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Original Research

Effect of COVID-19 lockdown on maternity care and maternal outcome in the Netherlands: a national quasi-experimental study

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ABSTRACT

Objectives: The COVID-19 pandemic and associated lockdowns disrupted health care worldwide. High-income countries observed a decrease in preterm births during lockdowns, but maternal pregnancy–related outcomes were also likely affected. This study investigates the effect of the first COVID-19 lockdown (March–June 2020) on provision of maternity care and maternal pregnancy–related outcomes in the Netherlands.
Study design: National quasi-experimental study.
Methods: Multiple linked national registries were used, and all births from a gestational age of 24+0 weeks in 2010–2020 were included. In births starting in midwife-led primary care, we assessed the effect of lockdown on provision of care. In the general pregnant population, the impact on characteristics of labour and maternal morbidity was assessed. A difference-in-regression-discontinuity design was used to derive causal estimates for the year 2020.
Results: A total of 1,039,728 births were included. During the lockdown, births to women who started labour in midwife-led primary care (49%) more often ended at home (27% pre-lockdown, +10% [95% confidence interval: +7%, +13%]). A small decrease was seen in referrals towards obstetrician-led care during labour (46%, −3% [−5%,−0%]). In the overall group, no significant change was seen in induction of

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labour (27%, +1% [−1%, +3%]). We found no significant changes in the incidence of emergency caesarean section (9%, −1% [−2%, +0%]), obstetric anal sphincter injury (2%, +0% [−0%, +1%]), episiotomy (21%, −0% [−2%, +1%]), or post-partum haemorrhage: >1000 ml (6%, −0% [−1%, +1%]).
Conclusions: During the first COVID-19 lockdown in the Netherlands, a substantial increase in homebirths was seen. There was no evidence for changed available maternal outcomes, suggesting that a maternity care system with a strong midwife-led primary care system may flexibly and safely adapt to external disruptions.

Introduction

The COVID-19 pandemic had a significant impact on healthcare systems globally, including on maternity care. There has been substantial interest in investigating the impact of the pandemic and associated lockdown measures on neonatal outcome, especially the reduction in preterm birth rates that was seen in many high-income countries.[1–3,4] Mitigation measures during the pandemic also resulted in significant changes in the provision of maternity care, including fewer face-to-face consultations, restrictions on the presence of companions during labour, and a reduction in available (hospital) capacity.[5] Observational evidence from several high-income countries was conflicting, but generally showed no increase in maternal morbidity, a small increase in assisted or operative deliveries, and a slight decrease in rates of induction of labour during the initial lockdown.[6–10]

Maternal health is a crucial component of public health: ensuring positive birth experiences, with the least-negative long-term consequences, has a positive effect on women's health and the health of their offspring. Importantly, respectful maternity care is considered a human right:[11] throughout the pandemic, the World Health Organization reinforced that ‘all pregnant and post-partum women […] have the right to high-quality care before, during, and after childbirth …’.[12] Concerns were raised regarding the impact of the pandemic and associated lockdown measures on maternal health care, also in various European countries.[13,14] It is therefore important to evaluate how the pandemic affected maternal pregnancy–related outcome and the provision of maternity care to inform responses to future major disruptive events, including pandemics.

The Netherlands has a well-established system of risk selection, where women with low-risk pregnancies receive midwife-led primary care by default.[15,16] Homebirths are relatively common in the Netherlands (13% of all women in 2019),[17] and an earlier non-quasi-experimental study across a majority of Dutch primary care midwifery practices showed an increase in homebirths and a decrease in episiotomies during the first COVID-19 lockdown.[18] However, no robust quasi-experimental or national study has been performed to confirm this shift in location of birth, and how it may have affected a range of maternal pregnancy–related outcomes in the Netherlands. Insight into how major disruptions such as that caused by the COVID-19 pandemic impact a maternity care system with a focus on primary care is important as it may inform policy to minimise such impact during future disruptive events.

The current study therefore aimed to investigate the impact of the first COVID-19 lockdown (March to June 2020) on the following: 1) the provision of maternity care, 2) characteristics of labour, and 3) maternal pregnancy–related outcomes in the Netherlands. The primary aim was to compare these outcomes in a general all-risk population. Secondarily, we also explored how these effects were affected by subgroups according to specific obstetrical risk factors and geographical area in the Netherlands.

Methods

We evaluated the effect of lockdown on maternal pregnancy–related outcomes in national perinatal registry data using the quasi-experimental difference-in-regression-discontinuity approach.[19–21] The design and analysis of this study was registered in the AsPredicted platform prior to undertaking data analysis (https://aspredicted.org/63T_K49). The manuscript was written in concordance with Strengthening the Reporting of Observational Studies in Epidemiology reporting guidelines.[22]

Data source

We used the data network infrastructure ‘Data-InfrAstructure for ParEnts and ChildRen’ (DIAPER), managed by the National Institute for Public Health and the Environment (RIVM).[23] Within DIAPER, the national Perinatal Registry (Perined) is linked at individual level to health-insurance-claims data (from Vektis, a healthcare data company) and socio-demographic data from Statistics Netherlands (CBS). Perined includes linked data from primary midwife-led care (‘Landelijke Verloskundige Registratie 1’), obstetrician-led care (‘Landelijke Verloskundige Registratie 2’), and neonatal care (‘Landelijke Neonatologie Registratie’).

In the national perinatal registry, there is no information on whether women were tested positive for COVID-19. This is not expected to affect our findings since we focus our analysis on the start of the first wave of the pandemic, when COVID-19 infection rates were still low.

Maternity care in the Netherlands

The Netherlands has a distinctive maternity system, with a focus on primary midwife-led care. This system is based on risk stratification of pregnancies. At the beginning of pregnancy, pregnancies of women are stratified into high- and low-riskcategories, based on current and past medical risk factors.[16] In the absence of risk factors before and during pregnancy, women give birth with their primary care midwife, either at home, in a primary care birth centre, or in a hospital. Throughout the course of pregnancy and labour, the emergence of risk factors such as hypertension, foetal growth restriction, or gestational diabetes may necessitate referral to secondary care. The aim of continuous risk stratification is to ensure that women receive the appropriate level of care throughout pregnancy.

Case selection

To understand the effect that lockdown may have had on pregnancy-related outcomes, we defined a broad and all-risk population of viable pregnancies. To achieve this, we excluded births prior to 24 weeks of gestational age; this gestational age represents the cut-off from which active neonatal support is offered in the Netherlands.[24] All remaining births, either in midwife-led care or obstetrician-led care were included, including multiple births (with each child represented as one birth). The analysis is performed at the level of individual born children.

Data definitions

Peripartum maternal pregnancy–related outcomes were selected based on their availability in the datasets and their potential for immediate change upon the initiation of lockdown measures. We considered three groups of outcomes. First, we evaluated outcomes that relate to the provision of maternity care by evaluating the rates of the following: labour that started in midwife-led primary care, home birth, intrapartum referral, and the use of (epidural) analgesia. Since the rates of home birth and intrapartum referral are only relevant for women who start labour in midwife-led primary care and reach a gestational age of 37 or higher, we restricted the analyses for these outcomes to this subgroup of women. Second, the characteristics of labour were assessed. This includes both the start of labour, through rates of induced labour, and elective caesarean section, as well as the actual mode of birth among those intending at the start of delivery to accomplish vaginal births (excluding elective caesarean sections): these births may end in a spontaneous vaginal birth, an assisted vaginal birth, or an emergency caesarean section. Third, maternal morbidity was assessed by evaluating rates of perineal damage and post-partum haemorrhage. Perineal damage was assessed in vaginal births by evaluating the use of episiotomy (in any direction) and the incidence of obstetric anal sphincter injury (OASI, grade 3 or 4 perineal ruptures). Post-partum haemorrhage was defined as the loss of more than 1000 ml blood in 24 h, as per the Dutch guideline.[17]

Characteristics used to describe cases and for sub-group analyses were as follows: maternal age at birth, parity, migration background, and household income. Migration background was defined by the country where the parents were born. Migration backgrounds were categorised into common groups in the Netherlands (Morocco, Surinam, Dutch Antilles, and Indonesia), Western countries (including the Northern Americas, Europe, and Australia), and other non-Western countries. Household income was the income of the highest earning member within the household. This variable was categorized into low (first quintile), medium (second to fourth quintile), and high income (fifth quintile).

Analysis plan

We used a difference-in-regression-discontinuity analysis. This approach evaluates the difference in trends of an outcome around a specific cut-off point of an assignment variable, which in our case is time (i.e. date of birth) before or during lockdown. Assignment of the births happening in a small window on each side of the cut-off can be assumed to be 'as good as random', which we can therefore exploit as a quasi-experiment. The local effect at the cut-off can be assumed to be causal if the difference-in-discontinuity assumptions are satisfied. There are two main assumptions:[21,25,26] first, we assume that the date of birth cannot be manipulated in any way due to the lockdown. Since pregnancies were conceived well before women knew about the lockdown, this assumption holds: the due date could not have been manipulated by the lockdown. Second, we assume that there were no other relevant policies or interventions potentially affecting the outcomes around the cut-off date. We argue that because the lockdown took up all attention of the healthcare workforce, it is unlikely that any other interventions were installed during the same period, and we are unaware of any. We performed graphical analysis to explore whether an intervention effect around the cut-off date was likely. Finally, we used a *difference*-in-discontinuity approach to address the issue that any change in the incidence of an outcome around the cut-off might be due to a recurring seasonal pattern. This adaptation of the regression discontinuity design includes information of births that occurred during the same period in previous years, as formalised by Grembi et al.[21] This method includes the week and year of birth as fixed effects in the model. Furthermore, covariates that are known to be correlated with outcome were included (age, parity, income, gestational age, and starting labour under primary or secondary care) to improve efficiency of the estimators.

The exposure of interest is the first COVID-19 lockdown in the Netherlands because the disruptions in care were unprecedented and a wide range of measures were taken, compared to an adjusted set of measures in the later lockdowns.[18,19] Moreover, COVID-19 infection rates were still low, thereby limiting the effect of COVID-19 infection itself on maternal pregnancy–related outcomes at the population level.[27] The Dutch government installed the first nationwide COVID-19 measures on 9 March 2020.[19] Additionally, in a previous study from our group, we undertook sensitivity analyses for different cut-off dates and found that 9 March was the clearest cut-off date.[19] Therefore, we used 9 March 2020 as the cut-off date to define which births occurred before or during the lockdown.

The optimal time window before and after the cut-off date is unknown: there is a trade-off between optimising sample size (larger time windows) and minimising bias (smaller time windows, which closely align with the trend break of interest). Therefore, we performed three separate analyses, where births that occurred 8, 12, and 16 weeks before and after 9 March 2020 were used in the analyses, respectively, approximating 2, 3, and 4 months. If the estimates from the sensitivity analyses were similar, we would favour the largest time interval because of higher statistical power. However, if a clear trend towards or from the null was seen in the estimates from the sensitivity analyses, we would favour the smaller interval to minimise bias. The analysis with a 4-month period before and after the cut-off date requires data from births in the year prior to the cut-off date. We could therefore not use birth year 2010 because data from 2009 were not available. Therefore, we used data from 2 to 4 months prior and after 9 March 2011 up till 2020 in the analysis, resulting in the analysis of 10 consecutive years of births in the Netherlands.

The largest subset of data, four months before and after 9 March 2020, as well as equivalent periods in previous years, was described to give an overview of the Dutch pregnant population. Statistics appropriate for distribution and data type were used, and the percentage missing data per variable was reported.

Date of birth is the primary assignment variable of our main analyses. Out of privacy reasons, we did not gain access to date of birth for the vast majority of births. For missing cases, we indirectly calculated the date of birth using the estimated due date and the gestational age at birth, which were both available. Consecutively, multiple imputations with chained equations was used to handle other missing data. Only data with a less than 10% missing observations per variable were included (an arbitrary threshold, defined in the preregistration).[28,29] As part of this approach, five imputed datasets were created. In variables where the percentage of missing data exceeded the threshold, the variable was omitted from the analysis. The patient characteristics and outcomes were included in the imputation model as predictors. If missingness was not related to variables that are known to be correlated with outcome (age, parity, income, gestational age, starting labour under primary or secondary care), only births with registered outcome data were included to fit the model for the respective outcome under investigation, as in the published protocol. If the occurrence of missing values was related to those variables, we used the full imputed dataset to prevent selection bias.

Risk differences can be interpreted more intuitively than odds ratios. Therefore, we predicted for a hypothetical 'average' observation (with characteristics such as mean age, most common foetal sex, etc.) the probability of the outcome just before and after 9 March, 2020. The difference in these predictions and 95% confidence interval (CI) was calculated using standard frequentist statistics.

We also performed subgroup and sensitivity analyses as prespecified in AsPredicted (https://aspredicted.org/63T_K49), using a stratification approach. Because the secondary analyses result in a large number of hypothesis tests, we applied a false discovery rate of 5% to correct *P*-values and reported these in the supplemental material. When potentially relevant differences emerged in subgroups, we conducted a likelihood ratio test to assess the statistical significance of the subgroup differences, comparing models that included interaction terms with those that did not.

All analyses were performed in R (R Core Team (2022). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Version 4.2.3).

Role of the funding source

The funders of the study were not involved in the study design, data collection, data analysis, interpretation, or the writing of the manuscript.

Results

From the 2,045,837 registered births between 2010 and 2020 in the Netherlands, 1,039,728 were selected for our study (32/52 weeks of 10 consecutive years, which were 2011–2020). Most births were excluded because they fell outside the time window of interest (1,006,109 births, 49%), and 18,037 (0.9%) were excluded because they took place below 24 weeks' gestational age. Within this selection, all pregnancies in Perined could be linked to the other datasets.

In the years 2011–2020, mean maternal age at birth was 31.3 (standard deviation [SD]: 4.8) years, mean gestational age at birth was 39.4 (SD: 2.0) weeks, 44% women were nulliparous, and 13% of multiparous women had a previous Caesarean section (Table 1). While 23% of births were intended to occur at home before labour started, 14% actually took place at home. For women whose births start in midwife-led primary care, these percentages were 32% and 27%, respectively. Fourteen percent of women started their pregnancy in obstetrician-led care, 36% of births had been referred during pregnancy, and an additional 23% of births were referred during labour. Epidural analgesia was used in 19% of all births. The most common mode of birth was vaginal birth (74%), followed by Caesarean section (17%, either elective or emergency), and assisted vaginal (9%). Missing data were <10% for all relevant characteristics, except for the intended place of birth: this variable was missing in 24% of births and in 17% in the births that started in midwife-led primary care. Because this variable can offer additional information about actual place of birth, we deviated from our protocol and included this outcome in the main analysis (Table 2, supplementary material). Also, missingness in outcome variables was related to important confounding variables (Table 2, supplemental material). Therefore, excluding patients with missing observations would likely introduce selection bias. Therefore, we used the full-imputed datasets in our main analysis.

Around 9 March 2020, visual inspection showed a clear break in trends for several of the defined outcomes (Fig. 1), suggesting an intervention effect around the cut-off. This confirms the validity of our main analysis. Although precision of the main analysis was highest when using a period of four months around 9 March, the estimates were more conservative for the two-month period and therefore less likely to be biased. Therefore, we used the two-month time period for the remainder of our analyses (Fig. 2, Supplementary material).

Provision of maternity care changed substantially in the lockdown. More births that started in midwife-led primary care ended at home (proportion in the two months before lockdown: 27%; change during lockdown: +10% [95% CI: +7%, +13%]), and fewer births ended in birth centres or under supervision of a primary care midwife in hospitals (29%, −6% [−9%, −3%], Table 2). Births started in midwife-led primary care in similar

Table 1
Baseline characteristics of the study population born in the year 2010 up to 2020 and proportion of missing data.

	Overall (n = 1,039,728)	Missing (%)
Maternal age (years) (mean [SD])	31.3 (4.8)	0.0
Gestational age (weeks) (mean [SD])	39.4 (2.0)	0.3
Parity (%)		0.1
0	459,712 (44.3)	
1	375,667 (36.2)	
2	139,787 (13.5)	
3+	63,669 (6.1)	
Previous caesarean section in multiparous women (%)	77,862 (13.4)	0.0
Number of foetuses, current gestation (%)		0.0
1	1,007,027 (96.9)	
2	31,935 (3.1)	
3+	766 (0.1)	
Fetal/neonatal sex female (%)	505,993 (48.7)	0.1
Position (%)		1.9
Vertex	966,202 (94.7)	
Breech	42,159 (4.1)	
Other	11,385 (1.1)	
Hypertensive disorders (%)	24,246 (2.3)	0.0
Maternal ethnic background (%)		1.2
White Dutch	714,186 (69.5)	
Moroccan	44,833 (4.4)	
Turkish	36,842 (3.6)	
Surinamese	26,848 (2.6)	
Dutch Caribbean	13,425 (1.3)	
Other non-Western countries	82,796 (8.1)	
Other western countries	108,374 (10.5)	
Urbanisation (%)		1.6
Very rural	121,923 (11.9)	
Rural	179,810 (17.6)	
Moderately urban/intermediate	198,428 (19.4)	
Strongly urban	261,487 (25.6)	
Very strongly urban	260,997 (25.5)	
Income quintile (%), from 1 (low) to 5 (highest)		4.2
1	158,439 (15.9)	
2	126,260 (12.7)	
3	185,528 (18.6)	
4	247,655 (24.8)	
5	279,007 (28.0)	
Province (%)		3.0
Drenthe	25,229 (2.5)	
Flevoland	28,758 (2.8)	
Friesland	36,869 (3.6)	
Gelderland	118,739 (11.6)	
Groningen	31,670 (3.1)	
Limburg	52,117 (5.1)	
Noord-Brabant	140,237 (13.7)	
Noord-Holland	175,807 (17.2)	
Overijssel	70,569 (6.9)	
Utrecht	89,399 (8.7)	
Zeeland	18,641 (1.8)	
Zuid-Holland	234,169 (22.9)	

Abbreviation: SD = standard deviation.

Table 2
Main results of the outcomes for the 2-month-interval analysis.

Outcome	Group	Total *N* with observed outcome	*N* with outcome	Probability before lockdown	Difference in lockdown (95% CI)	OR in lockdown (95% CI)
Intended homebirths	Start in primary care	253,614	81,228	0.27	+0.04 (0.01–0.06)	1.17 (1.03–1.33)
Homebirths	Start in primary care	248,773	70,871	0.27	+0.10 (0.07–0.13)	1.54 (1.37–1.74)
Intended birth in primary care—not homebirth	Start in primary care	248,526	25,832	0.12	−0.01 (−0.03 to 0.00)	0.85 (0.71–1.01)
Birth in primary care—not homebirth	Start in primary care	248,778	67,336	0.29	−0.06 (−0.09 to −0.03)	0.74 (0.65–0.83)
Intended hospital birth	Start in primary care	248,526	142,031	0.60	−0.02 (−0.05 to 0.01)	0.93 (0.82–1.04)
Hospital birth	Start in primary care	248,773	110,555	0.44	−0.03 (−0.06 to −0.00)	0.88 (0.79–0.98)
Responsible begin birth primary care	All	525,045	257,851	0.48	−0.01 (−0.03 to 0.01)	0.97 (0.90–1.04)
Intrapartum referral	Start in primary care	248,778	113,278	0.46	−0.03 (−0.05 to 0.00)	0.90 (0.80–1.00)
Epidural	All	525,230	100,680	0.23	−0.01 (−0.03 to 0.00)	0.92 (0.84–1.00)
Epidural	Start in primary care	253,948	33,696	0.17	−0.03 (−0.05 to −0.01)	0.81 (0.70–0.94)
Mode start of labour	All					
IOL		523,956	126,090	0.27	+0.01 (−0.01 to 0.03)	1.05 (0.97–1.14)
pSC		523,956	43,430	0.09	+0.00 (−0.01 to 0.02)	1.02 (0.90–1.17)
Mode of birth, vs vaginal	All					
Assisted vaginal		467,700	42,788	0.08	−0.00 (−0.01 to 0.00)	0.93 (0.80–1.07)
Caesarean		467,700	43,559	0.09	−0.01 (−0.02 to 0.00)	0.92 (0.81–1.05)
Perineal damage, vs no damage	All					
3rd/4th degree		413,802	8861	0.02	+0.00 (−0.00 to 0.01)	1.16 (0.86–1.55)
Episiotomy		413,802	106,207	0.21	−0.00 (−0.02 to 0.01)	0.97 (0.87–1.07)
Major PPH	All	525,230	32,172	0.06	−0.00 (−0.01 to 0.01)	0.97 (0.83–1.13)

Abbreviations: CI = confidence interval; OR = odds ratio; PPH = post-partum haemorrhage; IOL = induction of labour; pCS = primary caesarean section.

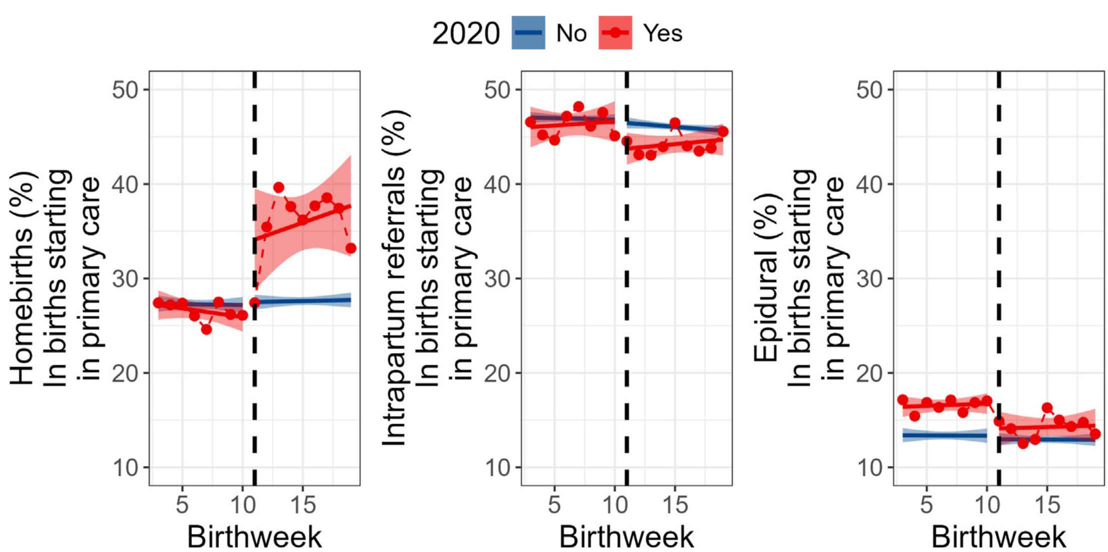

Fig. 1. The time trends of the changes in provision of care in women starting birth in primary care during the months before and after 9 March 2020 are shown in red, as proportion of births per week. The previous years (2010–2019) are shown as comparison in blue, and the observations are overlain with the mean trend before and after 9 March. For the purpose of this figure, the trend is estimated by a simple linear regression model. For all outcomes, see Fig. 1 Supplemental material. (For interpretation of the references to colour in this figure legend, the reader is referred to the Web version of this article.)

proportions as before (44%, −1%; 95 %CI: −3%, +1% within lockdown), but there were fewer intrapartum referrals (46%, −3% [−5%, −0%]). A common reason for referral is pain relief.[30] The use of epidural analgesia decreased in women that started labour in midwife-led primary care (17%, −3% [−5%, −1%]). This reduction was comparable to the overall reduction in intrapartum referrals.

Characteristics of labour did not change substantially in the lockdown. Although the rate of induction of labour showed an increasing trend during previous years (Fig. 1); no significant additional increase above this underlying trend was seen during the lockdown (27%, +1% [−1%, +3%], Table 2). The elective caesarean section rate also did not change (9% in the general population, +0% [−1%, +2%]). There was no significant difference in rate of assisted vaginal births (8%, −0% [−1%, +0%]) or emergency caesarean sections (9%, −1% [−2%, +0%]) among those that intend to accomplish a vaginal births (Table 2).

Observed maternal morbidity was similar in the lockdown period compared to that in the pre-lockdown period: no statistically significant changes in rates of OASI (2%, +0% [−0%, +1%]), episiotomies (21%, −0% [−2%, +1%]), or major post-partum haemorrhages were seen (6%, −0% [−1%, +1%]) in the general pregnant population (Table 2).

In sub-group analyses evaluating the provision of maternity care, we found that among women with high household income, homebirth rates increased somewhat more in the lockdown than

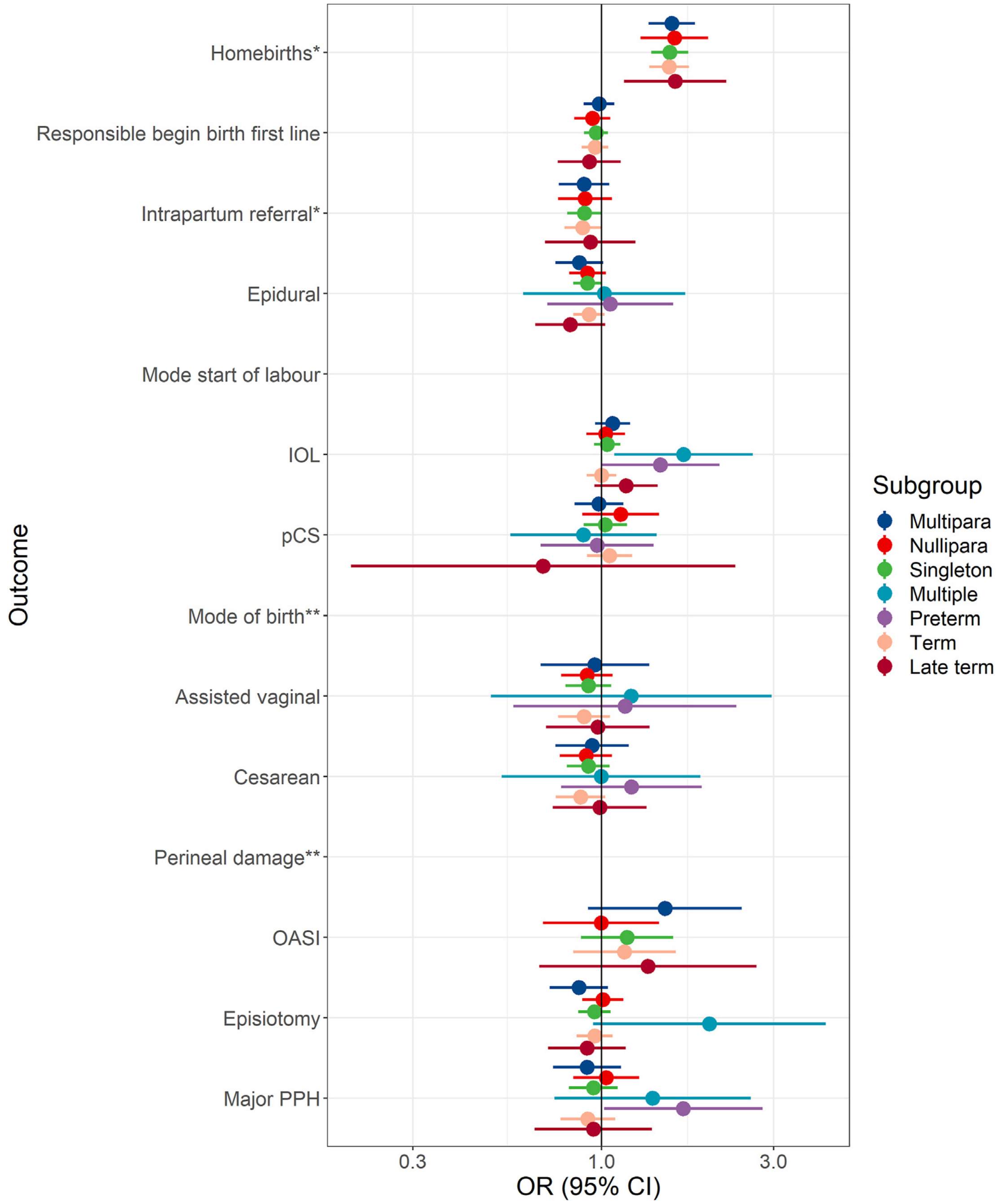

Fig. 2. A forest plot showing the effect estimates for sub-group analyses of the regression discontinuity analysis. The 2-month-interval analysis is shown. An odds ratio of above one indicates an increase in the lockdown period, and an odds ratio of below one indicates a decrease in the lockdown period. Multiple sub-group analyses are shown. *Only for births that started in midwife-led care; **only for births that were intended vaginal births. IOL: induction of labour; pCS: primary caesarean section = elective caesarean section; PPH: post-partum haemorrhage. Late term is defined as gestational age at birth above 41 weeks. The 'intended' location refers to the location where women had planned to give birth.

in women with low household income (+8% [+4%, +11%] vs +6% (+1%, +12%), respectively; *P*-value for interaction: <.001). Location of birth did not change differentially across other investigated sub-groups (Fig. 2). There were some geographical differences: the increase in homebirths was largest in the northern region of the Netherlands (Fig. 3). The reduction in rates of epidural analgesia was largest in the south of the Netherlands (Fig. 3).

In sub-group analyses evaluating the characteristics of labour, we found that induction of labour increased in the sub-groups of women with preterm births and multiple gestations, although the 95% confidence interval included the null for women with preterm births (16%, +6% [−0%, +12%], and 36%, +13 [+1%, +25%], respectively; Fig. 2 and Table 3 supplementary material). We formulated a post-hoc hypothesis that this increase in induction of labour could have been due to an increase in hypertensive disorders during lockdown. Therefore, we constructed a sensitivity analysis, where we excluded women with hypertensive disorders from the analysis, which showed comparable results for induction of labour (+5% [−0%, +11%] for preterm births and +13% [+1%, +25%] for multiple gestations).

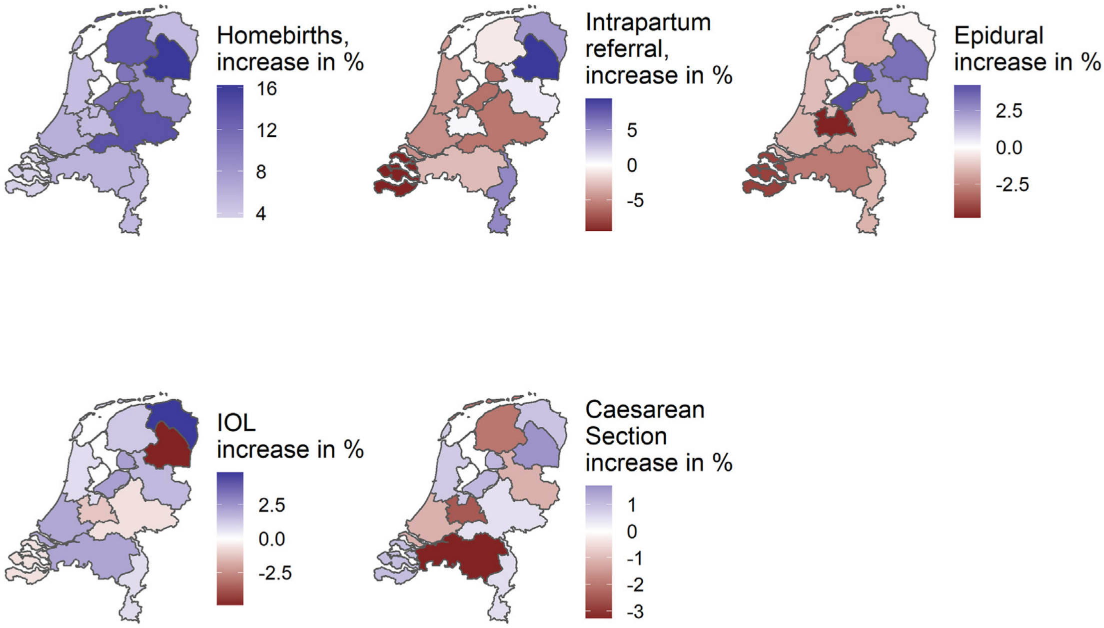

Fig. 3. Maps of the Netherlands are shown that display the effect estimates for the distribution in care, location of birth, pain relief during labour, and mode of start of birth per province. The 2-month-interval analysis is shown. IOL: induction of labour.

Discussion

This nationwide analysis of the first COVID-19 lockdown in the Netherlands provides insights into changes that occurred in maternity care, focussing on a maternal perspective. The most striking finding was a substantial increase in homebirths during the lockdown. This was associated with two shifts: primarily, we observed a shift within midwife-led primary care from births ending in primary care birth centres or in the hospital under supervision of a primary care midwife towards the home setting. Secondarily, there was a small decrease in women being referred to obstetrician-led care during labour, which seems to be explained by fewer requests for pain relief. We did not observe a significant change in induction of labour overall, suggesting that women who required induction of labour due to medical reasons were still referred to secondary care. Some subgroups analyses even suggested an increase in induction of labour, but these should be interpreted with caution. There were no statistically significant changes in mode of birth, or maternal morbidities for which data were available in the general pregnant population during the same period.

The shift of location of birth within midwife-led primary care that we observed is in concordance with trends in other high-income countries, albeit that the change in the Netherlands is much more pronounced.[18] The United Kingdom (UK) has a similar maternity care system as the Netherlands, but with a much lower homebirth rate of 2.1% in 2019.[31] Although the strategy in the UK was to try and contain the risk of COVID-19 within hospitals instead of in the community,[32,33] the homebirth rate in the entire year 2020 was still 0.3 percentage points higher than in the previous year.[31] The United States actually showed an increase in out-of-hospital births from 1.7% to 2.0% during the lockdown period, which is a relatively large increase compared to previous years.[34] In Ontario, Canada homebirth rates increased from 13% to 17% during the first lockdown.[35] The exact reasons why more women gave birth at home are unclear. The choice for location of birth is dependent on attitude, risk perception, and expectations of both caregivers and pregnant women towards homebirth, as well as the socio-cultural context.[36–40] Some studies suggest that women tended to avoid the hospital possibly to minimise the risk of contracting the virus, or due to the COVID-19 restrictions, which in some settings limited the presence of chosen support during hospital birth.[18] Nevertheless, women with primarily low-risk pregnancies reported no change in anxiety or depression[41] and even a decrease in fear of childbirth.[42] Also, women with low-risk pregnancies in the Netherlands and the UK rated their birth experience more positively than before the pandemic, appreciating ‘the willingness of staff to go above and beyond’.[43]

Importantly, in the Dutch setting, we did not observe a change in obstetric interventions, major post-partum haemorrhages, or OASI parallel to the increase in homebirths. Also, another study from our group shows that there is also no clear evidence for a change in adverse neonatal outcomes other than the previously identified reduction in preterm births.[44] The potential increase in post-partum haemorrhages in preterm births cannot be attributed to the increase in home births because these relate to different populations. In the UK, a small increase in obstetric interventions (including caesarean sections) was observed, which researchers attributed to the temporary closure of midwife-led care birth settings.[9] Our findings concur with that line of reasoning: in the Netherlands, births in midwife-led care birth settings actually increased, whereas rates of obstetric interventions remained largely unchanged.[18] However, in Canada and the United States, registry studies show small increases in the rate of caesarean births, whereas homebirth rates also increased during that period.[7,34,35,45] Our study shows that the Netherlands is an exception since we found no evidence for an increase in obstetric interventions such as caesarean sections. The most notable difference between healthcare responses was a larger increase in homebirths than in the other countries (absolute increases of 3% and .33% in Canada and the US, respectively), but we cannot exclude other (hospital-related) factors.

There are multiple observational studies showing lower rates of obstetric interventions and maternal morbidities for (intended) homebirths vs (intended) hospital births in women with low-risk pregnancies,[46–48] but randomised controlled evidence for this comparison will likely remain inconclusive.[49] To our knowledge, this is the first quasi-experimental study shedding some light on this scientific debate. With lower risk of confounding bias, but with similar risk of measurement bias, our study suggests that a sudden shift towards homebirth for women with low-risk pregnancies is not offset by an important increase in adverse maternal outcomes, at least not those that we were able to assess.

Limitations

This study had limitations common to studies with registry data. These include data-quality issues such as missing data and potential misclassification bias. The first was handled using multiple imputation, a common way of dealing with missing data.[28,29] When undertaking multiple imputation, we assumed that the data were missing due to a 'missing-at-random' mechanism, and thus the missing values can be estimated by observed other data.[29] Therefore, we included many relevant variables in the imputation model. Contrary to what was prespecified in the published analysis plan, we also included an outcome with over 10% missing values (i.e. intended place of birth). The rationale was that this provides more insight into choice of care. It is unlikely that this impacted the analyses for other outcomes, mostly because this variable was not included in the models that estimate the effect of lockdown on these outcomes. Misclassification bias also might have occurred in variables due to the error-prone definition and bottom-up collection of data from midwifery practices and hospitals. For example, augmentation of labour is not separately recorded from induction of labour. Therefore, when membranes rupture prematurely and later oxytocin is started when an intrauterine infection is suspected, this could either have been registered as a spontaneous birth with spontaneous rupture of membranes or as an induction of labour. We cannot distinguish between the two mechanisms. Also, registration quality might differ in different birth settings. The low incidence of hypertensive disorders likely indicates a degree of under-reporting of data.[50] Another source for misclassification bias is the inclusion of multiple gestations in the analysis due to the neonatal-level analysis they are counted double.

Finally, our study was limited by the availability of outcome data. We cannot report on changes in other important pregnancy-related outcomes, such as patient-reported outcome measures and patient-reported experience measures.[51] We therefore have to relate our results to other observational studies.[41–43]

The main strength of our study lies in the robust study design, which facilitates causal interpretation of our findings. Also, the nationwide registry provided us with sufficient power to arrive at precise estimates of the effect of lockdown on maternal pregnancy-related outcomes. Our study therefore provides a thorough overview of the impact of the first COVID-19 lockdown on maternal pregnancy–related outcome in the Netherlands and is to our knowledge, the first quasi-experimental study into the association between homebirths and outcome.

Further research should focus on women's perspectives on the accessibility and quality of care to better understand how to prioritise health care during similar crises. Moreover, based on the available data in the current database, we were unable to explore the reasons behind the increased induction of labour rate in preterm births and multiple gestations. Based on post-hoc analyses, this increase was not likely due to an increase in hypertensive disorders. This warrants further research with more detailed data concerning the start of labour.

Conclusions

During the first COVID-19 lockdown in the Netherlands, there was a clear increase in homebirths, mainly due to a shift within midwife-led primary care, as well as a slight reduction in referrals to obstetrician-led care. This increase was not associated with concurrent statistically significant changes in maternal pregnancy–related morbidity available in our routinely collected data or in mode of birth. Rates of induction of labour did not decrease, and adverse neonatal outcomes did not increase,[44] suggesting that access to secondary care for medically indicated inductions remained adequate.

Altogether, our results suggest that a maternity care system with a focus on midwife-led primary care can flexibly and safely adapt to external disruptions.

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Ethical approval

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Competing interests

None declared.

Contributions

The conceptualisation of the analysis method was the responsibility of BG, LB, LBO, AR, and JB, but all authors agreed on the proposed methodology, particularly regarding the exposure and outcome definitions, and the planned sub-group analyses. LBO, PK, and JB were involved with data merging and curation. The formal analysis, visualisation, and the writing of the original draft were done by BG, in close collaboration with NB, JB, and CdG. NB validated the code used in the analysis. The interpretation of the results and the revision and editing of the full manuscript was performed collaboratively by all authors. LB, LBO, AR, JB, SO, and CdG were involved in the project administration and funding acquisition.

Data-sharing agreement

Although privacy regulations prevent the sharing of underlying individual-level data, we will share the data export for number of observed outcomes per week on request. Researchers who are interested in the primary underlying data can contact RIVM to discuss access to the DIAPER data infrastructure (https://www.rivm.nl/monitoren-zwangerschap-en-geboorte/diaper)

Use of copyright protected material

No copyright-protected material was used in this manuscript.

Appendix A. Supplementary data

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