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Impact of COVID-19 on pregnancy-related healthcare utilisation: a prospective nationwide registry study

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ABSTRACT

Objective To assess the impact of COVID-19 on pregnancy-related healthcare utilisation and differences across social groups.

Design Nationwide longitudinal prospective registry-based study.

Setting Norway.

Participants Female residents aged 15–50 years (n=1 244 560).

Main outcome measures Pregnancy-related inpatient, outpatient and primary care healthcare utilisation before the COVID-19 pandemic (prepandemic: 1 January to 11 March 2020), during the initial lockdown (first wave: 12 March to 3 April 2020), during the summer months of low restrictions (summer period: 4 April to 31 August 2020) and during the second wave to the end of the year (second wave: 1 September to 31 December 2020). Rates were compared with the same time periods in 2019.

Results There were 130 924 inpatient specialist care admissions, 266 015 outpatient specialist care consultations and 2 309 047 primary care consultations with pregnancy-related diagnostic codes during 2019 and 2020. After adjusting for time trends and cofactors, inpatient admissions were reduced by 9% (adjusted incidence rate ratio (aIRR)=0.91, 95% CI 0.87 to 0.95), outpatient consultations by 17% (aIRR=0.83, 95% CI 0.71 to 0.86) and primary care consultations by 10% (aIRR=0.90, 95% CI 0.89 to 0.91) during the first wave. Inpatient care remained 3%–4% below prepandemic levels throughout 2020. Reductions according to education, income and immigrant background were also observed. Notably, women born in Asia, Africa or Latin America had a greater reduction in inpatient (aIRR=0.87, 95% CI 0.77 to 0.97) and outpatient (aIRR 0.90, 95% CI 0.86 to 0.95) care during the first wave, compared with Norwegian-born women. We also observed that women with low education had a greater reduction in inpatient care during summer period (aIRR=0.88, 95% CI 0.83 to 0.92), compared with women with high educational attainment.

Conclusion Following the introduction of COVID-19 mitigation measures in Norway in March 2020, there were substantial reductions in pregnancy-related healthcare utilisation, especially during the initial lockdown and among women with an immigrant background.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ Use of prospective national population-based registries covering all pregnancy-related healthcare utilisation of the entire Norwegian population for 2019 and 2020.
⇒ The data were derived from high-quality compulsory registries and linked at the individual level.
⇒ Although women who emigrated were excluded, unofficial population movement outside of Norway, such as normal travel, was not captured in the data sources; this may have impacted the validity of our findings if pregnant women with an immigrant background used medical care while visiting their country of birth to a greater extent than the year before the COVID-19 pandemic.

INTRODUCTION

Studies have shown that, in Norway and several other countries, COVID-related restrictions led to an interference in the delivery of primary and specialist (also referred to as secondary) healthcare for several conditions.[1] However, it is currently unknown if pregnancy-related care was affected, and whether pregnant women avoided attending healthcare following the start of the pandemic, possibly due to fear of infection, restrictions in travel or not wanting to be an extra burden to healthcare. Furthermore, we do not know if and how such COVID-related restrictions have affected the use of services for women in vulnerable groups.

From 12 March to 3 April 2020, the Norwegian government introduced several strict policies to restrict social contact and limit the spread of the SARS-CoV-2, such as the closures of borders and schools, and restrictions on social gatherings.[2 3] These mitigation measures were relatively consistent with certain European countries such as Denmark and Germany, but not as stringent as in countries like Italy, Spain and France. Hospitals limited non-emergency consultations to prepare for an influx of patients with COVID-19.[1] Primary care migrated services to electronic consultations when possible. On 4 April, restrictions were relaxed, and the SARS-CoV-2 infection rate remained low through the summer of 2020.[4] Infection rates increased again at the end of summer starting from August to October/November in a so-called ‘second wave’ and restrictions were again implemented, although during this period restrictions were coordinated at the local level and aligned according to local infection rates.

Norway has a tax-funded universal healthcare system, which aims to deliver equal and adequate healthcare for the entire population, regardless of income, educational attainment, occupation or immigrant background. However, the utilisation of healthcare services is not always equal among all socioeconomic groups.[5] Women with lower socioeconomic status may also be at a higher baseline risk of poorer pregnancy-related outcomes, such as hypertensive disorders of pregnancy, preterm birth, etc.[6] It is currently unknown whether the COVID-19 pandemic exacerbated existing inequalities in the uptake of pregnancy-related healthcare services.

We aimed to investigate if the initial lockdown and further restrictions throughout 2020 in Norway impacted pregnancy-related care both in primary and specialist settings compared with the same periods in previous year. We also investigated whether any change in use of pregnancy-related care during the pandemic differed according to socioeconomic position and immigrant background.

METHODS

Design and data sources

We conducted a nationwide longitudinal prospective registry-based study in Norway using the national emergency preparedness register established to provide knowledge for handling the COVID-19 pandemic (Beredt C19).[7] Beredt C19 contains individual-level data from several national registries, covering the entire Norwegian population of 5.4 million residents, and linked using the unique personal identifier given to all Norwegian residents at birth or on immigration. The Beredt C19 data used for this study originated from the Norwegian Patient Registry (NPR) (all inpatient and outpatient admissions from all hospitals in Norway), the Norwegian Registry for Primary Health Care (all consultations with all general practitioners and emergency primary healthcare),[8] the National Population Register (age, sex, country of birth, date of death) and Statistics Norway (educational attainment, household income, country of birth). These registries are considered of high quality.[8]

Population

The study sample consisted of all women aged 15–50 years from the general population of Norway with a personal identification number in the Norwegian population register between 1 January 2019 and 31 December 2020 (n=1 244 560). Women who had not been assigned a personal identification number (eg, tourists, short-term stays, migrants without legal residence) or who immigrated to Norway after 1 January 2019 were not included. Persons who emigrated during the study period were excluded (n=53 306).

Outcomes

We studied utilisation of all-cause pregnancy-related primary and specialist (also referred to as secondary/tertiary) care services by constructing three binary outcome variables: (1) inpatient-based admission lasting at least 1 day, (2) hospital-based outpatient consultations, and (3) primary care consultations (ie, general practitioners or emergency wards) in the primary care database. Pregnancy-related specialist care contacts were defined as any registration with the International Classification of Diseases 10th Edition (ICD-10) codes O00–O99 for the chapter ‘Pregnancy, childbirth and the puerperium’, and supplementary codes Z33 (pregnant state, incidental), Z34 (supervision of normal pregnancy), Z35 (supervision of high-risk pregnancy), Z36 (antenatal screening), Z37 (outcome of delivery) and Z39 (postpartum care and examination). Pregnancy-related primary care was defined as any registration with International Classification of Primary Care 2 codes in Chapter W (pregnancy, childbearing, family planning). Consultations included postpartum care. We included all episodes in which a pregnancy-related diagnosis was used (either as the primary or secondary reason for the admission/consultation). We counted only one registration per woman per calendar day for each given outcome.

Study setting

In Norway, pregnancy health services are offered by the national public healthcare system and are free of charge to all residents irrespective of employment status or immigrant background. According to Norwegian law, all women have the right to decide to have an abortion through the 12th week of pregnancy. The guidelines for prenatal care include nine pregnancy consultations with a midwife or physician, although more may be offered if required. The consultations include assessment of lifestyle and physical and mental health, fetal diagnostics and ultrasounds, blood pressure measurements, blood and urine samples, a symphysis-fundus measurement, assessment of fetal heartbeat and movements, oral glucose tolerance tests and assessment of the location of the fetus. Education regarding assistance in the preparation for pregnancy and childbirth, maternity leave, breast feeding and recommendations on infant nutrition are also included during the consultations. Further samples and tests, or referral to specialist care, may also be deemed necessary by the midwife or doctor. Women who do not speak fluent Norwegian have the right to an interpreter during the consultations. Women will give birth either at a midwifery-led unit, hospital maternity ward, specialist clinic or, although rarely (less than 0.5% of all births),[9] at home—depending on the mother’s choice, health and the availability in the woman’s geographic area. Midwives are responsible for assisting during delivery for all uncomplicated births, whereas doctors with special training in obstetrics will take over the care during the delivery if any problems arise.

Statistical analyses

We compared daily consultations/admissions of the outcomes before lockdown (prepandemic: 1 January 2020 to 11 March 2020), during lockdown (first wave: 12 March 2020 to 3 April 2020) after lockdown during the summer months of low restrictions/infections (summer period: 4 April 2020 to 31 August 2020) and the autumn months during the 'second wave' until the end of restrictions (second wave: 1 September 2020 to 31 December 2020). From the daily number of events for each period, we calculated the daily incidence rates (IR), defined as the total number of pregnancy-related primary, inpatient or outpatient specialist care events for the period of interest (prepandemic: 70 days; first wave: 22 days; summer period: 149 days; second wave: 121 days), divided by the number of days for each period and the total number of women aged 15–50 years from the Norwegian population, or relevant subgroup, as per 1 January 2020, and given as estimates per 100 000 women. The IRs were calculated separately for each of the defined periods during 2020 and 2019. Rates in 2020 and 2019 were compared by calculating the incidence rate ratios (IRRs) by Poisson regression models. We also calculated the adjusted IRR and CIs by adding the other cofactors to the model (ie, age groups, country/region of birth, educational attainment and household income). To account for annual service drops during Easter holidays, in which the dates change from year to year, we included a dummy variable in the Poisson regression analyses, in which 1 was used for all events that occurred during the Easter vacation period and 0 otherwise. To account for seasonal trends of other factors than the COVID-related restrictions, we additionally calculated IRR and CIs calibrating prepandemic period to 1.0 and multiplying all the following IRRs for the other time periods by this difference. Thus, if the prepandemic IRR was 0.96 we multiplied the IRRs at first wave, summer period and second wave by (1.00/0.96) 1.04 for that series. The calibration factor was calculated separately for each subgroup.

We also evaluated whether any changes in the pregnancy-related healthcare use during the pandemic varied according to country/region of birth ('Norway', 'European Union (EU), European Economic Area (EEA), US, Canada, Australia and New Zealand (NZ)', 'Asia, Africa, Latin America'); educational attainment ('Low education' (total years of education: 0–10), 'Middle education' (11, 12, 13 years), 'High education' (14 years or more)); and household income (quintiles of the entire population, excluding women with negative household incomes). Women missing data regarding educational attainment or income were excluded in the subgroup analyses. We further tested for interaction according to these background characteristics by including product terms in the Poisson regression model. We also investigated if pregnancy-related specialist healthcare services affected acute or planned/elective services equally as recorded in the NPR.

Stata/MP V.16 for Windows was used for all statistical analyses (Software: Release 16, College Station, Texas, USA).

Patient and public involvement

This study consists of national compulsory registry data collected at the government level for all Norwegian residents. There was no patient or public involvement in the study planning or application process, neither during the analysis nor dissemination of results.

RESULTS

There were 64 049 inpatient specialist care admissions in 2020 compared with 66 875 admissions in 2019; 134 024 outpatient specialist care consultations in 2020 compared with 131 991 consultations in 2019; and 1 181 081 primary care consultations in 2020 compared with 1 127 966 consultations in 2019—registered with diagnostic codes related to pregnancy. Personal characteristics of the cohort are described in table 1.

All-cause pregnancy-related care and subgroup analyses

IRs, IRRs and CIs for overall and subgroups displaying differences in pregnancy-related services during the first wave, the summer period and the second wave during 2020 compared with 2019 are displayed in figure 1 for inpatient care, figure 2 for outpatient care and figure 3 for primary care. After adjusting for all cofactors and prepandemic differences, there was a 9%, 17% and 6% reduction in the IRR of pregnancy-related inpatient, outpatient and primary care services, respectively. Although inpatient, outpatient and primary care services rebounded following the initial lockdown, IRRs remained 3%, 6% and 5% below prepandemic rates during the summer period, respectively. During the second wave, outpatient and primary care services returned to similar prepandemic rates, whereas inpatient care services remained reduced by 4%.

Women born in Asia, Africa and Latin America had a 13% greater reduction in the IRR inpatient care and 10% greater reduction in IRR primary care services during the first wave, compared with women born in Norway. A 5% greater reduction was also observed during the summer period and the second wave for outpatient care, and 10% and 5% greater reduction for primary care services for the first wave and second wave for primary care—when comparing women born in Asia, Africa and Latin America to women born in Norway. A 6% and 7% greater reduction in IRR inpatient care was also observed for women born in the EU/EEA, USA, Canada, Australia and NZ compared with Norway during the summer period and the second wave, respectively, but not for any other care services (figures 1–3).

Table 1 Personal characteristics of the cohort

	Women with at least one pregnancy-related consultation in 2019 or 2020 (n=129 990)	Women with no pregnancy-related consultations in 2019 or 2020 (n=1 114 570)
	n (%)	n (%)
Person-years	259 980	2 229 140
Age, years (mean±SD)	30.76±5.14	33.14±10.71
Country of birth		
Norway	91 626 (70.49)	858 496 (77.02)
EU/EEA, USA, Canada, Australia, NZ	21 082 (10.81)	103 394 (9.28)
Asia, Africa, Latin America	24 312 (18.70)	152 680 (13.70)
Educational attainment		
Low (less than 10 years)	21 078 (16.22)	245 231 (22.00)
Middle (11–13 years)	27 186 (20.91)	313 222 (28.10)
High (14 years or more)	70 960 (54.59)	462 940 (41.54)
Unknown	10 766 (8.28)	93 177 (8.36)
Household income		
Quintile 1 (lowest)	35 899 (27.62)	351 285 (31.52)
Quintile 2	53 488 (41.15)	3 033 499 (29.92)
Quintile 3	37 078 (28.52)	398 425 (35.75)
Unknown	3525 (2.71)	31 361 (2.81)

EEA, European Economic Area; EU, European Union; NZ, New Zealand.

Women with the lowest level of education had a 12% greater reduction in inpatient care during the summer period compared with persons with the highest level of education. Women with an upper secondary education had a 9% greater reduction during the first wave compared with women with a higher degree. Conversely, women with the lowest level of education had a 6% and 3% increased likelihood of an outpatient and primary care consultation, respectively, during the second wave compared with women with a higher degree (figures 1–3).

Women in the lowest household income quintile had a 4% and 6% greater reduction in primary care services during the summer period and the second wave, respectively. No other differences were observed between household income quintiles (figures 1–3).

Cause-specific pregnancy-related healthcare

IRs, IRRs and 95% CIs for cause-specific pregnancy-related care across each period are depicted in figure 4. No significant changes in deliveries (ICD-10: Z37) were observed from 2020 compared with 2019. Pregnancy consultations with registrations of abortive outcome (ICD-10: O00–O08) were reduced by 15% initially after lockdown and continued to be lower (8%) during the summer period before returning to prepandemic rates. Oedema, proteinuria and hypertensive disorders in pregnancy, childbirth and the puerperium (ICD-10: I10–O16) were reduced by 13% during the summer period and by 10% during the second wave. Of note, due to the absolute numbers of consultations, the finding was a 22% reduction in the IRR of other maternal disorders related to pregnancy (ICD-10: O20–O29) during the first wave before returning to prepandemic levels. Significant reductions were observed across all other pregnancy-related diagnoses and especially during the first wave, except for complications of labour and delivery (O60–O75). Very similar reductions were observed for both acute and elective care, which were reduced during the first wave by 10% and 2% during the summer period before returning to prepandemic rates by the second wave (figure 4).

Twenty-eight-day IRR comparing 2020 rates to previous years

After adjusting for prepandemic time trends, the crude 28-day IRR for pregnancy-related healthcare utilisation in all women aged 15–50 years in 2020, as compared with the same period in 2019, was reduced during the initial lockdown period for both primary care consultations and specialist care services (figure 5). All services rebounded in the following months to pre-2020 levels, before being slightly reduced again in August and September during the second wave of the pandemic. Following this second wave, rates again increased to prepandemic levels. In the last time period (17–31 December) inpatient admissions were reduced substantially, whereas both outpatient and primary care consultations increased to above prepandemic levels (figure 5).

Specialist care (inpatient)

Group/ Time-period	Sub-group	Daily IR events per 100,000 (2020/2019)	Crude IRR (95% CI)	Adjusted for confounding and pre-pandemic IRR (95% CI)
Overall				
Pre-pandemic		16.04/16.22	0.99 (0.96, 1.02)	1.00 (reference)
First wave		15.41/17.17	0.90 (0.86, 0.94)	0.91 (0.87, 0.95)
Summer through		15.91/16.57	0.96 (0.95, 0.98)	0.97 (0.96, 0.99)
Second wave		14.32/15.07	0.95 (0.93, 0.97)	0.96 (0.94, 0.98)
Country/region of birth				
Pre-pandemic	Norway (reference)	14.66/15.04	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	18.62/18.37	1.04 (0.96, 1.13)	1.00 (reference)
	Asia, Africa, Latin America	22.22/21.58	1.06 (0.99, 1.12)	1.00 (reference)
First wave	Norway (reference)	14.51/15.85	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	16.55/18.93	0.95 (0.83, 1.10)	0.92 (0.80, 1.07)
	Asia, Africa, Latin America	20.01/23.79	0.92 (82, 1.03)	0.87 (0.77, 0.97)
Summer period	Norway (reference)	14.93/15.39	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	17.52/18.55	0.97 (0.92, 1.03)	0.94 (0.88, 0.99)
	Asia, Africa, Latin America	20.58/22.05	0.96 (0.92, 1.01)	0.92 (0.87, 0.95)
Second wave	Norway (reference)	13.07/13.51	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	16.59/17.68	0.97 (0.91, 1.03)	0.93 (0.88, 0.99)
	Asia, Africa, Latin America	20.00/22.10	0.94 (0.89, 0.98)	0.89 (0.84, 0.93)
Educational attainment				
Pre-pandemic	Low	11.94/12.41	0.96 (0.90, 1.03)	1.00 (reference)
	Middle	12.23/13.16	0.93 (0.87, 0.99)	1.00 (reference)
	High (Reference)	20.57/20.59	1.00 (reference)	1.00 (reference)
First wave	Low	11.06/12.97	0.90 (0.79, 1.02)	0.94 (0.82, 1.06)
	Middle	10.98/13.71	0.84 (0.75, 0.94)	0.90 (0.81, 1.02)
	High (Reference)	20.77/21.83	1.00 (reference)	1.00 (reference)
Summer period	Low	10.34/12.41	0.85 (0.81, 0.89)	0.88 (0.83, 0.92)
	Middle	11.79/12.57	0.95 (0.91, 0.99)	1.02 (0.98, 1.06)
	High (Reference)	21.40/21.55	1.00 (reference)	1.00 (reference)
Second wave	Low	10.87/11.58	0.99 (0.94, 1.05)	1.03 (0.98, 1.09)
	Middle	10.48/11.27	0.99 (0.94, 1.04)	1.06 (1.01, 1.12)
	High (Reference)	18.20/19.31	1.00 (reference)	1.00 (reference)
Household income				
Pre-pandemic	Quintile 1 (lowest)	13.61/12.17	1.24 (1.16, 1.32)	1.00 (reference)
	Quintile 2	22.23/24.33	1.01 (0.95, 1.07)	1.00 (reference)
	Quintile 3 (reference)	12.70/13.90	1.00 (reference)	1.00 (reference)
First wave	Quintile 1 (lowest)	13.61/12.17	1.15 (1.03, 1.30)	0.93 (0.83, 1.05)
	Quintile 2	22.23/24.33	0.91 (0.82, 1.01)	0.90 (0.81, 1.00)
	Quintile 3 (reference)	12.70/13.90	1.00 (reference)	1.00 (reference)
Summer period	Quintile 1 (lowest)	13.64/13.33	1.24 (1.19, 1.30)	1.00 (0.96, 1.05)
	Quintile 2	20.35/25.43	1.04 (1.00, 1.08)	1.02 (0.98, 1.06)
	Quintile 3 (reference)	12.72/14.43	1.00 (reference)	1.00 (reference)
Second wave	Quintile 1 (lowest)	21.39/23.60	1.20 (1.14, 1.27)	0.97 (0.92, 1.02)
	Quintile 2	21.39/23.60	1.04 (0.99, 1.10)	1.03 (0.98, 1.08)
	Quintile 3 (reference)	12.69/14.52	1.00 (reference)	1.00 (reference)

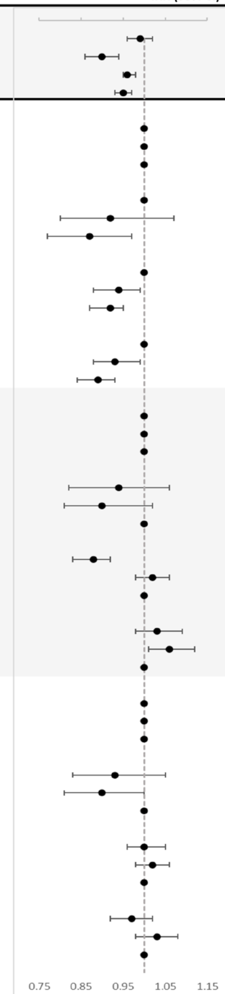

Figure 1 Incidence rates and incidence rate ratios of inpatient admissions prior to the lockdown (prepandemic: 1 January to 11 March), during the initial lockdown (first wave: 12 March to 3 April), summer period with light restrictions (summer period: 4 April to 31 August) and second period of increasing case numbers and increasing local restrictions (second wave: 1 September to 31 December) in 2020, compared with admissions from the same time periods from 2019 by subgroups. Educational attainment: low=less than 10 years compulsory education; middle=12–13 years senior school education; high=more than 13 years tertiary education. SEs were clustered by person to account for multiple events. Incidence rates reflect the number of daily events over 100 000 women aged 15–50 years for 2020 compared with 2019. Women aged 15–50 years from the general population of Norway (2020) served as the denominator. Adjusted model controlled for age in years and all other factors in the table and prepandemic estimates. Prepandemic differences were adjusted for by dividing 1.0 by the IRR at the prepandemic period and then multiplying all IRR values by this value (ie, 1.00/IRR prepandemic*IRR first wave, summer period, second wave). Aus, Australia; Can, Canada; EEA, European Economic Area; EU, European Union; IR, incidence rate; IRR, incidence rate ratio; NZ, New Zealand.

DISCUSSION

Main findings

In this registry-based study from Norway, we found evidence of a substantial decline in the utilisation of primary and specialist care services for pregnancy-related care during the initial lockdown on 12 March 2020. There was a greater reduction observed in pregnancy-related specialist and primary care for women born in Asia, Africa and Latin America, compared with women born in Norway, and among women in the lowest household income quintile compared with women in the highest household quintile. Differences between educational groups were less clear, with some evidence of a greater reduction in pregnancy-related care in women with low education compared with women with high education in inpatient care during the summer period, and outpatient care during the first wave, although with increased rates in this group during the second wave. Reductions were also observed across most pregnancy-related medical diagnoses and for both acute and elective care.

Specialist care (outpatient)

Period	Sub-groups	Daily IR events per 100,000 2020/2019	Crude IRR (CI)	Adjusted for confounding and pre-pandemic IRR (CI)
Overall				
Pre-pandemic		33.74/32.29	1.05 (1.03, 1.06)	1.00 (reference)
First wave		30.34/34.82	0.87 (0.85, 0.90)	**0.83 (0.81, 0.86)**
Summer through		29.84/30.21	0.99 (0.98, 1.00)	**0.94 (0.92, 0.96)**
Second wave		31.63/29.86	1.06 (1.05, 1.07)	1.01 (0.98, 1.03)
Country/region of birth				
Pre-pandemic	Norway (reference)	31.21/29.99	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	34.61/33.90	0.98 (0.93, 1.03)	1.00 (reference)
	Asia, Africa, Latin America	47.80/44.33	1.04 (0.99, 1.08)	1.00 (reference)
First wave	Norway (reference)	28.01/32.25	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	32.35/34.55	1.08 (0.97, 1.20)	1.09 (0.98, 1.21)
	Asia, Africa, Latin America	42.41/49.83	0.98 (0.91, 1.06)	0.94 (0.88, 1.02)
Summer period	Norway (reference)	27.70/27.91	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	30.51/31.51	0.98 (0.94, 1.02)	0.99 (0.95, 1.03)
	Asia, Africa, Latin America	41.50/42.11	0.99 (0.96, 1.02)	**0.95 (0.93, 0.99)**
Second wave	Norway (reference)	29.04/27.34	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	33.85/31.62	1.01 (0.96, 1.05)	1.03 (0.98, 1.07)
	Asia, Africa, Latin America	44.78/42.89	0.98 (0.95, 1.02)	**0.95 (0.92, 0.98)**
Educational attainment				
Pre-pandemic	Low	28.14/27.69	0.96 (0.92, 1.00)	1.00 (reference)
	Middle	26.79/26.75	0.94 (0.91, 0.99)	1.00 (reference)
	High (Reference)	41.93/39.52	1.00 (reference)	1.00 (reference)
First wave	Low	24.61/29.12	0.93 (0.86, 1.00)	0.97 (0.90, 1.05)
	Middle	23.22/29.51	0.87 (0.80, 0.94)	**0.91 (0.85, 0.99)**
	High (Reference)	38.72/42.56	1.00 (reference)	1.00 (reference)
Summer period	Low	25.17/25.82	0.98 (0.95, 1.01)	1.02 (0.99, 1.05)
	Middle	23.04/24.22	0.96 (0.93, 0.99)	1.01 (0.99, 1.04)
	High (Reference)	37.17/37.32	1.00 (reference)	1.00 (reference)
Second wave	Low	27.41/25.69	1.01 (0.98, 1.05)	**1.06 (1.02, 1.09)**
	Middle	24.34/24.11	0.96 (0.93, 0.99)	1.02 (0.99, 1.05)
	High (Reference)	38.39/36.41	1.00 (reference)	1.00 (reference)
Household income				
Pre-pandemic	Quintile 1 (lowest)	30.73/26.39	1.23 (1.17, 1.28)	1.00 (reference)
	Quintile 2	46.52/47.09	1.04 (1.00, 1.08)	1.00 (reference)
	Quintile 3 (reference)	25.54/26.88	1.00 (reference)	1.00 (reference)
First wave	Quintile 1 (lowest)	28.78/28.66	1.27 (1.17, 1.38)	1.05 (0.96, 1.14)
	Quintile 2	41.25/51.21	1.02 (0.95, 1.10)	0.98 (0.91, 1.06)
	Quintile 3 (reference)	22.33/28.30	1.00 (reference)	1.00 (reference)
Summer period	Quintile 1 (lowest)	28.76/26.01	1.23 (1.19, 1.27)	0.99 (0.96, 1.02)
	Quintile 2	39.88/42.30	1.05 (1.02, 1.08)	1.00 (0.96, 1.03)
	Quintile 3 (reference)	22.04/24.55	1.00 (reference)	1.00 (reference)
Second wave	Quintile 1 (lowest)	31.61/27.68	1.19 (1.15, 1.23)	0.97 (0.93, 1.00)
	Quintile 2	42.16/40.85	1.07 (1.04, 1.11)	0.99 (0.98, 1.06)
	Quintile 3 (reference)	21.97/22.85	1.00 (reference)	1.00 (reference)

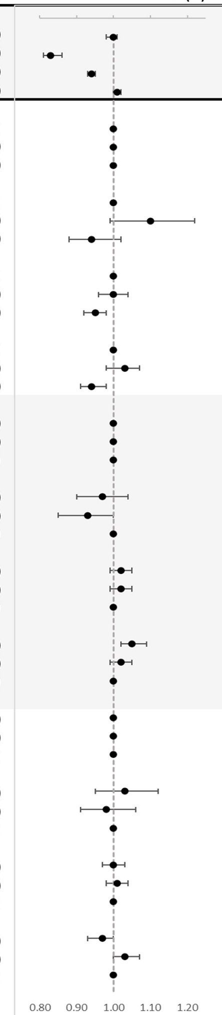

Figure 2 Incidence rates and incidence rate ratios of outpatient consultations prior to the lockdown (prepandemic: 1 January to 11 March), during the initial lockdown (first wave: 12 March to 3 April), summer period with light restrictions (summer period: 4 April to 31 August) and second period of increasing case numbers and increasing local restrictions (second wave: 1 September to 31 December) in 2020, compared with admissions from the same time periods from 2019 by subgroups. Educational attainment: low=less than 10 years compulsory education; middle=12–13 years senior school education; high=more than 13 years tertiary education. SEs were clustered by person to account for multiple events. Incidence rates reflect the number of daily events over 100 000 women aged 15–50 years for 2020 compared with 2019. Women aged 15–50 years from the general population of Norway (2020) served as the denominator. Adjusted model controlled for age in years and all other factors in the table and prepandemic estimates. Prepandemic differences were adjusted for by dividing 1.0 by the IRR at the prepandemic period and then multiplying all IRR values by this value (ie, 1.00/IRR prepandemic*IRR first wave, summer period, second wave). Aus, Australia; Can, Canada; EEA, European Economic Area; EU, European Union; IR, incidence rate; IRR, incidence rate ratio; NZ, New Zealand.

Strengths and weaknesses of the study

The major strengths of our study included the prospective national population-based coverage of all pregnancy-related healthcare utilisations of the entire Norwegian population. This included both primary and specialist care. This limited potential selection bias which typically influences results from smaller hospital studies with limited coverage. The data were derived from high-quality national compulsory registries with comprehensive coverage.[10] Specifically, we used all contacts in public primary and specialist healthcare services in Norway. The registries have also been shown to have high levels of quality and validity in several studies.[8 11] Therefore, the impact of information bias, such as recall bias, was negligent. The individual-level data allowed for adjusted and subgroup analyses.

Seasonal trends in factors other than COVID-related restrictions may account for changes observed when comparing 2020 to the previous year, introducing noise to our models. Such changes include a trend towards

Primary care

Period	Sub-groups	Daily IR events per 100,000 2020/2019	Crude IRR (CI)	Adjusted for confounding and pre-pandemic IRR (CI)
Overall				
Pre-pandemic		212.22/199.09	1.07 (1.06, 1.08)	1.00 (reference)
First wave		236.69/246.34	0.96 (0.95, 0.97)	0.90 (0.89, 0.91)
Summer through		165.33/162.37	1.02 (1.01, 1.02)	0.95 (0.94, 0.95)
Second wave		185.51/175.34	1.06 (1.05, 1.07)	0.99 (0.98, 1.00)
Country/region of birth				
Pre-pandemic	Norway (reference)	224.61/210.79	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	153.28/143.74	1.02 (0.98, 1.07)	1.00 (reference)
	Asia, Africa, Latin America	217.40/203.15	1.02 (0.99, 1.05)	1.00 (reference)
First wave	Norway (reference)	255.05/261.28	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	167.31/174.85	0.98 (0.92, 1.04)	0.98 (0.92, 1.04)
	Asia, Africa, Latin America	228.80/255.79	0.92 (0.88, 0.97)	0.90 (0.86, 0.95)
Summer period	Norway (reference)	173.89/169.71	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	124.30/122.44	1.01 (0.98, 1.05)	1.00 (0.97, 1.04)
	Asia, Africa, Latin America	167.65/168.94	0.99 (0.97, 1.03)	0.97 (0.95, 1.00)
Second wave	Norway (reference)	196.24/183.37	1.00 (reference)	1.00 (reference)
	EU/EEA, USA, Can, Aus, NZ	135.05/131.16	0.98 (0.95, 1.03)	0.97 (0.94, 1.01)
	Asia, Africa, Latin America	186.85/183.52	0.97 (0.95, 1.00)	0.95 (0.93, 0.98)
Educational attainment				
Pre-pandemic	Low	179.93/173.59	0.98 (0.95, 1.01)	1.00 (reference)
	Middle	200.39/194.19	0.97 (0.94, 1.00)	1.00 (reference)
	High (Reference)	280.63/262.00	1.00 (reference)	1.00 (reference)
First wave	Low	192.45/214.02	0.92 (0.88, 0.97)	0.95 (0.91, 1.00)
	Middle	225.15/235.60	0.98 (0.94, 1.02)	1.01 (0.97, 1.05)
	High (Reference)	326.52/334.08	1.00 (reference)	1.00 (reference)
Summer period	Low	146.19/144.88	0.92 (0.88, 0.97)	0.95 (0.91, 1.00)
	Middle	156.49/158.61	0.98 (0.94, 1.03)	1.01 (0.97, 1.05)
	High (Reference)	207.94/204.61	1.00 (reference)	1.00 (reference)
Second wave	Low	162.04/153.73	1.00 (0.97, 1.02)	1.03 (1.00, 1.05)
	Middle	171.53/169.47	0.98 (0.95, 1.01)	1.01 (0.98, 1.03)
	High (Reference)	236.06/224.36	1.00 (reference)	1.00 (reference)
Household income				
Pre-pandemic	Quintile 1 (lowest)	209.30/176.06	1.16 (1.13, 1.20)	1.00 (reference)
	Quintile 2	268.05/251.34	1.00 (0.97, 1.05)	1.00 (reference)
	Quintile 3 (reference)	270.83/276.27	1.00 (reference)	1.00 (reference)
First wave	Quintile 1 (lowest)	234.30/220.11	1.17 (1.11, 1.24)	1.01 (0.97, 1.06)
	Quintile 2	307.15/320.92	1.01 (0.97, 1.05)	1.01 (0.97, 1.06)
	Quintile 3 (reference)	312.87/348.98	1.00 (reference)	1.00 (reference)
Summer period	Quintile 1 (lowest)	168.49/152.96	1.11 (1.08, 1.14)	0.96 (0.93, 0.98)
	Quintile 2	201.46/198.74	0.99 (0.97, 1.03)	1.00 (0.98, 1.02)
	Quintile 3 (reference)	200.26/209.90	1.00 (reference)	1.00 (reference)
Second wave	Quintile 1 (lowest)	194.42/171.55	1.09 (1.07, 1.12)	0.94 (0.92, 0.97)
	Quintile 2	228.09/217.23	0.99 (0.97, 1.01)	0.99 (0.97, 1.01)
	Quintile 3 (reference)	219.62/222.03	1.00 (reference)	1.00 (reference)

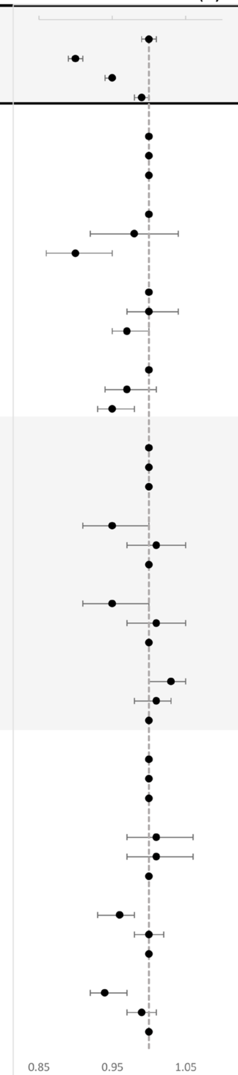

Figure 3 Incidence rates and incidence rate ratios of primary care consultations prior to the lockdown (prepandemic: 1 January to 11 March), during the initial lockdown (first wave: 12 March to 3 April), summer period with light restrictions (summer period: 4 April to 31 August) and second period of increasing case numbers and increasing local restrictions (second wave: 1 September to 31 December) in 2020, compared with admissions from the same time periods from 2019 by subgroups. Educational attainment: low=less than 10 years compulsory education; middle=12–13 years senior school education; high=more than 13 years tertiary education. SEs were clustered by person to account for multiple events. Incidence rates reflect the number of daily events over 100 000 women aged 15–50 years for 2020 compared with 2019. Women aged 15–50 years from the general population of Norway (2020) served as the denominator. Adjusted model controlled for age in years and all other factors in the table and prepandemic estimates. Prepandemic differences were adjusted for by dividing 1.0 by the IRR at the prepandemic period and then multiplying all IRR values by this value (ie, 1.00/IRR prepandemic*IRR first wave, summer period, second wave). Aus, Australia; Can, Canada; EEA, European Economic Area; EU, European Union; IR, incidence rate; IRR, incidence rate ratio; NZ, New Zealand.

treating patients in the outpatient care setting in recent years and a reduction in inpatient care or declining rates of births. However, it is expected that such changes are consistent throughout the year and are observable by a general increase or decrease before the pandemic arrived in Norway. Therefore, by comparing rates in 2020 with 2019 and adjusting for time effects based on the difference observed before the pandemic to previous years, we were able to control for seasonal confounding and other time trends. Such adjustments are typically not possible in non-population-based studies.

As this study was based on Norwegian registries and healthcare, we lacked information regarding unofficial population movement outside of Norway, such as normal travel. We did have information regarding women who emigrated officially during this period, and to prevent

Specialist care (inpatient & outpatient events combined)

Groups	Period	Daily IR events per 100,000 2020/2019	Crude IRR (CI)	Adjusted for confounding and pre/pandemic IRR (CI)
ICD-10 Diagnostic codes				
Z37 Outcome of delivery	Pre-pandemic	13.23/13.46	0.98 (0.96, 1.01)	1.00 (reference)
	First wave	13.66/14.20	0.96 (0.92, 1.01)	0.98 (0.94, 1.03)
	Summer	13.99/14.24	0.98 (0.97, 1.00)	1.00 (0.99, 1.02)
	Second wave	11.90/12.57	0.95 (0.93, 0.97)	0.97 (0.95, 1.00)
O00-O08 Pregnancy with abortive outcome	Pre-pandemic	8.25/7.81	1.06 (1.01, 1.11)	1.00 (reference)
	First wave	6.86/7.66	0.90 (0.82, 0.97)	**0.85 (0.77, 0.92)**
	Summer	6.77/6.90	0.98 (0.95, 1.02)	**0.92 (0.90, 0.96)**
	Second wave	7.75/7.39	1.05 (1.01, 1.09)	0.99 (0.95, 1.03)
O10-O16 Oedema, proteinuria and hypertensive disorders in pregnancy, childbirth and the puerperium	Pre-pandemic	2.25/2.24	1.07 (0.94, 1.21)	1.00 (reference)
	First wave	2.40/2.51	0.96 (0.80, 1.15)	0.90 (0.75, 1.07)
	Summer	2.30/2.48	0.93 (0.85, 1.01)	**0.87 (0.79, 0.94)**
	Second wave	2.22/2.31	0.96 (0.87, 1.06)	**0.90 (0.81, 0.99)**
O20-O29 Other maternal disorders predominantly related to pregnancy	Pre-pandemic	14.02/13.50	1.04 (0.98, 1.10)	1.00 (reference)
	First wave	11.84/14.67	0.81 (0.75, 0.87)	**0.78 (0.72, 0.84)**
	Summer	12.70/12.54	1.01 (0.97, 1.06)	0.97 (0.93, 1.02)
	Second wave	13.50/13.16	1.03 (0.98, 1.08)	0.98 (0.94, 1.03)
O30-O48 Maternal care related to the fetus and amniotic cavity and possible delivery problems	Pre-pandemic	22.14/21.31	1.04 (1.00, 1.08)	1.00 (reference)
	First wave	20.80/22.37	0.93 (0.88, 0.98)	**0.89 (0.85, 0.94)**
	Summer	20.34/21.01	0.97 (0.94, 1.00)	**0.93 (0.90, 0.96)**
	Second wave	19.87/19.38	1.03 (0.99, 1.06)	0.98 (0.95, 1.02)
O60-O75 Complications of labour and delivery	Pre-pandemic	22.27/22.95	1.01 (0.98, 1.05)	1.00 (reference)
	First wave	22.45/23.00	0.98 (0.92, 1.04)	0.97 (0.91, 1.03)
	Summer	23.16/23.00	1.01 (0.98, 1.03)	1.00 (0.97, 1.02)
	Second wave	20.51/20.97	0.98 (0.95, 1.00)	0.97 (0.94, 1.00)
O85-O92 Complications predominantly related to the puerperium	Pre-pandemic	2.28/2.40	0.95 (0.86, 1.05)	1.00 (reference)
	First wave	1.61/2.26	0.71 (0.60, 0.85)	**0.75 (0.63, 0.89)**
	Summer	2.11/2.47	0.85 (0.80, 0.92)	**0.91 (0.84, 0.97)**
	Second wave	1.95/2.31	0.85 (0.78, 0.92)	**0.89 (0.82, 0.97)**
O94-O99 Other obstetric conditions, not elsewhere classified	Pre-pandemic	7.18/6.74	1.07 (1.01, 1.13)	1.00 (reference)
	First wave	7.09/7.60	0.93 (0.86, 1.01)	**0.87 (0.80, 0.94)**
	Summer	6.81/6.58	1.03 (0.99, 1.08)	0.96 (0.93, 1.01)
	Second wave	6.70/6.14	1.09 (1.04, 1.15)	1.02 (0.97, 1.07)
Health care urgency				
Acute	Pre-pandemic	82.24/80.21	1.03 (1.01, 1.04)	1.00 (reference)
	First wave	80.28/87.13	0.92 (0.90, 0.94)	**0.90 (0.87, 0.94)**
	Summer	75.32/76.11	0.99 (0.98, 1.00)	**0.98 (0.96, 0.99)**
	Second wave	73.53/73.38	1.00 (0.99, 1.01)	0.99 (0.97, 1.01)
Elective	Pre-pandemic	81.13/79.12	1.02 (1.01, 1.04)	1.00 (reference)
	First wave	79.15/85.90	0.92 (0.90, 0.94)	**0.90 (0.87, 0.94)**
	Summer	74.35/75.14	0.98 (0.98, 0.99)	**0.98 (0.96, 0.99)**
	Second wave	72.56/72.42	1.00 (0.99, 1.01)	1.00 (0.99, 1.01)

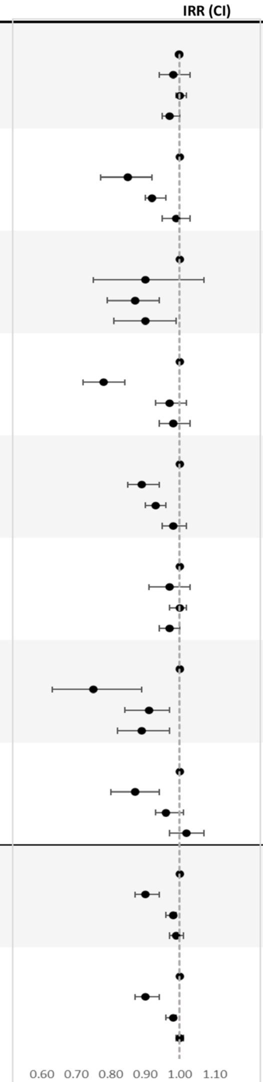

Figure 4 Incidence rates and incidence rate ratios of specialist care prior to the lockdown (prepandemic: 1 January to 11 March), during the initial lockdown (first wave: 12 March to 3 April), summer period with light restrictions (summer period: 4 April to 31 August) and second period of increasing case numbers and increasing local restrictions (second wave: 1 September to 31 December) in 2020, compared with consultations from the same time periods from 2019 by diagnostic groups and urgency of care. SEs were clustered by person to account for multiple events. Incidence rates reflect the number of daily events over 100 000 women aged 15–50 years for 2020 compared with 2019. Women aged 15–50 years from the general population of Norway (2020) served as the denominator. Adjusted model controlled for age in years and all other factors in the table and prepandemic estimates. Adjustments for prepandemic differences by dividing 1.0 by the IRR at the prepandemic period and then multiplying all IRR values by this value (ie, 1.00/IRR prepandemic*IRR first wave, summer period, second wave). ICD-10, International Classification of Diseases 10th Edition; IR, incidence rate; IRR, incidence rate ratio.

confounding, we excluded this group from the study. Lastly, analyses are based on observational data, and impacts of COVID-19 on healthcare utilisation may be related to confounders that we did not consider in the current study. Therefore, residual confounding cannot be excluded.

Comparison with related studies and interpretations

Few other studies have investigated the impact of the COVID-19 pandemic during COVID-related restrictions on pregnancy-related healthcare utilisation. In a cross-sectional study investigating rates of care on an obstetrics and gynaecological department in a large-scale hospital in Israel, a dramatic decrease in the number of visits and admissions in March and April between 18% (births) and 37% (visits to obstetrics triage) was reported.[12] Similar findings based on single-hospital studies have been reported in other countries.[13 14] We found between 10% and 17% reductions in pregnancy-related care in

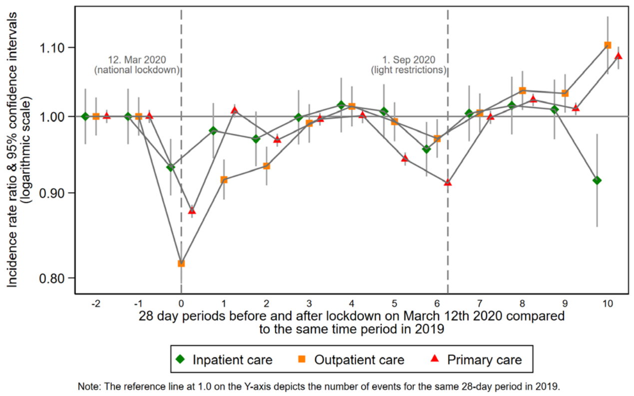

Figure 5 Crude incidence rate ratios of pregnancy-related healthcare utilisation in women aged 15–50 years comparing 28-day periods before and after lockdown on 12 March in 2020 compared with the same period from 2019. Time trends prior to lockdown, such as falling fertility rates, have been adjusted for by calibrating IRRs prior to 12 March to 1.0 and then multiplying the following IRRs by this difference. The number of total days sampled between points 9 and 10 was 14 days (17–31 December).

inpatient and outpatient services, respectively, during this period. This difference may be explained by likely bias associated with single-site studies compared with a population-based study with complete coverage. The authors also reported increased rates of high-risk patients who presented with hypertensive disorders of pregnancy or gestational diabetes. We found no evidence for increased rates of hypertensive disorders of pregnancy or gestational diabetes, rather a reduction in the upper ICD-10 category of 'Oedema, proteinuria and hypertensive disorders in pregnancy, childbirth and the puerperium' during the summer period and the second wave, as well as 'other maternal disorders predominantly related to pregnancy' during the first wave, which has the subcategory of 'diabetes mellitus in pregnancy'.

One national-based study found reductions between 5% and 6% in preterm delivery (<37 weeks) at the national level in the USA over 2020 compared with previous years and no effect on caesarean delivery rates.[15] Conversely, a registry-based study using data from Norway, Sweden and Denmark found no evidence of a reduction in preterm birth following the introduction of COVID-19 mitigation measures.[16] In Norway, as is common in many high-income countries, there has been a decreasing trend in fertility rates for many years.[17] We found no evidence of a further decline beyond this trend during 2020 following the introduction of COVID-19 mitigation measures. Recent reports show increased birth rates by the start of 2021 compared with previous years,[17] suggesting that the pandemic may have eventually led to an increase in fertility rates in Norway.

One likely explanation for the reductions in pregnancy-related healthcare utilisation we observed may be pregnant women socially isolating due to fear of COVID-19 infection resulting in delayed or complete avoidance of seeking medical care when perceived as not strictly necessary or urgent. A UK survey of 524 pregnant women found changes to services led to essential clinical care being missed and distress and emotional trauma for women.[18] Similarly, a Danish survey study of 257 pregnant women found that 90% were isolated at home most of the time due to fear of COVID-19 and that 15% had consequently missed an appointment with their midwives.[19] Another explanation regarding the reduction of specialist care may relate to a higher threshold for admitting patients to hospital during the pandemic.[1] This may also explain increased rates of primary care observed during some points of 2020, which needed to 'catch-up' for a backlog of planned pregnancy-related services. It is also possible, given the current study included pregnancy-related healthcare as a main or secondary diagnosis, that there simply was a reduction in incidence of other diseases, including other infections than COVID-19, and a reduction in detrimental exposures during COVID-related restrictions. Obvious examples include reductions in pneumonia due to reduced social contact.

We observed significantly greater reductions of up to 23% in pregnancy-related care services for women not born in Norway. Although some differences were also observed for pregnancy-related care services between persons with lower educational attainment and household income, these findings were generally not as strong or consistent. Specifically, women with the lowest educational attainment had a 22% greater reduction in inpatient care during the summer period, suggesting that this group took longer to return to prepandemic levels of inpatient care. Conversely, though, this group had a small increase in outpatient and primary care during the second wave, compared with women with the highest education, suggesting some heterogeneity in the interaction of socioeconomic factors on the impact of the pandemic on pregnancy-related healthcare. Pregnant women in the second lowest household income quintile had a greater reduction in primary care during the summer period and second wave period, compared with women in the top earning household income quintile. However, no other differences were found. The mechanisms underlying inequalities in use of pregnancy-related healthcare among women with an immigrant background are likely complex and may, in part, reflect structural barriers. Additionally, changing health information related to the pandemic may be difficult to access due to cultural and linguistic barriers. Studies have found that persons with an immigrant background in Norway were less likely, for example, to use digital forms of healthcare as an alternative during the pandemic.[20] Another explanation may be that some pregnant women with an immigrant background travelled back to their country of birth temporally and received care there, in which case the current study was unable to track healthcare utilisation outside of Norway. Irrespective of the underlying mechanism, the finding is concerning given that immigrant women in Norway have a higher baseline risk of pregnancy complications, including a high prevalence of gestational diabetes.[21]

CONCLUSION

Overall, we found a substantial reduction in pregnancy-related healthcare utilisation following the initial first wave due to the COVID-19 pandemic in both primary and specialist care settings. Greater reductions in pregnancy-related care among women with an immigrant background suggest that the pandemic may have affected pregnancy-related healthcare in some vulnerable groups unequally. Although we observed some suggestions of greater reductions in care among women of lower socioeconomic status, these were generally less consistent. An understanding of how pandemic mitigation measures have influenced pregnancy-related care is important to identify interventions that might be implemented to ensure a good follow-up of pregnant women during future pandemics.

Contributors SEH, CMB and KT conceptualised the study. CMB analysed the data and wrote the first draft of the manuscript. All authors (CMB, FM, KT, JMK, LO, MCM, SEH) contributed to the interpretation of data and writing of the manuscript, and agree with the manuscript's results and conclusions. CB was responsible for the overall content as the guarantor. All authors read and approved the final manuscript.

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Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Norwegian legislation does not require consent from individuals to conduct research using the national registries. Ethical approval was obtained for this study from the Regional Committee of Medical and Health Research Ethics of South/East Norway (reference number: 141135).

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data may be obtained from a third party and are not publicly available.

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