


BMJ Open Neonatal outcomes and indirect consequences following maternal SARS-CoV-2 infection in pregnancy: a systematic review

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ABSTRACT

Objectives To identify the association between maternal SARS-CoV-2 infection in pregnancy and individual neonatal morbidities and outcomes, particularly longer-term outcomes such as neurodevelopment.

Design Systematic review of outcomes of neonates born to pregnant women diagnosed with a SARS-CoV-2 infection at any stage during pregnancy, including asymptomatic women.

Data sources MEDLINE, Embase, Global Health, WHOLIS and LILACS databases, last searched on 28 July 2021.

Eligibility criteria Case-control and cohort studies published after 1 January 2020, including preprint articles were included. Study outcomes included neonatal mortality and morbidity, preterm birth, caesarean delivery, small for gestational age, admission to neonatal intensive care unit, level of respiratory support required, diagnosis of culture-positive sepsis, evidence of brain injury, necrotising enterocolitis, visual or hearing impairment, neurodevelopmental outcomes and feeding method. These were selected according to a core outcome set.

Data extraction and synthesis Data were extracted into Microsoft Excel by two researchers, with statistical analysis completed using IBM SPSS (Version 27). Risk of bias was assessed using a modified Newcastle-Ottawa Scale.

Results The search returned 3234 papers, from which 204 were included with a total of 45 646 infants born to mothers with SARS-CoV-2 infection during pregnancy across 36 countries. We found limited evidence of an increased risk of some neonatal morbidities, including respiratory disease. There was minimal evidence from low-income settings (1 study) and for neonatal outcomes following first trimester infection (17 studies). Neonatal mortality was very rare. Preterm birth, neonatal unit admission and small for gestational age status were more common in infants born following maternal SARS-CoV-2 infection in pregnancy in most larger studies.

Conclusions There are limited data on neonatal morbidity and mortality following maternal SARS-CoV-2 infection, particularly from low-income countries and following early pregnancy infections. Large, representative studies addressing these outcomes are needed to understand the consequences for babies born to women with SARS-CoV-2.

PROSPERO registration number CRD42021249818.

STRENGTHS AND LIMITATIONS OF THIS STUDY

- ⇒ Large sample size both of individual studies and overall number of pregnancies and births included.
- ⇒ Focus on neonatal outcomes and indirect consequences for infants born to mothers with a diagnosis of SARS-CoV-2 during pregnancy, as opposed to purely obstetric outcomes.
- ⇒ Limited data available from low-income and middle-income countries, early pregnancy infections and more granular neonatal outcomes such as neurodevelopmental outcomes.

INTRODUCTION

Pregnant women have been treated as an 'at risk' group for severe disease during the SARS-CoV-2 pandemic.¹ Initial evidence suggested that infection with SARS-CoV-2 in pregnancy was associated with severe obstetric morbidity,² including higher rates of preterm birth, pre-eclampsia and caesarean delivery.^{3 4} Early case reports suggested that vertical transmission was possible, although rare.^{2 5-9} However, increasingly, research indicates that neonatal infections are mostly mild,¹⁰ suggesting that the risk to neonates from maternal infection is more likely to be as a result of the indirect effects of being born to a mother with SARS-CoV-2 infection, rather than from perinatal or postnatal infection with SARS-CoV-2. Other viral infections, such as Zika virus, in early pregnancy have been associated with adverse neurodevelopmental outcomes¹¹; however, the neurodevelopmental impact of maternal SARS-CoV-2 in pregnancy is unclear.

Previous reviews of neonatal outcomes from maternal SARS-CoV-2 infections have been limited by the quality and amount of evidence available, with many studies consisting of case reports and case series or with small sample sizes.¹²⁻¹⁴ As larger, population-based

or national studies emerge, an opportunity has arisen to examine neonatal outcomes following maternal infection in greater detail, including longer-term outcomes. In this systematic review, we summarise current evidence on neonatal outcomes after maternal SARS-CoV-2 infection in pregnancy, aiming to quantify the association with specific neonatal morbidities and longer-term outcomes that will be important to families.

METHODS

The review protocol was preregistered and is available with PROSPERO (17 May 2021, ID CRD42021249818).

Eligibility criteria

We included peer-reviewed publications of case-control and cohort studies. Preprint articles identified from relevant living systematic reviews were included. We excluded studies of overlapping populations, identified by hospital, date of study period and number of participants. Preprint articles were identified as reporting duplicate populations by the same means. We accepted studies of the babies of pregnant women with a diagnosis of SARS-CoV-2 during pregnancy. A diagnosis of SARS-CoV-2 was defined as positive PCR testing at any stage, lateral flow/rapid antigen testing or locally accepted clinical criteria in order to enable inclusion of studies early in the pandemic or in resource-limited settings where PCR testing may not have been widely available. Studies diagnosing SARS-CoV-2 infection using serology alone were only included if their participants were recruited during the first 9 months of 2020, with the assumption that these participants would mostly have contracted their primary SARS-CoV-2 infection during pregnancy. In case-control studies, we included any study with a comparison group of pregnant women without any diagnosis of SARS-CoV-2 during pregnancy. We allowed studies published after 1 January 2020, although studies published after this date but including data from prior to 1 January 2020 were also included. No language or geographic restrictions were applied.

We included studies describing any of the following infant outcomes: preterm birth (<37 weeks gestation), small for gestational age (<10th centile birth weight for gestational age on appropriate neonatal growth charts), low birth weight (defined as <2500 g), admission and length of stay in neonatal unit, level and duration of respiratory support, diagnosis of culture-positive sepsis during neonatal admission, evidence of brain injury (including seizures, abnormal brain imaging or diagnosis of hypoxic ischaemic encephalopathy),¹⁵ necrotising enterocolitis, other gastrointestinal disease, visual or hearing impairment, quality of life, neurodevelopmental outcomes, exclusive breast feeding and all-cause infant mortality. Selection of neonatal outcomes was informed by a core outcome set developed with health professionals, parents and researchers.¹⁶

Search process

MEDLINE, Embase, Global Health, WHOLIS and LILACS databases were searched (see online supplemental appendix 1 for search terms used). The LILACS database was searched for all papers relating to 'SARS-CoV-2', 'covid' and 'coronavirus', owing to its differing search functionality from the other databases. The last search was completed on 28 July 2021.

Results were uploaded to the Rayyan QCRI platform (Rayyan—a web and mobile app for systematic reviews, 2016¹⁷), and duplicates removed using the duplicate removal tool available on this platform. All titles were screened independently by two reviewers (SS and AS) and subsequently abstracts screened by both. Where there was disagreement, the title/abstract was screened by a third reviewer (CG).

Data were extracted into Microsoft Excel (V.2201) by SS or SA using a proforma with the outcomes described above, study type and dates, location, participant definition and numbers, and method of SARS-CoV-2 diagnosis. Any outcome data not reported was assumed not to have been collected as part of the study. Pregnancies were assumed to be singleton pregnancies unless otherwise specified. A modified Newcastle-Ottawa Scale¹⁸ was used for assessment of study quality, with studies scoring 4 and above (out of a possible 11) deemed as eligible for inclusion. Statistical analysis was completed using Microsoft Excel, SPSS (IBM SPSS Statistics for Macintosh, V.25, 2017)¹⁹ and R (R Studio V.2021.09.01²⁰), including calculation of proportion of infants in each study with each outcome, and descriptive statistics of rates of outcomes identified. Weighted means were calculated by dividing the number of infants included in each study by the total number of infants included in the review to find a weighting factor. Each outcome rate was then multiplied by that study's weighting factor, and all the results summed to find the overall weighted mean. Independent sample Kruskal-Wallis tests were used to determine whether there was a significant difference in outcome rates between country income levels as defined by the World Bank.²¹ Forest plots were created using R,²⁰ using a random effects model only. Further meta-analysis was not performed due to heterogeneity in study populations and outcome reporting. Results are reported according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

Patient and public involvement

Patients and the public were not directly involved in the design of this study. However, this study seeks to address some of the knowledge gaps raised by expectant families as part of an online survey of women pregnant or breast feeding during the COVID-19 pandemic.²²

RESULTS

Search results

A total of 3234 papers were identified from the literature search after duplicates were removed. A total of 204 papers were deemed as eligible for inclusion. Of these, 37 papers were case-control studies, and 167 were cohort

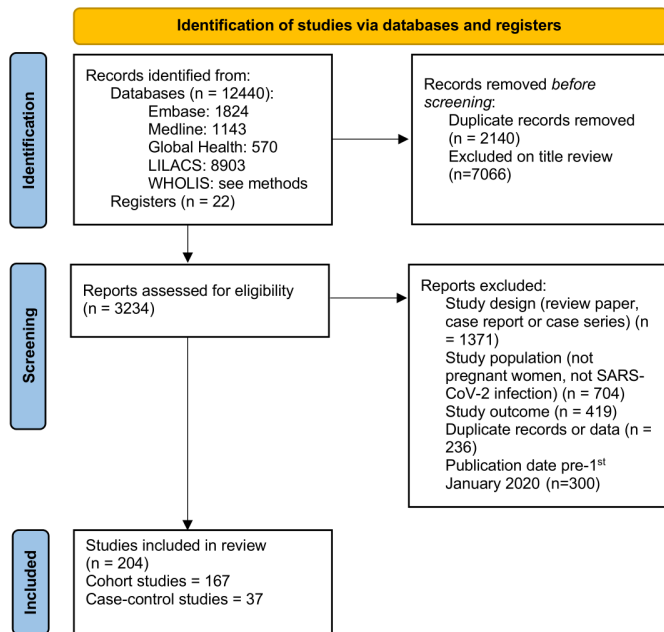


Figure 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses study selection flow chart.

studies (see figure 1 for PRISMA summary of study selection process). A total of 36 countries were represented, with an additional 6 international papers. Overall, 118 studies were from high-income countries, and only 1 from a low-income country.²³ Study periods ranged from 8 December 2019 to 18 March 2021. Across all studies, a total of 838 743 pregnancies and 786 884 live births were studied, of which 57 059 mothers had received a diagnosis of SARS-CoV-2 infection in pregnancy and had given birth to 45 646 babies. The majority of studies only included women with in their third trimester of pregnancy, with 17 (8.3%) studies including any participants in the second trimester (2%–49% of total participants in each study), and 20 (9.8%) including any first-trimester participants (1%–51% of total participants in each study). Overall, 76% of studies (156) used PCR testing alone to identify cases of SARS-CoV-2. The details of included studies can be found in table 1, and a full results table is available in

		Studies, n	Participants, n
Study type	Case-control	37	793 680
	Cohort	167	45 063
Income group	High	118	809 562
	Upper middle	56	15 027
	Lower middle	24	7174
	Low	1	137
Stages of pregnancy included in study	First trimester included	20	2212
	Second trimester included	17	2141

online supplemental appendix 2. The range of bias assessment scores according to the Newcastle-Ottawa Scale were 4–8, with a median score of 6.

Neonatal morbidity

Of the included studies, neonatal outcomes were less commonly reported than obstetric outcomes. Need for admission to a neonatal unit was the most frequently reported outcome, with data extracted for 761 489 infants, respectively (97.2% of included infants overall). However, neonatal outcomes such as need for non-invasive respiratory support, neurological disease, sepsis and necrotising enterocolitis were only reported in a minority of infants (<95 000) and studies included in this review.

The weighted mean rate of admission to a neonatal unit for babies born to mothers infected with SARS-CoV-2 was 11%, although it was not clear in some studies how many of these admissions were for isolation purposes as opposed to clinical need. In total, 8 of the 19 case-control studies reporting neonatal unit admission rates found a significant association between neonatal unit admission and maternal infection (including 432 512 infants, in comparison to 306 407 infants included in studies finding no association, see table 2 and figure 2). The need for non-invasive respiratory support among babies born to mothers with SARS-CoV-2 was reported for 6037 infants (weighted mean rate 1%, see table 3). Neurological disease (reported for 3376 SARS-CoV-2 exposed infants, range 0%–7%, weighted mean rate 0.2%), Necrotising enterocolitis (NEC - reported for 2937 SARS-CoV-2 exposed infants, weighted mean rate 0.02%) and confirmed bacterial infection (reported for 4697 SARS-CoV-2 exposed infants, range 0%–7%, weighted mean rate 0.09%) were all reported in a minority of studies. Few case-control studies reported on neonatal morbidity in detail, with only 2 studies of 88 238 infants examining the need for respiratory support, gastrointestinal disease, neurological disease and sepsis. Only 1 small case-control study of 79 infants found maternal SARS-CoV-2 infection to be associated with neurological morbidity (specifically, seizures), affecting 1 (7%) of the exposed infants and none of those non-exposed.²⁴ One large study of 88 159 infants finding an increased risk of need for respiratory support in babies born to infected mothers found that this association may be explained by prematurity.²⁵ No study controlled for prematurity in assessing the association between maternal infection and neurological morbidity.

Birth outcomes

The method of delivery was reported in 184 studies (including 784 395 births), with a weighted mean of 38% of births occurring via caesarean. Of the 28 case-control studies reporting on caesarean delivery as an outcome, 12 studies found a significant association with maternal SARS-CoV-2, although these studies were much larger than those not finding an association (including 651 224 births as compared with 9751 births).

Table 2 Results of case-control studies

		Studies finding significant association		Studies not finding significant association	
		Studies, n	Participants in studies, n	Studies, n	Participants in studies, n
Birth outcomes	Caesarean delivery	12	651 224	16	9751
	Premature delivery (<37 weeks)	10	648 804	16	9807
	Small for gestational age	1	219	10	648 318
	Low birth weight	1	2130	1	110
Neonatal outcomes	Admission to neonatal care	8	432 512	11	306 407
	Need for non-invasive respiratory support	2	88 238	0	0
	Need for mechanical ventilation	2	88 238	0	0
	Neurological disease	1	79	1	88 159
	Necrotising enterocolitis	0	0	0	0
	Other gastrointestinal disease	0	0	0	0
	Sepsis	0	0	2	88 214
Infant outcomes	Hearing impairment	2	191	0	0
	Developmental outcomes	0	0	0	0
	Any breast feeding (exclusive or mixed feeding)	2	145	2	88 422
	Infant or neonatal death	0	0	10	96 688

Preterm birth (<37 gestational weeks) in SARS-CoV-2-affected pregnancies occurred at weighted mean rate of 14%. The median prematurity rate in SARS-CoV-2 affected pregnancies was 16%, owing to 4 smaller studies finding very high rates of prematurity. Most larger studies reported a higher risk of preterm birth (10 studies including 648 804 births), but several smaller studies did not (10 studies including 9807 births, see figure 3). Prematurity rates in pregnancies affected by SARS-CoV-2 were not significantly different across income categories, except for rates being significantly

higher in upper-middle-income countries (mean 22.7%) compared with high-income countries (mean 16.3%, $p=0.043$).

A total of 54 studies reported rates of small for gestational age births, including 753 945 infants. The range was 0%–44%, and the weighted mean was 4%. Overall, 25 studies examined the rates of low birth weight. These included only 5108 infants and found a range of low birth weight rates of 0%–50%, with a weighted mean of 1%.

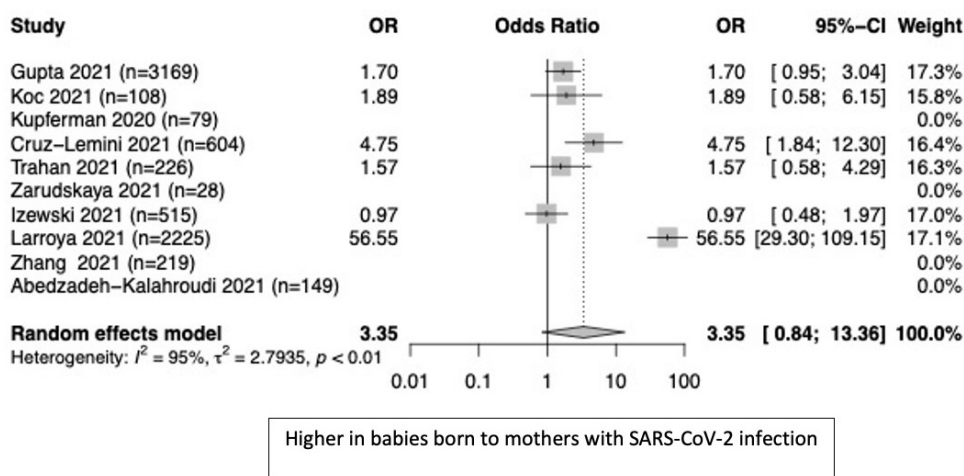
**Figure 2** Forest plot for neonatal intensive care unit admission.

Table 3 Results from all COVID-19-positive pregnancies (pooled cohort studies and case-control studies)

		Studies reporting, n	SARS-CoV-2 exposed infants included, n	Weighted mean	Range
Birth outcomes	Premature delivery (<37 weeks)	165	42 726	13.8%	0%–81%
	Small for gestational age	55	23 911	4.0%	0%–44%
	Low birth weight	25	3629	1.0%	0%–50%
Neonatal outcomes	Admission to neonatal care	118	31 413	11.0%	0%–100%
	Need for non-invasive respiratory support	27	6037	1.0%	0%–80%
	Need for mechanical ventilation	27	5341	0.4%	0%–20%
	Neurological disease	13	3376	0.2%	0%–7%
	Necrotising enterocolitis	10	2937	0.0%	0%–22%
	Other gastrointestinal disease	6	360	0.0%	0%–5%
	Sepsis	15	4697	0.1%	0%–7%
	Infant outcomes	Hearing impairment	4	197	0.1%
Developmental outcomes		2	339	0.0%	0%–64%
Breast feeding		38	7565	12.0%	0%–100%
Infant or neonatal death		99	23 826	0.4%	0%–18%

Breast feeding

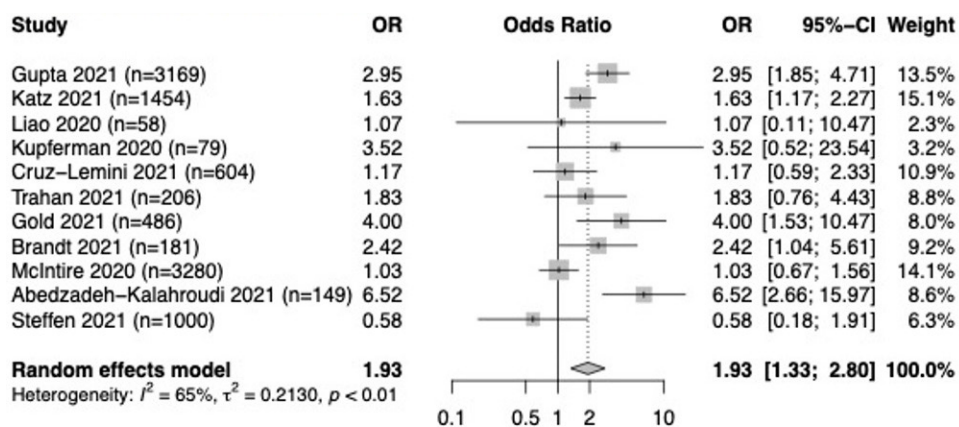
Breastfeeding rates among babies born to mothers with SARS-CoV-2 varied significantly across the 39 studies (96 174 infants) reporting this outcome: 0%–100% (weighted mean 12%). Of the studies reporting breast feeding as an outcome, 11 (28.2%) reported breastfeeding status at hospital discharge and 8 (20.5%) reported breastfeeding status at hospital discharge. The longest follow-up of breast feeding was 2 months, in three studies. In seven studies, it was unclear at what point breastfeeding status was recorded.

Four case-control studies including 88 567 babies examined breast feeding by maternal SARS-CoV-2 infection status: 2 small studies (145 infants) found a significant negative association between maternal SARS-CoV-2 infection and breast feeding,^{24 26} whereas 2 other studies (88 422 infants) did not find any significant association

between maternal SARS-CoV-2 and breast feeding. Among studies without a SARS-CoV-2-negative comparator group, one found that asymptomatic mothers were more likely to breast feed than those with symptoms,²⁷ and one found a significant difference in breastfeeding rates both in hospital and at home between those who were separated (0% in hospital, 12.2% at home) from their babies and those who were not (22.2% in hospital, 27.8% at home).²⁸

Neurodevelopmental outcomes

In total, 2 cohort studies of 339 infants examined developmental outcomes. One study found that psychomotor development was normal at 6 months in all 282 infants born following maternal SARS-CoV-2 infection during pregnancy.²⁹ A second study examined neurobehavioural development using the Ages and Stages Questionnaire



Higher in babies born to mothers with SARS-CoV-2 infection

Figure 3 Forest plot for premature delivery.

at 3 months in 57 exposed infants,³⁰ and found that 28 (63.6%) had concerning features in the social–emotional developmental domain,³⁰ and that abnormal development was associated with length of mother–baby separation.³⁰ In total, 2 studies of 191 infants found higher rates of abnormal auditory brainstem response hearing tests (44.9%, 53 vs 23.7%, 28) and poorer otoacoustic emission test results in babies born to mothers infected with SARS-CoV-2.^{31 32}

Mortality

In all studies reporting neonatal or infant mortality, there were 512 deaths reported. A total of 10 case–control studies of 96 688 infants examined neonatal mortality, and none found a significant difference in mortality rate between neonates born to infected mothers and controls. The only study in a low-income country reported no neonatal deaths.²³

DISCUSSION

We report the largest systematic review of neonatal and infant outcomes of babies born to women with SARS-CoV-2 in pregnancy, including 57 059 pregnancies and 45 646 babies where mothers had been infected with SARS-CoV-2 during pregnancy from 114 countries. Building on previous studies which concentrated on timing and method of delivery,^{3 4} we have examined available data on neonatal morbidity, which may have long-term consequences. Additionally, we included pregnancies with a maternal SARS-CoV-2 infection irrespective of whether the mother was symptomatic or asymptomatic, in contrast to earlier studies focusing on hospitalised or severely unwell mothers. Unfortunately, limited study numbers made it impossible to meta-analyse outcomes in symptomatic women compared with asymptomatic women. The exclusion of case series and case reports reduced the impact of selection bias, and we excluded duplicate populations from our analysis.

Obstetric outcomes

As in other reviews, we found that maternal infection with SARS-CoV-2 during pregnancy is associated with higher rates of prematurity.^{8 33 34} We found that prematurity rates were highest in upper-middle-income countries, although they were similar to those in lower-middle-income countries. This could be due to iatrogenic premature delivery rather than spontaneous preterm labour, but more study will be required to determine the aetiology.

Neonatal outcomes

We also found some evidence that maternal infection with SARS-CoV-2 is associated with increased rates of admission to the neonatal intensive care unit. The reason for this could be the increase in prematurity, as reported above, but it should be noted that some of these admissions may be for isolation purposes, an observation period, or for the care of a baby whose mother is severely unwell

and unable to care for the baby herself. Additionally, in resource-limited settings, specialist neonatal intensive care may not be available—hence, this is not a generalisable marker for neonatal morbidity in all settings.

Evidence is limited and conflicting as to the association between maternal SARS-CoV-2 in pregnancy and short-term or long-term neonatal morbidity. The strongest evidence supports an association between maternal infection and an increased risk of respiratory disease mediated by preterm birth, but not of neurological or gastrointestinal morbidity.²⁵ We identified few, small studies that examined longer-term developmental outcomes; these found an apparent association between maternal SARS-CoV-2 infection and adverse outcomes in early infancy (3 months),^{29 30} but more studies that follow infants up over a longer time period will be needed to determine the true effect of maternal SARS-CoV-2 infection on development. It is imperative that these concerning findings are examined using standardised and validated neurodevelopmental assessments, and with the same assessment tools throughout multiple studies to allow meta-analysis. These findings also highlight the critical importance of examining neurodevelopment of offspring exposed to SARS-CoV-2 in-utero or in early life definitively through larger studies. Two small studies reported an association between maternal SARS-CoV-2 infection and offspring hearing impairment in healthy newborns without any specific risk factors for hearing impairment,^{31 32} further supporting the importance of following up children exposed to SARS-CoV-2 in pregnancy. More recently, a systematic review has also found a potential link between maternal SARS-CoV-2 and hearing impairment, although this association remains controversial.³⁵

We were unable to examine the impact by trimester of maternal SARS-CoV-2 infection due to a paucity of studies examining offspring of first or second trimester infection. Other viruses such as Zika virus are known to be harmful to the developing fetus when contracted in the first or second trimester,³⁶ so there is a reasonable suspicion that this could be true for SARS-CoV-2. Future studies should focus on examining this critical question, particularly as the virus becomes endemic.

Our study did not find clear evidence that maternal SARS-CoV-2 infection is associated with a reduction in breast feeding. Reductions reported in some studies may relate to mother–baby separation or maternal symptoms as opposed to a direct effect of the virus: one study finding lower breastfeeding rates in cases was based in China, which recommended against breast feeding if a lactating woman was infected with SARS-CoV-2.²⁶ Those finding no difference were based in Sweden²⁵ where there were no recommendations to restrict breast feeding, and in the USA,³⁷ we were unable to verify the exact guidance used by USA-based study hospitals at the time of data collection. We chose not to report vertical transmission of SARS-CoV-2 in this review, as identified studies varied widely in the timing and type of SARS-CoV-2 testing undertaken in

newborns, making a true diagnosis of vertical transmission difficult to accurately report.

Reassuringly, we did not find any evidence of an increased risk of neonatal or infant death with maternal SARS-CoV-2 infection. This is in contrast to other coronaviruses such as MERS, which has been linked with neonatal mortality rates of up to 33%.⁴ However, in the studies we identified, it was difficult to determine which neonatal or infant deaths might be attributable specifically to SARS-CoV-2 infection during pregnancy. We elected not to include case reports and case series in this review, but it should be noted that cases of severe SARS-CoV-2 infections in neonates have been reported.^{38–40} Although the incidence is likely to be low, this review does not seek to exclude severe neonatal infection with SARS-CoV-2 as a possibility.

Country income groups

This review identifies a crucial lack of data regarding the consequences for women in lower-income settings. Our findings suggest that some of the adverse perinatal outcomes may be more common in lower-middle-income and upper-middle-income countries than in high-income countries, such as prematurity, but we had insufficient evidence to determine whether this trend continued into low-income countries. Birth rates are consistently higher in lower-income settings,⁴¹ and so many more pregnant women may be affected by SARS-CoV-2 infection in these regions⁴² where specialist neonatal care may be limited.

Limitations

Our study has several limitations. First, we chose to include studies defining SARS-CoV-2 infection by locally accepted clinical criteria as well as by PCR test confirmation. This decision was made as, particularly in lower-resourced settings, the availability and use of PCR testing may have been limited at various points throughout the pandemic and we wanted to ensure data from these settings would be included wherever possible. Although our data may therefore include women with similar, non-COVID-19 illnesses, the majority of included studies did use PCR testing.

Although we identified many studies reporting perinatal outcomes, there was little information reporting neonatal morbidity in depth. Granular detail describing the indirect neonatal consequences of maternal SARS-CoV-2 infection during pregnancy remain unclear. This limitation is particularly pronounced for neurodevelopmental outcomes. With the SARS-CoV-2 declared pandemic 2 years ago, we hope that more information regarding these crucial outcomes will emerge soon; one trial is currently recruiting (the ASPIRE trial) which will follow-up infant outcomes for 1.5 years,⁴³ and another (the SINEPOST study) will examine development from 18 months onwards.⁴⁴

It should also be acknowledged that given the time taken to accurately extract, synthesise and report outcomes, our search was last updated over a year ago. Furthermore,

we found that studies varied widely on their reporting of severity of maternal disease and maternal symptoms; therefore, we were unable to study the effect of maternal symptomology on neonatal outcomes.

Finally, we found limited evidence from middle-income, and particularly, low-income countries, and little data regarding infections in early pregnancy. These are key research priorities to allow clinicians to adequately inform expectant families.

CONCLUSION

There is a lack of evidence surrounding neonatal morbidity and longer-term outcomes for babies born to SARS-CoV-2-infected mothers, although there is an association with prematurity, caesarean delivery and admission to the neonatal unit. Neonatal and child health researchers should attempt to address this crucial evidence gap to adequately inform families, healthcare professionals and public health responses.

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Contributors The study was designed by SS and SA with input from CG, CB and KLD. Data extraction and analysis was completed by SS and SA, with CG participating where there was disagreement over inclusion of papers. SS prepared the manuscript, which was reviewed and edited by all. SS is responsible for the overall content as guarantor.

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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 Ethical approval was not required for this study, as it involved only retrieval and synthesis of data from previously published studies.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available upon reasonable request.

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Appendix 1 – Search strategy

Embase search via Ovid, last updated 28/07/2021.

#	Searches	Results
1	Pregnan*	723025
2	Third trimester pregnancy/ or first trimester pregnancy/ or “parameters concerning the fetus, newborn and pregnancy”/ or pregnancy/ or pregnancy complication/ or high risk pregnancy/ or pregnancy disorder/ or second trimester pregnancy/ or pregnancy outcome/	498419
3	Antenat*	51397
4	Gestat*	297546
5	Matern*	379690
6	Maternity ward/ or maternity care/	21247
7	Breastfeed*	35731
8	Breast feeding/ or mother/ or breast milk/	140234
9	Lactat*	227694
10	Lactation/	39318
11	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10	1220052
12	COVID*	147977
13	Sars-cov-2	52773
14	Coronavirus	166814
15	Severe acute respiratory syndrome coronavirus 2/ or coronavirus disease 2019/ or coronavirus infection/	146237
16	12 or 13 or 14 or 15	187862
17	Stillb*	23397
18	Stillbirth/ or congenital malformation/	98283
19	Intrauterine adj demise	239
20	Intrauterine adj death	1647
21	Pregnancy adj loss	10662
22	Miscarr*	25084
23	Spontaneous adj abortion	39613
24	Spontaneous abortion/	38012
25	Fetus death/	15764
26	17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25	158662
27	Neonat*	303927
28	Infan*	701133
29	Newborn/	366307
30	Infant/ or hospitalized infant/ or infant disease/ or infant mortality/ or high risk infant/ or infant care/	477647
31	27 or 28 or 29 or 30	995198
32	Infect*	2546071
33	Infection/ or infection complication/ or infection risk/ or intrauterine infection/ or perinatal infection/	378561

34	Sepsis	201867
35	Newborn sepsis/ or sepsis/	157457
36	Nicu or neonatal adj admission	2739
37	Newborn intensive care/ or neonatal intensive care unit/	37168
38	Premat*	263202
39	Prematurity/ or premature labour/	130336
40	Small adj for adj gestational adj age or sga	20340
41	Small for date infant/	15970
42	Low adj birthweight	7252
43	Low birth weight/	31063
44	Operative adj delivery	1711
45	Instrumental delivery/	3855
46	Caesarean or c-section or cesarean	107540
47	Cesarean section/	92477
48	Instrumental delivery or ventouse or forceps or vacuum extraction	27358
49	Vacuum extraction/ or forceps delivery/ or forceps/	13907
50	Ventilat*	291355
51	Respiratory adj distress	100158
52	CPAP or BiPAP	18918
53	Ventilated patient/ or artificial ventilation/	137133
54	Continuous positive airway pressure/ or bilevel positive airway pressure	3083
55	Respiratory distress/	32246
56	Seizure or convulsion or fit	361565
57	Seizure/ or "seizure, epilepsy or convulsion"/	133064
58	Hypoxic ischaemic encephalopathy or hie	12140
59	Hypoxic ischaemic encephalopathy/	8490
60	Therapeutic cooling or induced hypothermia	171749
61	Brain ischemia/ or induced hypothermia/ or cooling/	171749
62	MRI or magnetic resonance imaging or eeg or electroencephalogram or cruss or cranial ultrasound or brain scan or brain imaging	1108432
63	Neuroimaging/ or nuclear magnetic resonance imaging/ or functional magnetic resonance imaging/ or electroencephalogram/	1011212
64	Hypoton* or hyperton* or abnormal tone or spasticity or cerebral palsy or neurological disease or neurological abnormality	118366
65	Spasticity/ or cerebral palsy/ or muscle hypertonia/ or neurologic disease/	176148
66	Cognitive ability or learning difficulty or learning disability or developmental delay	36605
67	Learning disorder/ or developmental delay/ or developmental disorder/ or mental deficiency/	93582

68	Gastrointestinal disease or nec or necrotising enterocolitis or necrotizing enterocolitis	104188
69	Gastrointesinal disease/ or necrotizing enterocolitis/	95690
70	Visual impairment or visually impaired or blind*	494101
71	Visual impairment/ or blindness/	73184
72	Hearing impair* or deaf*	87073
73	Hearing impairment/	46891
74	Quality of life or "quality of life"/	637206
75	Vertical transmi*	17715
76	Vertical transmission/	14908
77	32-76, combined with OR	5907734
78	77 and 31	459481
79	78 or 26	593511
80	11 and 16 and 79	1824

Medline search via Ovid, last updated 28/07/2021.

#	Searches	Results
1	Pregnan*	1047802
2	Pregnancy trimester, third/ or pregnancy trimester, second/ or pregnancy trimester, first/ or pregnancy/ or pregnancy, high-risk/ or pregnancy outcome/ or pregnancy complications/	911420
3	Antenat*	41206
4	Prenatal care/	29574
5	Gestat*	261469
6	Matern*	359413
7	Perinatal care/	4983
8	Breastfeed*	30017
9	Breast feeding/ or mothers/	81408
10	Lactat*	224527
11	Lactation/	44082
12	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11	1454976
13	COVID*	156147
14	Sars-cov-2	99388
15	Coronavirus	98845
16	Covid-19/ or sars-cov-2/ or coronavirus/	97776
17	13 or 14 or 15 or 16	175760
18	Stillb*	17756
19	Stillbirth/	5353
20	Intrauterine adj demise	142
21	Intrauterine adj death	1477
22	Pregnancy adj loss	6997
23	Miscarr*	15892
24	Spontaneous adj abortion	7719

25	Spontaneous abortion/	20453
26	Fetal death/ or congenital abnormalities/	57641
27	18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26	106523
28	Neonat*	309101
29	Infan*	1335539
30	Infant, newborn/	626610
31	Infant/ or infant care/ or infant mortality/ or infant death/ or infant health/	841541
32	28 or 29 or 30 or 31	1450833
33	Infect*	2447138
34	Infections/	39946
35	Sepsis	133814
36	Neonatal sepsis/ or sepsis/	63823
37	Nicu or neonatal admission	11656
38	Intensive care units, neonatal/	15858
39	Premat*	223778
40	Infant, premature/ or gestational age/ or premature birth/	139364
41	Small for gestational age or sga	16965
42	Infant, small for gestational age/ or birth weight/	46772
43	Low adj birthweight	7841
44	Infant, low birth weight/	19191
45	Operative adj delivery	1256
46	Extraction, obstetrical/	2534
47	Caesarean or c-section or cesarean	78432
48	Cesarean section/ or delivery, obstetric/	72546
49	Instrumental delivery or ventouse or forceps or vacuum extraction	14655
50	Vacuum extraction, obstetrical/ or obstetrical forceps/	2720
51	Ventilat*	201282
52	Respiratory adj distress	61778
53	CPAP or BiPAP or Continuous positive airway pressure or bilevel positive airway pressure	16071
54	Ventilation/ or respiration, artificial/	58137
55	Continuous positive airway pressure/ or positive-pressure respiration/ or noninvasive ventilation/	27370
56	Respiratory distress syndrome/	21490
57	Seizure or convulsion or fit	208598
58	Seizures/	56493
59	Hypoxic ischaemic encephalopathy or hypoxic ischemic encephalopathy or hie	5083
60	Hypoxia-ischaemia, brain/ or asphyxia neonatorum	13249
61	Therapeutic cooling or induced hypothermia	2598
62	Brain ischemia/ or hypothermia, induced/	75818

63	MRI or magnetic resonance imaging or eeg or electroencephalogram or cruss or cranial ultrasound or brain scan or brain imaging	707043
64	Neuroimaging/ or magnetic resonance imaging/ or electroencephalogram/	575390
65	Hypoton* or hyperton* or abnormal tone or spasticity or cerebral palsy or neurological disease or neurological abnormality	103230
66	Muscle spasticity/ or cerebral palsy/ or muscle hypertonia/ or muscle hypotonia/ or nervous system diseases/	78506
67	Cognitive ability or learning difficulty or learning disability or developmental delay	23602
	Learning disabilities/ or developmental disabilities/ or intellectual disability/	87101
69	Gastrointestinal disease or nec or necrotising enterocolitis or necrotizing enterocolitis	15271
70	Gastrointestinal diseases/ or enterocolitis, necrotizing/	43975
71	Visual impairment or visually impaired or blind*	395483
72	Vision disorders/	28486
73	Hearing impair* or deaf*	62891
74	Hearing loss/ or deafness/ or persons with hearing impairments/	43064
75	Quality of life or "quality of life"/	380511
76	Vertical transmi*	7322
77	Infectious disease transmission, vertical/	17257
78	33-77, combined with OR	5028529
79	78 and 32	548597
80	79 or 27	636683
81	12 and 17 and 80	1143

Global health search via Ovid, last updated 28/07/2021

#	Searches	Results
1	Pregnan*	126717
2	Pregnancy trimester, third/ or pregnancy trimester, second/ or pregnancy trimester, first/ or pregnancy/ or pregnancy, high-risk/ or pregnancy outcome/ or pregnancy complications/	99638
3	Antenat*	17826
4	Prenatal care/	3506
5	Gestat*	112821
6	Matern*	86406
7	Breastfeed*	25392
8	Breast feeding/ or mothers/	51651

9	Lactat*	50673
10	Lactation/	12941
11	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10	229179
12	COVID*	36404
13	Sars-cov-2	15628
14	Coronavirus	44855
15	Severe acute respiratory syndrome coronavirus/	5256
16	12 or 13 or 14 or 15	46013
18	Stillb*	4753
19	Stillbirth/	4006
20	Intrauterine adj demise	9
21	Intrauterine adj death	139
22	Pregnancy adj loss	923
23	Miscarr*	3987
24	Spontaneous adj abortion	3435
25	Spontaneous abortion/	2942
26	Fetal death/ or congenital abnormalities/	15922
27	18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26	21539
28	Neonat*	59142
29	Infan*	156485
30	Neonates/ or infants/	122421
31	Infant care/ or infant mortality/ or infant death/ or infant health/	5195
32	28 or 29 or 30 or 31	176742
33	Infect*	1187975
34	Infections/	488566
35	Sepsis	25827
36	Sepsis/	18064
37	Nicu or neonatal admission	2676
38	Premat*	32208
39	Premature infants/ or prematurity/	20675
40	Small for gestational age or sga	4240
41	Infant, small for gestational age/ or birth weight/	13532
42	Low adj birthweight	3185
43	Low birth weight infants/	8798
44	Operative adj delivery	117
45	Caesarean or c-section or cesarean	9334
46	Caesarean section/	5734
47	Instrumental delivery or ventouse or forceps or vacuum extraction	863
48	Parturition complications/	1384
49	Ventilat*	20633
50	Respiratory adj distress	6548
51	CPAP or BiPAP or Continuous positive airway pressure or bilevel positive airway pressure	701
52	Ventilation/ or artificial respiration/	4243

53	Acute respiratory distress syndrome/	1453
54	Seizure or convulsion or fit	27459
55	Seizures/	3152
56	Hypoxic ischaemic encephalopathy or hypoxic ischemic encephalopathy or hie	456
57	Therapeutic cooling or induced hypothermia	157
58	MRI or magnetic resonance imaging or eeg or electroencephalogram or cruss or cranial ultrasound or brain scan or brain imaging	15860
59	Magnetic resonance imaging/ or electroencephalogram/	6065
60	Hypoton* or hyperton* or abnormal tone or spasticity or cerebral palsy or neurological disease or neurological abnormality	5668
61	Cerebral palsy/ or nervous system diseases/	18651
62	Cognitive ability or learning difficulty or learning disability or developmental delay	1816
63	Learning disabilities/ or mental disorders/ or people with mental disabilities/	49942
64	Gastrointestinal disease or nec or necrotising enterocolitis or necrotizing enterocolitis	3697
65	Gastrointestinal diseases/	10201
66	Visual impairment or visually impaired or blind*	48935
67	Vision disorders/	3331
68	Hearing impair* or deaf*	5024
69	Hearing impairment/ or deafness/ or people with hearing impairment/	4259
70	Quality of life or "quality of life"/	35856
71	Vertical transmi*	5345
72	Vertical transmission/	3839
73	33-72, combined with OR	1392378
74	72 and 32	93930
75	74 or 27	110446
76	75 and 16 and 11	570

LILACS

1	SARS-CoV-2 or COVID or Coronavirus	8903
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Title	Year	First author	ID	Country	Start date	End date	Type of study	Bias assessment	Number of mothers total	Number of case mothers	Number of babies total	Number of case babies	Population	Exposure
Vertical transmission and kidney damage in newborns whose mothers had coronavirus disease 2019 during pregnancy	2020	He	DOI: 10.1016/j.ijantimicag.2020.106260	China	01/01/2020	01/04/2020	Cohort	4	22	22	22	22	All neonates born to mothers with COVID-19 at one centre	COVID-19 diagnosed on clinical criteria
Increased C-sections and preterm births in SARS-CoV-2 infection during pregnancy	2021	Carrasco	WHO: covidwho-1250003	Spain	15/03/2020	31/07/2020	Cohort	5	105	105	107	107	Infected pregnant women	
Microbiological features and follow-up of neonates born to mothers with covid-19	2021	Vazquez	WHO: covidwho-1250829	Spain	15/03/2020	30/11/2020	Cohort	5	115	115	282	282	All exposed neonates, 130 in first wave and 152 in second wave	Laboratory-confirmed COVID-19 infection, unclear of method of confirmation
COVID-19 infection in high-risk south african pregnancies with and without HIV	2021	De Waard	WHO: covidwho-1250086	South Africa	01/05/2020	31/07/2020	Cohort	5	100	100	91	91	All pregnant women	Laboratory-confirmed COVID-19 infection, unclear of method of confirmation
The impact of the novel coronavirus infection COVID-19 on the mother-placenta-fetus system	2021	Nizyaeva	DOI: 10.24075/brsmu.2021.020	Russia	01/03/2020	01/05/2020	Cohort	5	66	66	42	42	All pregnant women. Multiple pregnancies excluded.	PCR-confirmed COVID-19 and control group with negative PCR test and no signs of COVID-19
Clinical outcomes of maternal and neonate with COVID-19 infection - Multicenter study in Saudi Arabia	2021	Al-Matary	DOI: 10.1016/j.jiph.2021.03.013	Saudi Arabia	01/03/2020	01/11/2020	Cohort	5	288	288	200	200	All pregnant women	PCR-confirmed COVID-19
Characteristics, clinical and laboratory data and outcomes of pregnant women with confirmed SARS-CoV-2 infection admitted to Al-Zahra tertiary referral maternity center in Iran: a case series of 24 patients	2021	Vaezi	DOI: 10.1186/s12884-021-03764-y	Iran	10/03/2020	15/04/2020	Cohort	5	24	24	11	11	All pregnant women	Laboratory-confirmed COVID-19 infection, unclear of method of confirmation
Outcomes of newborns to mothers with COVID-19	2021	Ghema	DOI: 10.1016/j.idnow.2021.03.003	Morocco	01/01/2020	01/12/2020	Cohort	6	30	30	30	30	All neonates admitted to NICU whose mothers had COVID-19	
SARS-CoV-2 prevalence and maternal-perinatal outcomes among pregnant women admitted for delivery: Experience from COVID-19-dedicated maternity hospital in Jammu, Jammu and Kashmir (India)	2021	Gupta	DOI: 10.1002/jmv.27074	India	01/09/2020	30/11/2020	Case-control	6	3165	108	3165	108	All pregnant women delivering during study period	PCR-confirmed COVID-19
Prevalence, clinical features, and outcomes of SARS-CoV-2 infection in pregnant women with or without mild/moderate symptoms: Results from universal screening in a tertiary care center in Mexico City, Mexico	2021	Cardona-Perez	DOI: 10.1371/journal.pone.0249584	Mexico	22/04/2020	25/05/2020	Case-control	7	250	70	219	39	All pregnant women who were asymptomatic or with mild/moderate COVID-19 symptoms	PCR-confirmed COVID-19

Course of Covid 19 and fetomaternal outcome at a tertiary care hospital	2021	Furrukh	ISSN: 2957-899X	Pakistan	08/04/2020	07/07/2020	Cohort	5	47	47	24	24	All pregnant women	PCR-confirmed COVID-19
Clinical and obstetric characteristics of pregnant women with Covid-19: A case series study on 26 patients	2021	Abedzadeh-Kalahroudi	DOI: 10.1016/j.tjog.2021.03.012	Iran	01/03/2020	01/05/2020	Cohort	5	56	56	55	55	All pregnant women	PCR or radiological diagnosis of COVID-19
Fetal and perinatal outcome following first and second trimester covid-19 infection: Evidence from a prospective cohort study	2021	Rosen	DOI: 10.3390/jcm10102152	Israel	01/03/2020	01/02/2021	Cohort	6	55	55	29	29	All pregnant women	PCR-confirmed COVID-19 before 26 weeks gestation
Hearing screening outcomes in neonates of SARS-CoV-2 positive pregnant women	2021	Alan	DOI: 10.1016/j.jiporl.2021.110754	Turkey	01/04/2020	01/12/2020	Cohort	7	141	141	118	118	All neonates born to mothers with COVID-19, multiple gestation and risk factors for hearing loss excluded	PCR-confirmed COVID-19
Perinatal outcomes of pregnancies resulting from assisted reproduction technology in SARS-CoV-2-infected women: a prospective observational study	2021	Calvo	DOI: 10.1016/j.fertnstert.2021.04.005	Spain	26/02/2020	05/11/2020	Cohort	6	1347	1347	1347	1347	All pregnant women	PCR-confirmed COVID-19
The incidence, characteristics and outcomes of pregnant women hospitalized with symptomatic and asymptomatic SARS-CoV-2 infection in the UK from March to September 2020: A national cohort study using the UK Obstetric Surveillance System (UKOSS)	2021	Vousden	DOI: 10.1371/journal.pone.0251123	UK	01/03/2020	31/08/2020	Cohort	7	1148	1148	1019	1019	All hospitalised pregnant women	PCR-confirmed COVID-19
Neonatal SARS-CoV-2 infections in breastfeeding mothers	2021	Shlomai	DOI: 10.1542/peds.2020-010918	Israel	01/03/2020	01/05/2020	Cohort	5	53	53	55	55	All pregnant women delivering during study period	PCR-confirmed COVID-19
COVID-19 in pregnancy-characteristics and outcomes of pregnant women admitted to hospital because of SARS-CoV-2 infection in the Nordic countries	2021	Engjom	DOI: 10.1111/aogs.14160	Denmark, Finland, Iceland, Sweden and Norway	01/03/2020	30/06/2020	Cohort	5	56	56	51	51	All pregnant women admitted to hospital for at least 24h	PCR-confirmed SARS-CoV-2 in 14 days before admission
Consequences of SARS-CoV-2 disease on maternal, perinatal and neonatal outcomes: A retrospective observational cohort study	2021	Abdulghani	DOI: 10.31083/j.ceog.2021.02.2361	Saudi Arabia	01/03/2020	31/05/2020	Cohort	6	62	62	63	63	All pregnant women	PCR-confirmed COVID-19
Pre and post-natal epidemiological and clinical features of neonates born from mothers infected with COVID-19 and 14-day follow-up post discharge in Lima, Peru	2021	Lizama	DOI: 10.20453/RMH.V32i1.3942	Peru	15/03/2020	30/06/2020	Cohort	6	206	206	206	206	All pregnant women	Laboratory-confirmed COVID-19 infection, unclear of method of confirmation
Childbirth care among sars-cov-2 positive women in Italy	2021	Donati	DOI: 10.3390/ijerph18084244	Italy	25/02/2020	31/07/2020	Cohort	5	525	525	538	538	All pregnant women; until end of March 2020 only symptomatic and contacts screened, then all	PCR-confirmed COVID-19

Association of Maternal SARS-CoV-2 Infection in Pregnancy with Neonatal Outcomes	2021	Norman	DOI: 10.1001/jama.2021.5775	Sweden	11/03/2020	31/01/2021	Case-control	8	84719	2286	88159	2323	All live-born infants, malformations excluded except PDA	PCR-confirmed COVID-19; from June 2020 all women tested vs just symptomatic women
Maternal and Neonatal Morbidity and Mortality among Pregnant Women with and without COVID-19 Infection: The INTERCOVID Multinational Cohort Study	2021	Villar	DOI: 10.1001/jamapediatrics.2021.1050	International	02/03/2020	02/10/2020	Case-control	8	2130	706	2130	706	All pregnant women	PCR, radiological or clinical criteria based diagnosis of COVID-19
Retrospective Analysis of Clinical Characteristics and Neonatal Outcomes of Pregnant Women with SARS-CoV-2 Infection	2021	Chen	DOI: 10.1007/s11596-021-2347-9	China	01/02/2020	30/03/2020	Cohort	5	8	8	9	9	All pregnant women	COVID-19 diagnosed on clinical criteria
Mother-Infant Dyads with COVID-19 at an Urban, Safety-Net Hospital: Clinical Manifestations and Birth Outcomes	2021	Sabharwal	DOI: 10.1055/s-0041-1726429	USA	31/03/2020	06/08/2020	Cohort	5	75	75	75	75	All symptomatic pregnant women delivering during study period	PCR-confirmed COVID-19
Effect of SARS-CoV-2 Infection on Pregnancy Outcomes in an Inner-City Black Patient Population	2021	Liu	DOI: 10.1007/s10900-021-00988-z	USA	10/04/2020	10/06/2020	Case-control	6	335	56	335	56	All women who delivered	PCR-confirmed COVID-19
Short-term developmental outcomes in neonates born to mothers with COVID-19 from Wuhan, China	2021	Zeng	DOI: 10.1007/s12519-021-00426-z	China	01/02/2020	15/05/2020	Cohort	6	68	68	72	72	All neonates born to women with COVID-19	COVID-19 diagnosed on clinical criteria
The Society for Obstetric Anesthesia and Perinatology (SOAP) COVID-19 Registry: An analysis of outcomes among pregnant women delivering during the initial SARS-CoV-2 outbreak in the United States	2021	Katz	DOI: 10.1213/ANE.0000000000005592	USA	19/03/2020	31/05/2020	Case-control	7	1454	490	1454	490		PCR-confirmed COVID-19 within 14 days of delivery date
Experience of covid-19 infections in neonates in tertiary care centre in North Karnataka, India: A prospective cohort study	2021	Charki	ISSN: 0971-9032	India	01/05/2020	01/10/2020	Cohort	5	26	26	28	28	All neonates born to women with COVID-19	PCR-confirmed COVID-19
Outcomes of Neonates Born to Mothers with Severe Acute Respiratory Syndrome Coronavirus 2 Infection at a Large Medical Center in New York City	2021	Dumitriu	DOI: 10.1001/jamapediatrics.2020.4298	USA	13/03/2020	24/04/2020	Cohort	6	100	100	101	101	All neonates born to women with COVID-19	PCR-confirmed COVID-19
Management of labour, puerperium, and lactation in SARS-CoV-2 positive women. Multicentric study in the Valencian Community.	2021	Vila-Candel	DOI: 10.1016/j.enfcli.2021.01.006	Spain	01/03/2020	30/06/2020	Cohort	5	13	13	13	13	All pregnant women who delivered	PCR-confirmed COVID-19
Impact of evolving practices on SARS-CoV-2 positive mothers and their newborns in the largest public healthcare system in America.	2021	Malhotra	DOI: 10.1038/s41372-021-01023-8	USA	01/03/2020	09/05/2020	Cohort	7	286	286	290	290	All pregnant women who delivered	PCR-confirmed COVID-19
Characteristics and Pregnancy Outcomes of Asymptomatic and Symptomatic Women with COVID-19: Lessons from Hospitals in Wuhan.	2021	Luo	DOI: 10.3855/jidc.14010	China	30/01/2020	15/04/2020	Cohort	5	41	41	42	42	All pregnant patients admitted	PCR or radiological diagnosis of COVID-19
Association of Maternal Perinatal SARS-CoV-2 Infection With Neonatal	2021	Angelidou	DOI: 10.1001/jamanetworkopen.2021.7523	USA	01/03/2020	31/07/2020	Cohort	6	250	250	255	255	All mother-infant dyads whose delivery and	PCR-confirmed COVID-19

Outcomes During the COVID-19 Pandemic in Massachusetts.													discharge fell within the study period	
SARS-CoV-2 infection in pregnant women and newborns in a Spanish cohort (GESNEO-COVID) during the first wave.	2021	Carrasco	DOI: 10.1186/s12884-021-03784-8	Spain	15/03/2020	31/07/2020	Cohort	6	105	105	107	107	All pregnant women delivering during study period	PCR, serological or clinical criteria based diagnosis of COVID-19
Pregnancy and perinatal outcomes of women with coronavirus disease (COVID-19) pneumonia: a preliminary analysis.	2020	Liu	DOI: 10.2214/AJR.20.23072	China	20/01/2020	10/02/2020	Cohort	6	11	11	11	11		PCR-confirmed COVID-19
Characteristics and outcomes of pregnant women admitted to hospital with confirmed SARS-CoV-2 infection in UK: national population based cohort study.	2020	Knight	DOI: 10.1136/bmj.m2107	U.K	01/03/2020	14/04/2020	Cohort	7	427	427	259	259		PCR-confirmed COVID-19
Clinical features and outcomes of pregnant women suspected of coronavirus disease 2019.	2020	Yang	DOI: 10.1016/j.jinf.2020.04.003	China	20/01/2020	05/03/2020	Case-control	6	55	13	57	13	All pregnant women delivering during study period	PCR-confirmed COVID-19
Clinical features and obstetric and neonatal outcomes of pregnant patients with COVID-19 in Wuhan, China: a retrospective, single-centre, descriptive study.	2020	Yu	DOI: 10.1016/S1473-3099(20)30176-6	China	01/01/2020	08/02/2020	Cohort	6	7	7	7	7		PCR-confirmed COVID-19
Covid-19 in pregnant women: General data from a French National Survey.	2020	Cohen	DOI: 10.1186/s12958-020-00605	France	Not stated		Cohort	4	88	88	14	14		PCR, serological or radiological diagnosis of COVID-19
Association Between Mode of Delivery Among Pregnant Women With COVID-19 and Maternal and Neonatal Outcomes in Spain.	2020	Martinez-Perez	DOI: 10.1001/jama.2020.10125	Spain	12/03/2020	06/04/2020	Cohort	7	82	82	78	78		PCR-confirmed COVID-19
Vaginal delivery in SARS-CoV-2-infected pregnant women in Northern Italy: a retrospective analysis.	2020	Ferrazzi	DOI: 10.1111/1471-0528.16278	Italy	01/03/2020	20/03/2020	Cohort	5	42	42	42	42		PCR-confirmed COVID-19
Characteristics and Outcomes of 241 Births to Women With Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection at Five New York City Medical Centers.	2020	Khoury	DOI: 10.1097/AOG.0000000000004025.	USA	12/03/2020	12/04/2020	Cohort	6	241	241	245	245		PCR-confirmed COVID-19
Evaluating Clinical Course and Risk Factors of Infection and Demographic Characteristics of Pregnant Women with COVID-19 in Hamadan Province, West of Iran.	2020	Sattari	DOI: 10.34172/jrhs.2020.22	Iran	06/01/2020	21/06/2020	Cohort	6	50	50	25	25		COVID-19 diagnosed on clinical criteria
Birth and Infant Outcomes Following Laboratory-Confirmed SARS-CoV-2 Infection in Pregnancy	2020	Woodworth	DOI: 10.15585/mmwr.mm6944e2.	USA	29/03/2020	14/10/2020	Cohort	5	5252	5252	4495	4495		?
Pregnant women with COVID-19 and risk of adverse birth outcomes and maternal-fetal vertical transmission: a population-based cohort study in Wuhan, China.	2020	Yang	DOI: 10.1186/s12916-020-01798-1	China	13/01/2020	18/03/2020	Cohort	6	65	65	58	58		PCR or clinical criteria based diagnosis of COVID-19

Maternal and neonatal outcomes in COVID-19 infected pregnancies: a prospective cohort study.	2020	Pirjani	DOI: 10.1093/jtm/taaa158	Iran	01/03/2020	01/09/2020	Cohort	8	43	43	43	43	PCR-confirmed COVID-19
Neonatal outcome in 29 pregnant women with COVID-19: A retrospective study in Wuhan, China.	2020	Wu	DOI: 10.1371/journal.pmed.1003195	China	30/01/2020	10/03/2020	Cohort	5	29	29	29	29	PCR or radiological diagnosis of COVID-19
Pregnancy and postpartum outcomes in a universally tested population for SARS-CoV-2 in New York City: a prospective cohort study.	2020	Prabhu	DOI: 10.1111/1471-0528.16403	USA	24/03/2020	20/04/2020	Cohort	8	70	70	69	69	PCR-confirmed COVID-19
SARS-CoV-2 infection among hospitalized pregnant women: reasons for admission and pregnancy characteristics - eight U.S. health care centers, March 1-May 30, 2020.	2020	Panagiotakopoulos	DOI: 10.15585/mmwr.mm6938e2.	USA	01/03/2020	30/05/2020	Cohort	5	105	105	93	93	All hospitalised pregnant women PCR-confirmed COVID-19
Characteristics and maternal and birth outcomes of hospitalized pregnant women with laboratory-confirmed COVID-19 - COVID-NET, 13 states, March 1-August 22, 2020.	2020	Delahoy	DOI: 10.15585/mmwr.mm6938e1.	USA	01/03/2020	22/08/2020	Cohort	6	458	458	448	448	PCR-confirmed COVID-19
Safety of vaginal delivery in women infected with COVID-19.	2021	Lopian	DOI: 10.1016/j.pedneo.2020.10.010.	Israel	23/03/2020	08/05/2020	Cohort	5	21	21	21	21	PCR-confirmed COVID-19
Pregnancy with COVID-19 infection and fetomaternal outcomes.	2021	Sharma	DOI: 10.14260/jemds/2021/5	India	21/04/2020	07/09/2020	Cohort	6	125	125	97	97	PCR-confirmed COVID-19
Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) universal screening in gravids during labor and delivery.	2021	Saviron-Cornudella	DOI: 10.1016/j.ejogrb.2020.11.069.	Spain	31/03/2020	31/08/2020	Cohort	4	6	6	6	6	PCR-confirmed COVID-19
Clinical findings and disease severity in hospitalized pregnant women with coronavirus disease 2019 (COVID-19).	2020	Savasi	DOI: 10.1097/AOG.0000000000003979.	Italy	23/02/2020	28/03/2020	Cohort	5	77	77	57	57	PCR-confirmed COVID-19
Neonatal management and outcomes during the COVID-19 pandemic: an observation cohort study.	2020	Salvatore	DOI: 10.1016/S2352-4642(20)30235-2	USA	22/03/2020	17/05/2020	Cohort	8	116	116	120	120	PCR-confirmed COVID-19
Maternal COVID-19 infection, clinical characteristics, pregnancy, and neonatal outcome: a prospective cohort study.	2020	Antoun	DOI: 10.1016/j.ejogrb.2020.07.008	UK	01/02/2020	01/04/2020	Cohort	6	23	23	20	20	PCR-confirmed COVID-19
Outcomes of maternal-newborn dyads after maternal SARS-CoV-2.	2020	Verma	DOI: 10.1542/peds.2020-005637	USA	01/03/2020	10/05/2020	Cohort	6	149	149	149	149	PCR-confirmed COVID-19
Effects of severe acute respiratory syndrome coronavirus 2 infection on pregnant women and their infants: a retrospective study in Wuhan, China.	2020	Yang	DOI: 10.5858/arpa.2020-0232-SA.	China	20/01/2020	19/03/2020	Cohort	6	23	23	23	23	PCR-confirmed COVID-19
Coronavirus disease 2019 in pregnancy was associated with maternal morbidity and preterm birth.	2020	Sentilhes	DOI: 10.1016/j.ajog.2020.06.022.	France	01/03/2020	03/04/2020	Cohort	5	54	54	21	21	PCR or clinical criteria based diagnosis of COVID-19
Clinical characteristics of 46 pregnant women with a severe acute respiratory syndrome coronavirus 2	2020	Lokken	DOI: 10.1016/j.ajog.2020.05.031.	USA	21/01/2020	17/04/2020	Cohort	5	46	46	8	8	PCR-confirmed COVID-19

infection in Washington state.														
SARS-CoV-2/COVID-19 infection in pregnancy and its outcome in a rural tertiary care centre of West Bengal.	2020	Saha	WHO: covidwho-1001351	India	Not stated	Not stated	Cohort	5	3	3	3	3	All women attending hospital	PCR-confirmed COVID-19
The impact of COVID-19 infection on labor and delivery, newborn nursery, and neonatal intensive care unit: prospective observational data from a single hospital system.	2020	Griffin	DOI: 10.1055/s-0040-1713416	USA	21/04/2020	05/05/2020	Cohort	8	27	27	27	27		PCR or clinical criteria based diagnosis of COVID-19
Clinical course of coronavirus disease-2019 in pregnancy.	2020	Pereira	WHO: covidwho-622517	Spain	14/03/2020	14/04/2020	Cohort	6	60	60	23	23		PCR-confirmed COVID-19
Pregnancy Outcomes in COVID-19: A Prospective Cohort Study in Singapore.	2020	Mattar	DOI: 10.47102/annals-acadmedsg.2020437.	Singapore	15/03/2020	22/08/2020	Cohort	6	16	16	5	5		PCR-confirmed COVID-19
A pandemic center's experience of managing pregnant women with COVID-19 infection in Turkey: A prospective cohort study.	2020	Sahin	DOI: 10.1002/ijgo.13318	Turkey	11/03/2020	11/06/2020	Cohort	7	29	29	10	10		PCR-confirmed COVID-19
Vertical Transmission of COVID-19 to the Neonate.	2020	Moreno	DOI: 10.1155/2020/8460672	USA	20/03/2020	30/04/2020	Cohort	6	19	19	21	21		PCR-confirmed COVID-19
Maternal and Neonatal Outcomes of Pregnant Women With Coronavirus Disease 2019 (COVID-19) Pneumonia: A Case-Control Study.	2020	Li	DOI: 10.1093/cid/ciaa352.	China	24/01/2020	29/02/2020	Cohort	6	16	16	17	17		PCR-confirmed COVID-19
Maternal and perinatal characteristics and outcomes of pregnancies complicated with COVID-19 in Kuwait.	2020	Ayed	DOI: 10.1186/s12884-020-03461-2	Kuwait	15/03/2020	31/05/2020	Cohort	5	185	185	167	167		PCR-confirmed COVID-19
Pregnancy Outcomes Among Women With and Without Severe Acute Respiratory Syndrome Coronavirus 2 Infection.	2020	Adhikari	DOI: 10.1001/jamanetworkopen.2020.29256	USA	18/03/2020	22/08/2020	Cohort	8	252	252	251	251		PCR-confirmed COVID-19
SARS-CoV-2 screening of asymptomatic women admitted for delivery must be performed with a combination of microbiological techniques: an observational study.	2020	Vinuela	DOI: 10.37201/req/088.2020.	Spain	06/05/2020	21/05/2020	Cohort	6	9	9	9	9		PCR-confirmed COVID-19
Disease severity and perinatal outcomes of pregnant patients with coronavirus disease 2019 (COVID-19).	2021	Metz	DOI: 10.1097/AOG.0000000000004339.	USA	01/03/2020	31/07/2020	Cohort	6	1291	1291	1196	1196		PCR-confirmed COVID-19
Assessing disease outcome in COVID-19 pregnancies in a tertiary referral center in South India: a single-center retrospective cohort study.	2020	Nambiar	DOI: 10.5005/jp-journals-10006-1822	India	01/04/2020	01/09/2020	Cohort	5	350	350	253	254		Laboratory-confirmed COVID-19 infection, unclear of method of confirmation
Screening of severe acute respiratory syndrome coronavirus-2 infection during labor and delivery using polymerase chain reaction and immunoglobulin testing.	2021	Saviron-Cornudella	DOI: 10.1016/j.jfs.2021.119200	Spain	31/03/2020	30/09/2020	Cohort	6	22	22	22	22		PCR-confirmed COVID-19

Management of gestational diabetes in women with a concurrent severe acute respiratory syndrome coronavirus 2 infection, experience of a single center in northern Italy.	2020	D'Ambrosi	DOI: 10.1002/ijgo.13434	Italy	01/03/2020	30/04/2020	Cohort	6	6	6	6	6	PCR-confirmed COVID-19
Epidemiology, management and risk of SARS-CoV-2 transmission in a cohort of newborns born to mothers diagnosed with COVID-19 infection.	2021	Solis-Garcia	DOI: 10.1016/j.janpede.2020.12.006	Spain	01/03/2020	17/08/2020	Cohort	6	73	73	75	75	PCR-confirmed COVID-19
Outcomes of neonates born to mothers with severe acute respiratory syndrome coronavirus 2 infection at a large medical center in New York city.	2021	Dumitriu	DOI: 10.1001/jamapediatrics.2020.4298	USA	13/03/2020	24/04/2020	Cohort	6	100	100	101	101	PCR or clinical criteria based diagnosis of COVID-19
Neonates born to mothers with COVID-19: data from the Spanish society of neonatology registry.	2021	Sanchez-Luna	DOI: 10.1542/peds.2020-015065	Spain	08/03/2020	26/05/2020	Cohort	6	493	493	503	503	PCR or serology-confirmed COVID-19
Comparison of hematological parameters and perinatal outcomes between COVID-19 pregnancies and healthy pregnancy cohort.	2021	Koc	DOI: 10.1515/jpm-2020-0403	Turkey	20/03/2020	25/07/2020	Case-control	7	39	39	39	39	All pregnant women admitted PCR-confirmed COVID-19
SARS-CoV-2 in pregnancy: maternal and perinatal outcome data of 34 pregnant women hospitalised between may and October 2020.	2021	Hall	DOI: 10.1515/jpm-2020-0499	Austria	11/05/2020	14/10/2020	Cohort	5	35	35	28	28	PCR-confirmed COVID-19
The Relationship between Status at Presentation and Outcomes among Pregnant Women with COVID-19.	2020	London	DOI: 10.1055/s-0040-1712164	USA	15/03/2020	10/04/2020	Cohort	6	58	58	55	55	PCR-confirmed COVID-19
Analysis of vaginal delivery outcomes among pregnant women in Wuhan, China during the COVID-19 pandemic.	2020	Liao	DOI: 10.1002/ijgo.13188	China	20/01/2020	02/03/2020	Case-control	7	10	10	10	10	All pregnant women delivering during study period COVID-19 diagnosed on clinical criteria
A multicenter study on epidemiological and clinical characteristics of 125 newborns born to women infected with COVID-19 by Turkish Neonatal Society.	2021	Oncel	DOI: 10.1007/s00431-020-03767-5	Turkey	15/03/2020	15/06/2020	Cohort	5	125	125	120	120	PCR-confirmed COVID-19
Assessment of Maternal and Neonatal SARS-CoV-2 Viral Load, Transplacental Antibody Transfer, and Placental Pathology in Pregnancies During the COVID-19 Pandemic.	2020	Edlow	DOI: 10.1001/jamanetworkopen.2020.30455	USA	02/04/2020	13/06/2020	Cohort	8	64	64	64	64	PCR-confirmed COVID-19
Maternal and perinatal outcomes of pregnant women with SARS-CoV-2 infection.	2021	World Association of Perinatal Medicine Working Group on COVID-19	DOI: 10.1002/uog.23107	Multiple	01/02/2020	30/04/2020	Cohort	6	388	388	266	266	PCR-confirmed COVID-19
Impact of the Coronavirus Infection in Pregnancy: A Preliminary Study of 141 Patients.	2020	Nayak	DOI: 10.1007/s13224-020-01335-3	India	01/04/2020	15/05/2020	Cohort	7	141	141	131	131	PCR-confirmed COVID-19
Perinatal COVID-19 in Latin America.	2020	Sola	DOI: 10.26633/RPSP.2020.47	Latin America	06/03/2020	30/05/2020	Cohort	5	86	86	86	86	All pregnant women PCR-confirmed COVID-19
Clinical characteristics, maternal and neonatal	2021	Ozsurmeli	DOI: 10.4149/BLL_2021_023	Turkey	11/03/2020	01/07/2020	Cohort	6	24	24	10	10	PCR-confirmed COVID-19

outcomes of pregnant women with SARS-CoV-2 infection in Turkey.															
Maternal, fetal and neonatal outcomes of large series of SARS-CoV-2 positive pregnancies in peripartum period: A single-center prospective comparative study.	2021	Hcini	DOI: 10.1016/j.ejogrb.2020.11.068	French Guiana	16/06/2020	16/08/2020	Cohort	6	137	137	127	127			PCR-confirmed COVID-19
Perinatal outcomes and serological results in neonates of pregnant women seropositive to SARS-CoV-2: A cross-sectional descriptive study.	2020	Davila-Aliaga	DOI: 10.5867/medwave.2020.11.8084.	Peru	15/04/2020	10/05/2020	Cohort	5	114	114	114	114	All pregnant women admitted		Serological diagnosis of COVID-19
Clinical Stratification of Pregnant COVID-19 Patients based on Severity: A Single Academic Center Experience.	2021	Berry	DOI: 10.1055/s-0041-1723761	USA	01/03/2020	01/07/2020	Cohort	6	91	91	60	60	All pregnant women admitted		PCR-confirmed COVID-19
Pregnancy and neonatal outcomes of COVID-19: coreporting of common outcomes from PAN-COVID and AAP-SONPM registries.	2021	Mullins	DOI: 10.1002/uog.23619	Worldwide	01/01/2020	25/07/2020	Cohort	7	3050	3050	3050	3050	All pregnant women		PCR-confirmed COVID-19
Updated experience of a tertiary pandemic center on 533 pregnant women with COVID-19 infection: A prospective cohort study from Turkey.	2021	Sahin Surel	DOI: 10.1002/ijgo.13460	Turkey	11/03/2020	10/09/2020	Cohort	6	533	533	131	131			PCR-confirmed COVID-19
Maternal and Neonatal Outcomes of COVID-19 in Pregnancy: A Single-Centre Observational Study.	2021	Singh	DOI: 10.7759/cureus.13184.	India	15/05/2020	15/11/2020	Cohort	6	132	132	125	125			PCR-confirmed COVID-19
Characteristics and outcomes of neonatal SARS-CoV-2 infection in the UK: a prospective national cohort study using active surveillance.	2021	Gale	DOI: 10.1016/S2352-4642(20)30342-4	UK	01/03/2020	30/04/2020	Cohort	8	17	17	66	66	All neonates with confirmed SARS-CoV-2		PCR-confirmed COVID-19
COVID-19 in a cohort of pregnant women and their descendants, the MOACC-19 study.	2021	Llorca	DOI: 10.1136/bmjopen-2020-044224	Spain	23/05/2020	22/10/2020	Cohort	6	14	14	14	14			PCR-confirmed COVID-19
Coronavirus disease 2019 in pregnancy	2020	Qiancheng	DOI: 10.1016/j.ijid.2020.04.065	China	15/01/2020	15/03/2020	Cohort	6	82	82	23	23			PCR-confirmed COVID-19
Clinical analysis of ten pregnant women with COVID-19 in Wuhan, China: A retrospective study	2020	Cao	DOI: 10.1016/j.ijid.2020.04.047	China	23/01/2020	23/02/3030	Cohort	5	10	10	10	10			PCR-confirmed COVID-19
Maternal, Perinatal and Neonatal Outcomes with COVID-19: A Multicenter Study of 242 Pregnancies and Their 248 Infant Newborns during Their First Month of Life	2020	Marin Gabriel	DOI: 10.1097/INF.0000000000002902	Spain	13/03/2020	31/05/2020	Cohort	6	242	242	248	248			PCR or serology-confirmed COVID-19
Clinical course of novel COVID-19 infection in pregnant women	2020	Shmakov	DOI: 10.1080/14767058.2020.1850683	Russia	Not stated	Not stated	Cohort	5	66	66	42	42	All pregnant women admitted		PCR-confirmed COVID-19
Vaginal delivery in SARS-CoV-2-infected pregnant women in Israel: a multicenter prospective analysis	2020	Rottenstreich	DOI: 10.1007/s00404-020-05854-2	Israel	15/03/2020	04/07/2020	Cohort	6	52	52	52	52			PCR-confirmed COVID-19
Clinical Analysis of Neonates Born to Mothers with or without COVID-19: A	2020	Liu	DOI: 10.1055/s-0040-1716505	China	17/01/2020	04/03/2020	Case-control	6	31	15	31	15			PCR or radiological

Retrospective Analysis of 48 Cases from Two Neonatal Intensive Care Units in Hubei Province																diagnosis of COVID-19
Characteristics of Newborns Born to SARS-CoV-2-Positive Mothers: A Retrospective Cohort Study	2020	Farghaly	DOI: 10.1055/s-0040-1715862	USA	01/03/2020	01/05/2020	Case-control	8	79	15	79	15				PCR-confirmed COVID-19
Poor maternal-neonatal outcomes in pregnant patients with confirmed SARS-Cov-2 infection: analysis of 145 cases	2021	Di Guardo	DOI: 10.1007/s00404-020-05909-4	Italy	01/03/2020	01/07/2020	Cohort	6	145	145	145	145				PCR-confirmed COVID-19
Coronavirus and birth in Italy: results of a national population-based cohort study	2020	Maraschini	DOI: 10.4415/ANN_20_03_17.	Italy	25/02/2020	22/04/2020	Cohort	7	146	146	147	147				PCR, serological or radiological diagnosis of COVID-19
Infant Outcomes Following Maternal Infection with SARS-CoV-2: First Report from the PRIORITY Study	2020	Flaherman	DOI: 10.1093/cid/ciaa1411	USA	22/03/2020	22/06/2020	Case-control	8	263	179	263	179				PCR-confirmed COVID-19
Incidence and clinical profiles of COVID-19 pneumonia in pregnant women: A single-centre cohort study from Spain	2020	San-Juan	DOI: 10.1016/j.eclinm.2020.100407	Spain	05/03/2020	05/04/2020	Cohort	6	52	52	6	6				PCR-confirmed COVID-19
Vaginal delivery in SARS-CoV-2-infected pregnant women in Northern Italy: a retrospective analysis	2020	Ferrazzi	DOI: 10.1111/1471-0528.16278	Italy	01/03/2020	20/03/2020	Cohort	6	42	42	42	42				PCR-confirmed COVID-19
Obstetric Outcomes of SARS-CoV-2 Infection in Asymptomatic Pregnant Women	2021	Cruz-Lemini	DOI: 10.3390/v13010112.	Spain	23/03/2020	31/03/2020	Case-control	8	604	174	604	174				PCR-confirmed COVID-19
SARS-CoV-2 infection in pregnancy and newborn in a Spanish multicentric cohort (GESNEO-COVID)	2020	Carrasco	DOI: doi.org/10.1186/s12884-021-03784-8	Spain	15/03/2020	31/07/2020	Cohort	6	105	105	107	107				PCR or serology-confirmed COVID-19
Clinical course of severe and critical coronavirus disease 2019 in hospitalized pregnancies: a United States cohort study	2020	Pierce-Williams	DOI: 10.1016/j.ajogmf.2020.100134	USA	05/03/2020	20/04/2020	Cohort	6	64	64	33	33				PCR-confirmed COVID-19
Rates of seroprevalance of COVID-19 among pregnant patients in New York City	2021	Baptiste	DOI: 10.1016/j.ajog.2020.12.944	USA	24/06/2020	16/07/2020	Cohort	6	47	19	47	19				PCR or serology-confirmed COVID-19
Maternal and neonatal outcomes of pregnant patients with coronavirus disease 2019 (COVID-19): A multistate cohort	2021	Metz	DOI: 10.1016/j.ajog.2020.12.1204	USA	01/03/2020	31/07/2020	Cohort	6	1219	1219	1196	1196				PCR or serology-confirmed COVID-19
Obstetrical and neonatal outcomes among pregnancies with SARS-CoV-2	2021	Trahan	DOI: 10.1016/j.ajog.2020.12.385	Canada	22/03/2020	31/07/2020	Case-control	7	206	43	209	45				PCR-confirmed COVID-19
Comparison of clinical outcomes in pregnant women with and without COVID-19 based on disease severity	2021	Gold	DOI: 10.1016/j.ajog.2020.12.585	USA	01/03/2020	01/07/2020	Case-control	4	486	91	486	91	All pregnant women delivering during study period			Unclear
Neonatal outcomes of COVID-19 positive mothers	2021	Zarudskaya	DOI: 10.1016/j.ajog.2020.12.568	USA	01/03/2020	01/08/2020	Case-control	7	28	10	28	10				PCR-confirmed COVID-19
Perinatal outcomes of asymptomatic versus symptomatic COVID positive pregnant women	2021	Andrikopoulou	DOI: 10.1016/j.ajog.2020.12.097	USA	12/03/2020	12/08/2020	Cohort	6	157	157	156	156				PCR-confirmed COVID-19
Neonatal outcomes in pregnant women with diagnosis of COVID-19	2021	Izewski	DOI: 10.1016/j.ajog.2020.12.809	USA	01/03/2020	31/03/2020	Case-control	7	515	460	55	55				PCR-confirmed COVID-19

Infant outcomes and maternal COVID-19 status at delivery	2021	Zgutka	DOI: 10.1515/jpm-2020-0481.	USA	15/03/2020	15/06/2020	Case-control	5	184	60	186	62	PCR-confirmed COVID-19
Initial review of pregnancy and neonatal outcomes of pregnant women with COVID-19 infection	2021	Ogamba	DOI: 10.1515/jpm-2020-0446	USA	17/03/2020	04/06/2020	Cohort	6	40	40	25	25	PCR or serology-confirmed COVID-19
Impact of SARS-CoV-2 Infection on Pregnancy Outcomes: A Population-Based Study	2021	Crovetto	DOI: 10.1093/cid/ciab104	Spain	15/03/2020	31/05/2020	Case-control	8	2225	317	1338	178	PCR or serology-confirmed COVID-19
Management and short-term outcomes of infants born to mothers with active perinatal covid-19 infection	2021	Lamba	DOI: 10.1186/s12887-021-02872-0	USA	01/04/2020	01/10/2020	Cohort	5	43	43	43	43	PCR-confirmed COVID-19
Maternal and perinatal outcomes of pandemic Covid-19 in pregnancy in Basrah	2021	Sharief	ISSN: 2515-8260	Iraq	15/03/2020	01/11/2020	Cohort	6	135	135	110	110	PCR-confirmed COVID-19
Maternal, neonatal and placental characteristics of SARS-CoV-2 positive mothers	2021	Zhang	DOI: 10.1080/14767058.2021.1892637	USA	01/03/2020	01/08/2020	Case-control	8	219	142	219	142	PCR-confirmed COVID-19
Disease severity, pregnancy outcomes, and maternal deaths among pregnant patients with severe acute respiratory syndrome coronavirus 2 infection in Washington State	2021	Lokken	DOI: 10.1016/j.ajog.2020.12.1221	USA	01/03/2020	30/06/2020	Cohort	6	240	240	156	156	PCR-confirmed COVID-19
Maternal and perinatal outcomes in high vs low risk-pregnancies affected by SARS-COV-2 infection (Phase-2): The WAPM (World Association of Perinatal Medicine) working group on COVID-19	2021	D'Antonio	DOI: 10.1016/j.ajogmf.2021.100329	25 countries	04/04/2020	28/10/2020	Cohort	6	887	887	874	874	PCR-confirmed COVID-19
Epidemiology of coronavirus disease 2019 in pregnancy: risk factors and associations with adverse maternal and neonatal outcomes	2021	Brandt	DOI: 10.1016/j.ajog.2020.09.043	USA	11/03/2020	11/06/2020	Case-control	8	183	122	184	123	PCR-confirmed COVID-19
Covid 19 infection in pregnant women and newborn infants at a single U.S. center: What disparities, testing and isolation practices can teach US	2020	Camelo	DOI: 10.1093/ofid/ofaa439.718	USA	31/03/2020	17/06/2020	Cohort	6	36	36	32	32	PCR-confirmed COVID-19
The association between SARS-CoV-2 infection and preterm delivery: a prospective study with a multivariable analysis	2021	Martinez-Perez	DOI: 10.1186/s12884-021-03742-4	Spain	23/03/2020	31/05/2020	Case-control	8	1009	246	1009	246	PCR-confirmed COVID-19
Pregnancy Outcomes among Women with and without Severe Acute Respiratory Syndrome Coronavirus 2 Infection	2020	Adhikari	DOI: 10.1001/jamanetworkopen.2020.29256	USA	18/03/2020	22/08/2020	Case-control	8	3374	252	3263	248	PCR-confirmed COVID-19
Clinicolaboratory profile of and outcomes in neonates born to covid-19-positive mothers	2021	Sehra	ISSN: 0972-2408	India	13/04/2020	31/07/2020	Cohort	6	120	120	120	120	PCR-confirmed COVID-19
Clinical Profile, Viral Load, Maternal-Fetal Outcomes of Pregnancy With COVID-19: 4-Week Retrospective, Tertiary Care Single-Centre Descriptive Study	2021	Bachani	DOI: 10.1016/j.jogc.2020.09.021	India	05/05/2020	05/06/2020	Cohort	6	57	57	56	56	PCR-confirmed COVID-19

Management and Early Outcomes of Neonates Born to Women with SARS-CoV-2 in 16 US Hospitals	2021	Congdon	DOI: 10.1055/s-0041-1726036	USA	01/03/2020	01/05/2020	Cohort	6	70	70	70	70	PCR-confirmed COVID-19
Maternal and neonatal outcomes of pregnant patients with COVID-19: A prospective cohort study	2021	Abedzadeh-Kalahrودي	DOI: 10.1002/ijgo.13661	Iran	01/03/2020	01/11/2020	Case-control	8	150	56	149	55	PCR-confirmed COVID-19
Multicentre Spanish study found no incidences of viral transmission in infants born to mothers with COVID-19	2020	Marin Gabriel	DOI: 10.1111/apa.15474	Spain	13/03/2020	29/03/2020	Cohort	6	42	42	42	42	PCR-confirmed COVID-19
SARS-CoV-2 Infection during Pregnancy in a Rural Midwest All-delivery Cohort and Associated Maternal and Neonatal Outcomes	2021	Steffen	DOI: 10.1055/s-0041-1723938	USA	01/05/2020	22/09/2020	Case-control	8	1000	61	1021	62	PCR-confirmed COVID-19
Maternal and perinatal outcomes of pregnant women with SARS-CoV-2 infection	2021	World Association of Perinatal Medicine Working Group on COVID-19	DOI: 10.1002/uog.23107	Multiple	01/02/2020	30/04/2020	Cohort	6	388	388	251	251	PCR-confirmed COVID-19
A single-center observational study on clinical features and outcomes of 21 SARS-CoV-2-infected neonates from India	2021	Nanavati	DOI: 10.1007/s00431-021-03967-7	India	15/04/2020	31/07/2020	Cohort	6	122	122	125	125	PCR-confirmed COVID-19
Perinatal outcomes in pregnant women with COVID-19 in Siberia and the Russian Far East	2021	Artymuk	DOI: 10.1080/14767058.2021.1881954	Russia	Not stated	25/12/2020	Cohort	5	8485	8485	2383	2383	
Prevalence and Risk Factors of Neonatal Covid-19 Infection: A Single-Centre Observational Study	2021	Ajith	DOI: 10.1007/s13224-021-01436-7	India	15/04/2020	15/10/2020	Cohort	6	350	350	223	223	PCR-confirmed COVID-19
Impact of Covid-19 in pregnancy on mother's psychological status and infant's neurobehavioral development: a longitudinal cohort study in China.	2020	Wang	DOI: 10.1186/s12916-020-01825-1	China	01/05/2020	31/07/2020	Cohort	6	72	72	57	57	PCR-confirmed COVID-19
Vertical Transmission of Novel Coronavirus (COVID-19) from Mother to Newborn: Experience from a Maternity Unit, The Indus Hospital, Karachi.	2020	Khan	DOI: 10.29271/jcpsp.2020.10.136	Pakistan	27/04/2020	16/06/2020	Cohort	6	66	66	67	67	PCR-confirmed COVID-19
Coronavirus disease 2019 in pregnant women: a report based on 116 cases.	2020	Yan	DOI: 10.1016/j.ajog.2020.04.014	China	20/01/2020	24/03/2020	Cohort	6	116	116	100	100	PCR or clinical criteria based diagnosis of COVID-19
Clinical profile of SARS-CoV-2 infected neonates from a tertiary government hospital in Mumbai, India.	2020	Kalamdani	DOI: 10.1007/s13312-020-2070-9	India	01/04/2020	31/05/2020	Cohort	5	185	185	185	185	PCR-confirmed COVID-19
Clinical profile, viral load, management and outcome of neonates born to COVID 19 positive mothers: a tertiary care centre experience from India.	2020	Anand	DOI: 10.1007/s00431-020-03800-7	India	01/04/2020	10/07/2020	Cohort	6	69	69	65	65	PCR-confirmed COVID-19
Clinical Manifestation and Neonatal Outcomes of Pregnant Patients With Coronavirus Disease 2019 Pneumonia in Wuhan, China.	2020	Xu	DOI: 10.1093/ofid/ofaa283	China	15/01/2020	15/03/2020	Cohort	6	64	64	23	23	PCR-confirmed COVID-19

Impact of SARS-CoV-2 on multiple gestation pregnancy.	2021	Mahajan	DOI: 10.1002/ijgo.13508	India	04/04/2020	10/09/2020	Cohort	6	879	879	633	633	PCR-confirmed COVID-19
The impact of perinatal severe acute respiratory syndrome coronavirus 2 infection during the peripartum period.	2021	Janssen	DOI: 10.1016/j.ajogmf.2020.100267	USA	25/03/2020	15/05/2020	Cohort	6	180	180	180	180	PCR-confirmed COVID-19
Maternal and perinatal characteristics of pregnant women with COVID-19 in a national hospital in Lima, Peru	2020	Huerta Saenz	DOI: 10.31403/rpgo.v66i2245	Peru	24/03/2020	07/05/2020	Cohort	6	37	37	35	35	PCR or rapid test confirmed COVID-19
An initiative to evaluate the safety of maternal bonding in patients with SARS-CoV-2 infection	2020	Cojocarú	DOI: 10.1080/14767058.2020.1828335	USA	01/03/2020	01/06/2020	Cohort	6	86	86	34	34	PCR-confirmed COVID-19
Short-term neonatal outcomes of colocating and breastfeeding infants of mothers who tested positive for sars-cov-2	2020	Krishnan	DOI: 10.1542/peds.147.3_MeetingAbstract.729	USA	19/03/2020	22/04/2020	Cohort	6	45	45	45	45	PCR-confirmed COVID-19
Impact of Maternal Severe Acute Respiratory Syndrome Coronavirus 2 Detection on Breastfeeding Due to Infant Separation at Birth	2020	Popofsky	DOI: 10.1016/j.jpeds.2020.08.004	USA	25/03/2020	30/05/2020	Cohort	6	160	160	160	160	PCR-confirmed COVID-19
SARS-CoV-2 in pregnancy: characteristics and outcomes of hospitalized and non-hospitalized women due to COVID-19	2020	Barbero	DOI: 10.1080/14767058.2020.1793320	Spain	03/03/2020	31/05/2020	Cohort	6	23	23	23	23	PCR-confirmed COVID-19
Clinical characteristics of COVID-19 in pregnant women: A retrospective descriptive single-center study from a tertiary hospital in Muscat, Oman	2021	Santhosh	DOI: 10.1002/ijgo.13427	Oman	24/03/2020	31/07/2020	Cohort	6	60	60	46	46	PCR-confirmed COVID-19
Clinical characteristics and pregnancy outcomes of women diagnosed with SARS-CoV-2 in London's most ethnically diverse borough: A cross-sectional study	2021	Milln	DOI: 10.1177/1753495X20985403	UK	12/03/2020	22/04/2020	Cohort	6	32	32	30	30	PCR-confirmed COVID-19
Evaluation of cochlear functions in infants exposed to SARS-CoV-2 intrauterine	2021	Celik	DOI: 10.1016/j.amjoto.2021.102982	Turkey	01/03/2020	01/12/2020	Cohort	8	73	37	73	37	PCR-confirmed COVID-19
Ultrasound and Doppler findings in pregnant SARS-CoV-2 positive women	2021	Soto-Torres	DOI: 10.1002/uog.23642	USA	01/05/2020	31/08/2020	Cohort	7	209	106	209	106	PCR or rapid test confirmed COVID-19
Maternal and perinatal outcomes of pregnant women with SARS-CoV-2 infection at the time of birth in England: national cohort study	2021	GuroI-Urganci	DOI: 10.1016/j.ajog.2021.05.016	UK	29/05/2020	31/01/2021	Case-control	7	342080	3527	338553	3527	All pregnant women delivering singletons PCR-confirmed COVID-19
Clinical characteristics of pregnant women with COVID-19 in Wuhan, China	2020	Chen	DOI: 10.1056/NEJMc2009226	China	08/12/2019	20/03/2020	Cohort	5	118	118	70	70	All pregnant women PCR or radiological diagnosis of COVID-19
Clinical features and the maternal and neonatal outcomes of pregnant women with coronavirus 2019	2020	Nie	DOI: 10.1101/2020.03.22.20041061	China	01/01/2020	01/02/2020	Cohort	5	33	33	28	28	All pregnant women PCR-confirmed COVID-19
Coronavirus disease 2019 among pregnant Chinese women: case series data on	2020	Wu	DOI: 10.1111/1471-0528.16276	China	31/01/2020	09/03/2020	Cohort	5	13	13	5	5	All pregnant women admitted PCR-confirmed COVID-19

the safety of vaginal birth and breastfeeding Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection during pregnancy in China: a retrospective cohort study Prevalence of SARS-CoV-2 among patients admitted for childbirth in southern Connecticut Clinical characteristics of pregnant women with Coronavirus disease 2019 in Wuhan, China COVID-19 during pregnancy: A case series from an universally tested population from the north of Portugal Routine screening for SARS-CoV-2 in unselected pregnant women at delivery COVID-19 in the second half of pregnancy: prevalence and clinical relevance Racial-ethnic disparities and pregnancy outcomes in SARS-CoV-2 infection in a universally-tested cohort in Houston, Texas Fetomaternal outcome in COVID-19 infected pregnant women: a preliminary clinical study COVID-19 infection during pregnancy - maternal and perinatal outcomes: a tertiary care centre study A study of breastfeeding practices, SARS-CoV-2 and its antibodies in the breast milk of mothers confirmed with COVID-19 Influence of race and ethnicity on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection rates and clinical outcomes in pregnancy Vertical transmission and materno-fetal outcomes in 13 patients with coronavirus disease 2019 Retrospective description of pregnant women infected with severe acute respiratory syndrome coronavirus 2, France Maternal and Fetal Outcomes of Pregnant Women Infected with Coronavirus Based on Tracking the Results of 90-Days Data in Hazrat -E-Rasoul Akram Hospital, Iran University of Medical Sciences	2020	Yin	DOI: 10.1101/2020.04.07.20053744	China	28/01/2020	28/02/2020	Cohort	7	31	31	17	17	All female patients	PCR-confirmed COVID-19
	2020	Campbell	DOI: 10.1001/jama.2020.8904	USA	02/04/2020	29/04/2020	Cohort	7	770	30	770	30	All pregnant women admitted for childbirth	PCR-confirmed COVID-19
	2020	Cheng	DOI: 10.1093/ofid/ofaa294	China	15/01/2020	23/02/2020	Cohort	6	111	111	17	17	All pregnant women admitted	PCR-confirmed COVID-19
	2020	Doria	DOI: 10.1016/j.ejogrb.2020.05.029	Portugal	25/03/2020	15/04/2020	Cohort	5	12	12	11	11	All pregnant women admitted	PCR-confirmed COVID-19
	2020	Diaz-Corvillon	DOI: 10.1371/journal.pone.0239887	Chile	27/04/2020	07/06/2020	Case-control	5	583	37	586	37	All pregnant women admitted	PCR-confirmed COVID-19
	2020	Ruggiero	DOI: 10.21203/rs.3.rs-34492/v1	Italy	07/04/2020	06/05/2020	Case-control	6	315	28	315	28	All pregnant women delivering during study period	PCR-confirmed COVID-19
	2020	Pineles	DOI: 10.1016/j.ejogrb.2020.09.012	USA	22/04/2020	22/07/2020	Case-control	7	935	77	935	77	All pregnant women admitted for childbirth	PCR-confirmed COVID-19
	2020	Shah	DOI: 10.18203/2320-1770.ijrcog20203843	India	15/04/2020	10/06/2020	Cohort	5	125	125	96	96	All pregnant women	PCR-confirmed COVID-19
	2020	Hassan	DOI: 10.18203/2320-1770.ijrcog20203853	India	01/03/2020	30/06/2020	Cohort	5	38	38	37	37	All pregnant women in third trimester	PCR-confirmed COVID-19
	2020	Peng	DOI: 10.1016/j.lanwpc.2020.100045	China	10/02/2020	01/04/2020	Case-control	7	64	24	66	25	All pregnant women	PCR-confirmed COVID-19
	2020	Emeruwa	DOI: 10.1097/AOG.00000000000004088	USA	13/03/2020	23/04/2020	Cohort	5	100	100	100	100	All pregnant women delivering during study period	PCR-confirmed COVID-19
	2020	Masmejan	DOI: 10.1016/j.cmi.2020.06.035	Switzerland	01/04/2020	06/05/2020	Cohort	5	13	13	13	13	All pregnant women admitted	PCR-confirmed SARS-CoV-2 or serology and positive contact
	2020	Vivanti	DOI: 10.3201/eid2609.202144	France	12/03/2020	12/04/2020	Cohort	5	100	100	36	36	All pregnant women	PCR-confirmed SARS-CoV-2
	2021	Chaichian	DOI: 10.30476/BEAT.2021.90434.1254	Iran	08/03/2020	28/12/2020	Cohort	5	14	14	13	13	All pregnant women hospitalised	PCR-confirmed SARS-CoV-2 and/or typical radiological features

Clinical Characteristics, Management, and Short-Term Outcome of Neonates Born to Mothers with COVID-19 in a Tertiary Care Hospital in India	2021	Malik	DOI: 10.1093/tropej/fmab054	India	14/04/2020	31/07/2020	Cohort	7	514	514	524	524	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Covid-19 and pregnancy: the experience of a tertiary maternity hospital	2021	Antsaklis	DOI: 10.1515/jpm-2021-0070	Greece	01/03/2020	31/12/2020	Cohort	5	40	40	35	35	All pregnant women admitted	PCR-confirmed SARS-CoV-2
Neonatal Outcomes in Pregnant Women Infected with COVID-19 in Babol, North of Iran: A Retrospective Study with Short-Term Follow-Up	2021	Akbarian-Rad	DOI: 10.1155/2021/9952701	Iran	10/02/2020	20/05/2020	Cohort	5	8	8	8	8	All pregnant women admitted for childbirth	PCR-confirmed SARS-CoV-2
Maternal-perinatal outcomes in pregnant women with COVID-19 in a level III hospital in Peru	2021	Davila-Aliaga	DOI: 10.17843/rpmesp.2021.381.6358	Peru	01/04/2020	30/06/2020	Cohort	5	43	43	43	43	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Neonatal outcomes of pregnant women with COVID-19 in a developing country setup	2021	Nayak	DOI: 10.1016/j.pedneo.2021.05.004	India	01/05/2020	20/10/2020	Cohort	5	162	162	165	165	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Maternal and Neonatal Outcomes of Pregnant Women with COVID-19: A Case-Control Study at a Tertiary Care Center in India	2021	Tadas	DOI: 10.5005/jp-journals-10006-1850a	India	01/05/2020	31/08/2020	Case-control	7	362	181	362	187	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Pregnancy Outcomes and SARS-CoV-2 Infection: The Spanish Obstetric Emergency Group Study	2021	Melguizo	DOI: 10.3390/v13050853	Spain	26/02/2020	05/11/2020	Case-control	7	2954	1347	2954	1347	All pregnant women	PCR-confirmed SARS-CoV-2
Placental pathology in COVID-19 affected pregnant women: A prospective case-control study	2021	Tasca	DOI: 10.1016/j.placenta.2021.04.002	Italy	01/03/2020	31/08/2020	Case-control	7	128	64	128	64	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Obstetric, maternal, and neonatal outcomes in COVID-19 compared to healthy pregnant women in Iran: a retrospective, case-control study	2021	Taghavi	DOI: 10.1186/s43043-021-00059-2	Iran	01/03/2020	30/11/2020	Case-control	7	110	55	110	55	All pregnant women admitted	PCR-confirmed SARS-CoV-2 and/or typical radiological features
Vertical transmission of SARS-CoV2 during pregnancy: A high-risk cohort	2021	Maeda	DOI: 10.1002/pd.5980	Brazil	12/04/2020	30/09/2020	Cohort	5	109	109	109	109	All pregnant women admitted	PCR-confirmed SARS-CoV-2
Consequences of Early Separation of Maternal-Newborn Dyad in Neonates Born to SARS-CoV-2 Positive Mothers: An Observational Study	2021	Conti	DOI: 10.3390/ijerph18115899	Italy	01/04/2020	18/03/2021	Cohort	6	37	37	37	37	All pregnant women admitted	PCR-confirmed SARS-CoV-2
Perinatal outcome and possible vertical transmission of coronavirus disease 2019: experience from North India	2021	Sharma	DOI: 10.3345/cep.2020.01704	India	01/04/2020	31/08/2020	Cohort	5	41	41	44	44	All pregnant women admitted	PCR-confirmed SARS-CoV-2
The Relationship between Status at Presentation and Outcomes among Pregnant Women with COVID-19	2020	London	DOI: 10.1055/s-0040-1712164	USA	15/03/2020	10/04/2020	Cohort	6	55	55	55	55	All pregnant women	PCR-confirmed SARS-CoV-2
Association of SARS-CoV-2 Test Status and Pregnancy Outcomes	2020	Ahlberg	DOI: 10.1001/jama.2020.19124	Sweden	25/03/2020	24/07/2020	Case-control	7	759	156	759	156	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Infants Born to Mothers with COVID-19 During Pregnancy: The First Four Months of the Pandemic	2020	Murphy	ISSN: 03323102	Ireland	01/03/2020	01/07/2020	Cohort	5	26	26	26	26	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2

Characteristics and outcomes of COVID-19 pneumonia in pregnancy compared with infected nonpregnant women	2021	Vizheh	DOI: 10.1002/ijgo.13697	Iran	01/03/2020	31/10/2020	Cohort	7	110	110	51	51	All pregnant women admitted	PCR-confirmed SARS-CoV-2
Comparing Infection Profiles of Expectant Mothers with COVID-19 and Impacts on Maternal and Perinatal Outcomes between the First Two Waves of the Pandemic	2021	Cunarro-Lopez	DOI: 10.3390/jpm11070599	Spain	01/03/2020	03/11/2020	Cohort	8	1295	1295	1295	1295	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Coronavirus disease 2019 in pregnancy: Maternal and perinatal outcome	2021	Agarwal	DOI: 10.4103/jehp.jehp_954_20	India	15/04/2020	30/06/2020	Cohort	5	65	65	48	48	All pregnant women admitted	PCR-confirmed SARS-CoV-2
COVID-19 infection in pregnancy: a single center experience with 75 cases	2021	Cakirca	DOI: 10.5603/GP.a2021.0118	Turkey	01/04/2020	31/08/2020	Cohort	5	75	75	34	34	All pregnant women admitted	PCR-confirmed SARS-CoV-2
Maternal and perinatal outcomes of pregnant women with SARS-CoV-2 infection at the time of birth in England: national cohort study	2021	Gurol-Urganc	DOI: 10.1016/j.ajog.2021.05.016	England	29/05/2020	31/01/2021	Case-control	7	342080	3527	302011	2555	All pregnant women delivering singletons	PCR-confirmed SARS-CoV-2
Neonatal outcome following maternal infection with SARS-CoV-2 in Germany: COVID-19-Related Obstetric and Neonatal Outcome Study (CRONOS)	2021	Mand	DOI: 10.1136/archdischild-2021-322100	Germany, Austria	03/04/2020	27/11/2020	Cohort	5	435	435	435	435	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Ocular Assessments of a Series of Newborns Gestationally Exposed to Maternal COVID-19 Infection	2021	Kiappe	DOI: 10.1001/jamaophthalmol.2021.1088	Brazil	01/04/2020	30/11/2020	Cohort	5	165	165	165	165	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2
Rooming-in, Breastfeeding and Neonatal Follow-up of Infants Born to Mothers with COVID-19	2021	Brito	DOI: 10.20344/amp.15441	Portugal	01/04/2020	31/12/2020	Cohort	5	77	77	77	77	All pregnant women delivering during study period	PCR-confirmed SARS-CoV-2