2)$ if $Week_{it} \geq 2$, and zero otherwise.

To facilitate the interpretation of our results, we applied simulations on our estimated models. This allows us to quantify the change in expected number of births due to the lockdown (i.e., births from mid-December 2020 until the end of July 2021). In the simulations, only women in the main study population are included, both in the simulations with and without the pandemic. We calculate the expected number of births within a specific week for a given woman from a prediction of the probability of having a child. This prediction is obtained from the regression function, where the effect of the pandemic is considered by including the effects of the *Treatment* variable and the interaction terms between *Treatment* and the dummy variables for the characteristics of the woman (when interaction terms are included). After having calculated the expected number of births for a specific week for a specific woman, births are summarized across all weeks and all women included in the calculations. From this, we calculate the percentual change in the number of expected births in a situation with no pandemic (the red dotted line in Figure 1) compared with a situation with the pandemic (the green solid line in Figure 1).

5. Results

5.1. Main findings

Table 2 shows the main estimation results for the birth equation presented above. We estimated two models. In model 1, we did not include the variables of women's characteristics, that is, age, parity, educational attainment, and work situation, while in model 2 these variables were included (but with no interaction effects).

The parameter related to *Treatment* shows the average effect of COVID-19 on the weekly probability for a woman giving birth to a child. The results show that this probability was higher during the pandemic than in the period prior to the pandemic, with the probability increasing by 0.0000796, or by 0.00796 percentage points. The estimated effect of the pandemic was the same in the two models; thus, controlling for the women's characteristics had no impact on the estimated effect of the pandemic. Because it may seem that such values are marginal, in the following, we present the results from the simulations on our estimated models to make them easier to interpret.

Table 2. Weekly probability of women giving birth to a child during the COVID-19 pandemic: Regression discontinuity model.

	Model 1			Model 2		
	Estimate[1]	*Std. Error*[1]	$P>\|t\|$	*Estimate*[1]	*Std. Error*[1]	$P>\|t\|$
Treatment	0.796	0.12	0.000	0.796	0.12	0.000
Age						
20-27 years (ref.)						
28-35 years				9.39	0.08	0.000
36-45 years				-4.17	0.08	0.000
Parity						
Childless (ref.)						
1 child				17.07	0.10	0.000
2+ children				-1.92	0.07	0.000
Educational attainment						
Compulsory				-1.19	0.07	0.000
Secondary				-3.04	0.06	0.000
University short (ref.)						
University long				4.32	0.09	0.000
Work situation						
Public administration						
Health and teaching				0.651	0.13	0.000
Service sector				-2.512	0.14	0.000
Industry				-0.0547	0.15	0.720
Other sectors				-0.811	0.14	0.000
Not working				-4.267	0.13	0.000
Intercept	8.86	0.17	0.000	7.519	0.21	0.000
Number of observations	176,336,741			176,336,741		
Number of women	1,033,155			1,033,155		

Note: In the model we control for the study population (*Year*), week number (*Week* and *Week sq*), and the turn of the year (*Mod*, *Mod_week* and *Mod_weeksq*) (see model specification, for further description).
[1]Estimates are multiplied with 10,000 to reduce the number of leading 0s.

Table 3 shows the percentage change in the predicted number of births due to the pandemic for all women and for different subgroups of women. The numbers for all women are based on the estimates presented in Table 2, while the numbers for the specified subgroups of women are based on estimates from the models with the respective interaction terms in Appendix Tables 1–4.

Table 3. Percent changes in the predicted number of births during the COVID-19 pandemic. Result from simulations based on the estimated models. [1]

	No of women	Predicted number of births		Relative change in the number of births. %
		Without the pandemic	With the pandemic	
All	902,363	30,930	33,158	**7.2**
Age				
20-27 years	263,307	5,673	5,858	3.3
28-35 years	296,169	18,821	20,655	**9.7**
36-45 years	342,887	6,436	6,645	3.2
Parity				
Childless	463,480	14,006	14,354	2.5
1 child	138,356	11,616	12,855	**10.7**
2+ children	300,527	5,308	5,949	**12.1**
Educational attainment				
Compulsory	175,362	5,086	5,109	**0.4**
Secondary	256,064	6,078	6,260	**3.0**
University short	297,792	11,471	12,627	**10.1**
University long	117,607	6,334	7,195	**13.6**
Work situation				
Public administration	36,905	1,492	1,649	**10.5**
Health and teaching	298,723	12,216	13,134	7.5
Service sector	133,430	3,795	3,779	**-0.4**
Industry	74,290	2,856	3,047	6.7
Other sectors	109,709	4,417	4,960	12.3
Not working	249,306	6,141	6,589	7.3

Note: The numbers for all women are based on the estimates presented in table 2, while the numbers for subgroups of women is based on estimates presented in appendix tables 1-4. Bold means that the interaction effect between treatment and the respectively dummy variable for age, parity, educational attainment, and work situation presented in the appendix table is statistically significant at 0.001 level.

[1] Corrected 15.06.2022

The pandemic led to an overall 7.2% increase in the predicted number of births according to our simulation results, which is in line with results from studies using data at the macro level for Norway (Aassve et al. 2021; Sobotka et al. 2021). If we look at the numbers for subgroups of women in Table 3, we observe some interesting differences. Regarding age, only among women aged 28–35 years do we find a statistically significant positive effect of the pandemic on fertility. For this group, the pandemic resulted in 9.7% higher predicted number of births. Women aged 28–35 years are in their prime years for childbearing compared with the younger and the older age groups. In Norway, age-specific birth rates have been highest among women aged 28–35 in recent years (Statistics Norway, 2022), which indicates that the fertility plans of younger or older women were less influenced by the pandemic.

Table 3 also highlights a noteworthy difference between childless women and women already having children. While the pandemic effect was not statistically significant among childless women, it was among mothers. For one-child mothers, the pandemic resulted in 10.7% higher predicted number of births according to our simulation results; for mothers with two or more children, it led to 11.7% higher predicted number of births. This means that the overall increase in fertility due to the pandemic was primarily driven by mothers having another child and not by women in transition to motherhood. Furthermore, the results of Table 3 show a positive effect of the pandemic on women's fertility for all educational groups, but that the level of the effect differs. The lowest increase in the predicted number of births related to the pandemic is observed among women without tertiary education; for women with only compulsory education, the increase was just 0.4% and for those with secondary education it was 3.0%. For women with higher education, the increase in the predicted number of births was highest for those with a long university education (13.6%) and slightly lower for those with a short university education (10.1%).

Lastly, with regard to women's work situation, our results provide little evidence that the pandemic has affected women's fertility differently depending on their labor market activity and the sector in which they were employed. One exception is among women working in public administration for whom we find a positive significant effect, with 10.5% higher predicted number of births due to the pandemic. In contrast, among women working in the service sector, there is a negative effect of the pandemic on fertility, although very small at just –0.4%.

5.2. Robustness checks

We carried out several robustness checks, and a summary is presented in Table 4. First, we checked the validity of the treatment variable. In the main model, we used the first national lockdown as a marker of the pandemic. To ensure that this was an adequate marker, we ran identical models as the main models without interaction variables, but for two different years before the pandemic (2019 and 2018) to see whether there were placebo effects. Indeed, we found such an effect (at the 10% significance level) for 2019 using 2017 and 2018 as the comparison population, but no effect for 2018 using 2017 as the comparison population. Running the same test for the models including the interaction variables between the treatment variable and respectively age, parity, educational attainment, and work situation (results not shown here), we found that some of the interaction variables for educational attainment and work situation were statistically significant for 2019, but not for 2018. As we only found the placebo effect for one year, we consider it as random and refrain from interpreting it.

Second, we tested whether the estimated effects were sensitive to the choice of time unit. We ran identical models as the main models on a 50% sample using days as the time unit. Using days gave an

enormous amount of data and the capacity (memory) of the server made it very difficult to run the models on samples larger than 50%. However, the conclusions remained the same (results not shown here) and we are therefore confident that weeks are an appropriate time unit for our analysis.
Third, we tested whether the estimated effects were sensitive to the number of weeks excluded around the cutoff point. We ran two identical models as the main models, but in the first we did not exclude any weeks, and in the second model, we excluded two weeks before and after the cutoff point. We found that the estimated effect of the pandemic was not affected by these modifications. We also applied these two modifications to the models including the interaction variables (results not shown here), and the results remained stable.

Fourth, we tested whether the estimated effects were sensitive to the length of the observation period. We ran identical models as the main models, but in one model we observed the women 25 weeks before and 25 weeks after the cutoff point, and in the other model we observed the women 10 weeks before and 41 weeks after the cutoff point. We found that the estimated effect of the pandemic on fertility remained stable, even if we applied the same modifications as the models including the interaction variables (results not shown here). Thus, we found no indication of the effect of the pandemic varying with the length of the follow-up period for our chosen time window.

Lastly, in our main models, the comparison population included 2017, 2018, and 2019 to ensure high robustness. To test whether the estimated effects were sensitive to the number of years included in the comparison population, we ran identical models as the main models, but where we only included 2019 in the comparison population. The results showed that the estimated effects remained the same, which also was the case when this change was implemented in the models with the interaction variables (results not shown here).

6. Discussion

Using a quasi-experimental design, this study addressed whether the COVID-19 pandemic affected the childbearing behavior of women in Norway. We used information from administrative register data covering the full population in Norway to explore whether the pandemic led to an overall change in fertility, and if women's fertility response to the pandemic differed by age, number of children, educational attainment, and work situation. The first national lockdown initiated due to the pandemic functioned as the treatment and marker of the pandemic and we compared women's fertility behavior before and after this date, that is, children conceived 1–19 weeks before and up to 32 weeks after the

lockdown and the birth of these children nine months later. The study design allows for causal interpretation of the effect of the pandemic on women's fertility behavior.
First, our results clearly showed that the pandemic had a positive effect on women's fertility. Overall, the pandemic resulted in a 7.2% increase in births. The main findings in international comparative studies is that there was a negative short-term effect of the pandemic on births in most countries while Norway stands out with positive short term effect on the fertility level (Aassve et al. 2021; Sobotka et al. 2021). We argued that the differences in how the pandemic affects the overall development of fertility rates are related to the economic consequences it has across different societies. That we have not seen a negative effect of the pandemic on women's fertility in Norway may stem from policy measures introduced to alleviate economic turmoil following a national lockdown. Nevertheless, this does not necessarily explain why we found a positive effect and an increase in fertility.

Second, our results showed that, with two exceptions, the pandemic has not affected women differently depending on their work situation. As noted, the direct consequences of the pandemic varied across sectors. Thus, we expected different fertility responses to the pandemic depending on the sector in which women were employed. As we only found minor differences between women working in different sectors, this indicates that the crisis management in Norway effectively weakened the negative consequences of the pandemic for women in most sectors. Interestingly, the two sectors that stood out with a significant effect of the pandemic on women's fertility were the service sector and the public administration sector. These two sectors can be placed on opposite ends of the spectrum with regard to general security and stability of job positions, as well as the direct impact of the lockdown related to the pandemic. The service sector is a large sector in which 15% of the women in our analysis worked (Table 1); it also has a young work force that includes many employees with temporary and part-time positions. In addition, the service sector was hit especially hard due to the restrictions following the lockdown, as many businesses had to close immediately and for an unknown period of time. We only found a negative effect of the pandemic on fertility among women working in this sector, although the effect was small. This is also a sector where the overall fertility is low compared with other sectors (Table 3), meaning that there would be fewer fertility intentions to postpone or to abandon compared with other sectors. As noted, it is likely that the generous governmental economic compensation, including increased payouts for those laid off, moderated the negative effects on women's fertility in this sector. In contrast, the sector that includes public administration jobs stands out as the only one where we saw a significant positive effect of the pandemic on women's fertility. This sector is part of the public sector with mainly secure job positions where no employees were laid off due to the pandemic. Public administration is also typically office work and women in this sector could easily adapt their work situation to the restrictions implemented after the lockdown by working from home. An explanation for the positive fertility effect for this group could be related to the argument that working from home might create a more balanced and less stressful situation, and that if people also felt economically secure, this could be seen as a favorable time to have children (Berrington et al. 2022).

Third, our results showed a positive effect of the pandemic on women's fertility among all educational groups, but the positive effect was strongest for women with tertiary education. Previous research for the Nordic countries has shown that women with low socioeconomic status comprise a higher proportion of childless women compared with those with higher socioeconomic status (Jalovaara et al. 2019). This raises questions about inequality in access to secure and stable jobs, and about who profits most from the existing social and family policies in the Norwegian welfare system (Lappegård 2020). If women with higher education are more likely to have secure and stable job positions, they could have benefited more from the policy measures taken to compensate for the economic and social consequences of the pandemic compared with women without tertiary education. Consequently, more women with higher education may have considered the pandemic as a favorable time to have children.

Finally, we observed an interesting conformity in our results regarding women's age and parity. Women aged 28–35 years, that is, the prime years for childbearing in Norway, contribute substantially to the positive effect of the pandemic on fertility. In parallel, the pandemic resulted in a significant increase of births among mothers, but not childless women. In Norway, there is a strong two-child norm (Lappegård and Kornstad 2020), where most women who have one child are highly likely to have a second child at some time. The positive effect of the pandemic on the childbearing behavior of mothers with two or more children is surprising, as there has long been an overall decline in higher parity fertility. Nevertheless, taken together, this age and parity pattern suggests that the group of women with a comparatively high likelihood for a birth in regular times are the main drivers behind the increase in fertility in Norway at the onset of the pandemic. An explanation for this could be that the social restrictions and being forced to spend more time at home prompted questions about children, especially among women of typical childbearing ages. For parents, the social restrictions may have led to a more balanced family life, which might have reinforced family-related values and prompted them to expand their family with another child during the pandemic. In other words, if people feel economically and socially secure, having children may still be considered favorable despite the pandemic, especially if they already hold latent fertility intentions.

In line with this argument, our results showed no significant increase in fertility among childless women or the younger and older age groups. This finding is also interesting in a longer perspective. Postponement of first births has been one of the main drivers behind the declining fertility level in Norway during the last decade, and it was expected that at a certain point some of these delayed births would be realized (Hellstrand et al., 2021). However, we did not observe such a catch-up effect for first births at the onset of the pandemic. The increase of age at first birth in 2021 (Statistics Norway 2022) indicates that the mechanisms influencing the postponement of motherhood have remained unchanged during the pandemic in Norway. While some mothers may have found it convenient to expand their families, women without the experience of having children seemed to be more reluctant to make this step into a new role as a mother under the specific circumstances of an ongoing pandemic.

Our study has several limitations. First, in our data we could not capture if women were laid off from their job after the lockdown or whether they suffered any other negative economic consequences due to the pandemic-related restrictions. There might be more differences in the effects of the pandemic that remain unseen due to the lack of more detailed information about women's situation. Second, we were not able to distinguish between women not working and whether they were unemployed, students, on welfare benefits, or homemakers. Thus, we were unable to capture potential differences in how these groups of women responded to the pandemic. Lastly, we only looked at women in this first study on individual responses in fertility to the pandemic. Inequality exists in the fertility behavior of women and men (Jalovaara et al. 2019) and their response to economic uncertainty (Kristensen 2019; Lappegård et al. 2022.). However, evaluation of such potential gender differences is beyond the scope of this article and should be addressed in future studies.

In conclusion, our study has demonstrated that the pandemic affected Norwegian women's fertility in an overall positive way, but we find substantial differences between groups of women. We argue that the increase in fertility was driven by women in life phases that have high fertility rates. At the same time, these groups were more likely to be in an economic and socially secure and stable situation where the restrictions due to the pandemic had limited influence on their life situation. Besides the significant increase in births among these specific groups, the childbearing behavior of other women was not negatively affected by the pandemic in Norway. This is related to the strong welfare state and the generous additional pandemic-related measures taken by the government, and the high trust in this system in the Norwegian population.

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Appendix

Appendix table 1. Weekly probability of women giving birth to a child during the COVID-19 pandemic: Regression discontinuity model including an interaction variable between treatment and age.

	Estimate[1]	*Std. Error*[1]	*P>|t|*
Treatment	0.227	0.139	0.102
Age			
20-27 years (ref.)			
28-35 years	9.11	0.08	0.000
36-45 years	-4.17	0.08	0.000
Treatment x age			
Treatment x 20-27 years (ref.)			
Treatment x 28-45 years	1.77	0.19	0.000
Treatment x 36-45 years	-0.0309	0.128	0.809
Intercept	7.607	0.212	0.000
Number of observations / Number of women	176,336,741	1,033,155	

Note: In the model we control parity, educational attainment, and work situation as well as for the study population (*Year*), week number (*Week* and *Weeksq*), and the turn of the year (*Mod*, *Mod_week* and *Mod_weeksq*) (see model specification, for further description).
[1]Estimates are multiplied with 10,000 to reduce the number of leading 0s

Appendix table 2. Weekly probability of women giving birth to a child during the COVID-19 pandemic: Regression discontinuity model including an interaction variable between treatment and parity

	Estimate[1]	*Std. Error*[1]	*P>|t|*
Treatment	0.244	0.132	0.066
Parity			
Childless (ref.)			
1 child	16.66	0.108	0.000
2+ children	-1.99	0.073	0.000
Treatment x parity			
Treatment x childless (ref.)			
Treatment x 1 child	2.65	0.29	0.000
Treatment x 2+ children	0.44	0.13	0.000
Intercept	7.61	0.21	0.000
Number of observations / Number of women	176,336,741	1,033,155	

Note: In the model we control parity, educational attainment, and work situation as well as for the study population (*Year*), week number (*Week* and *Weeksq*), and the turn of the year (*Mod*, *Mod_week* and *Mod_weeksq*) (see model specification, for further description).
[1]Estimates are multiplied with 10,000 to reduce the number of leading 0s

Appendix table 3. Weekly probability of women giving birth to a child during the COVID-19 pandemic: Regression discontinuity model including an interaction variable between treatment and educational attainment.

	Estimate[1]	*Std. Error*[1]	*P*>|*t*|
Treatment	1.252	0.161	0.000
Educational attainment			
Compulsory (incl. missing)	-0.995	0.071	0.000
Secondary	-2.883	0.063	0.000
University short (ref.)			
University long	4.133	0.099	0.000
Treatment x educational attainment			
Treatment x compulsory	-1.211	0.176	0.000
Treatment x secondary	-1.023	0.163	0.000
Treatment x University short (ref.)			
Treatment x University long	1.109	0.27	0.000
Intercept	7.446	0.212	0.000
Number of observations / Number of women	176,336,741	1,033,155	

Note: In the model we control parity, educational attainment, and work situation as well as for the study population (*Year*), week number (*Week* and *Week sq*), and the turn of the year (*Mod*, *Mod_week* and *Mod_weeksq*) (see model specification, for further description).
[1]Estimates are multiplied with 10,000 to reduce the number of leading 0s

Appendix table 4. Weekly probability of women giving birth to a child during the COVID-19 pandemic: Regression discontinuity model including an interaction variable between treatment and work situation.

	Estimate[1]	*Std. Error*[1]	*P*>|*t*|
Treatment	1.355	0.379	0.000
Work situation			
Health and teaching	0.711	0.141	0.000
Service sector	-2.292	0.149	0.000
Industry	0.0293	0.164	0.858
Other	-0.854	0.155	0.000
Not working	-4.144	0.142	0.000
Treatment x work situation			
Treatment x public administration (ref.)			
Treatment x health and teaching	-0.376	0.387	0.331
Treatment x service sector	-1.393	0.397	0.000
Treatment x industry	-0.527	0.443	0.234
Treatment x other	0.242	0.423	0.568
Treatment x not working	-0.775	0.381	0.042
Intercept	7.427	0.217	0.000
Number of observations / Number of women	176,336,741	1,033,155	

Note: In the model we control parity, educational attainment, and work situation as well as for the study population (*Year*), week number (*Week* and *Week sq*), and the turn of the year (*Mod*, *Mod_week* and *Mod_weeksq*) (see model specification, for further description).
[1]Estimates are multiplied with 10,000 to reduce the number of leading 0s