Impact of coronavirus disease 2019 on the clinical outcomes and placental pathology of pregnant women and their infants: A Systematic Review

Irina Oltean, MSc^a, Jason Tran^b, MD(c), Sarah Lawrence^{a,b,c}, MD, Brittany Ann Ruschkowski^b, MD(c), Na Zeng^b, MSc(c), Cameron Bardwell^b, MD(c), Youssef Nasr^b, MD(c), Joseph de Nanassy^{a,b,d}, MD, Dina El Demellawy^{a,b,d}, MD

^aChildren's Hospital of Eastern Ontario Research Institute, Ottawa, Ontario, Canada, K1H 8L1

^bDepartment of Medicine, University of Ottawa, Ottawa, Ontario Canada, K1H 8M5

^cDepartment of Pediatrics, Children's Hospital of Eastern Ontario, Ottawa, Ontario, Canada, K1H 8L1

^dDepartment of Pathology, Children's Hospital of Eastern Ontario, Ottawa, Ontario, Canada, K1H 8L1

Corresponding author: Dr. Dina El Demellawy, Department of Pathology, Children's Hospital of Eastern Ontario, Ottawa, ON, K1H 8L1, Canada, 613-737-7600 ext. 3846, deldemellawy@cheo.on.ca

Declaration of interests

None.

Word count

3 568

Abstract

Pregnant women are susceptible to viral infections due to physiological changes such as cell-mediated immunity. No severe adverse pregnancy or neonatal outcomes have been consistently reported in COVID-19 positive pregnancy cases. There are controversies around the role of COVID-19 in pregnancy. A systematic review was conducted to examine clinical maternal and neonatal clinical outcomes. Studies were included if they reported COVID-19 infection among pregnant women and/or COVID-19 positive neonates as validated by positive antibody testing or viral testing using Polymerase Chain Reaction. Case series, case reports, case-control studies, and comparative studies were included. 837 records were identified, resulting in 525 records for level I screening. 41 were included after full-text review. Results suggest elevated rates of ICU admission, gestational diabetes, preeclampsia, C-sections, pre-term birth, and CRP in comparison to pregnant women without SARS-CoV-2. Careful monitoring of pregnancies with SARS-CoV-2 to minimize adverse clinical outcomes is recommended.

Keywords

SARS-CoV-2; COVID-19; pregnant women; placental pathology; neonates; placenta diseases

Introduction

On January 30, 2020, The World Health Organization (WHO) declared the SARS-CoV-2 outbreak a public health emergency of international concern. Not two months later, the WHO characterized SARS-CoV-2 as a pandemic, reflecting its worldwide spread [1]. Although the virus is prevalent across all age groups, individuals that are immune-compromised such as the elderly and those with comorbidities are disproportionately affected with respect to severity of symptoms [2,3]. Pregnant women and their foetuses are particularly susceptible to infections such as pneumonia, pyelonephritis, and periodontal disease due to physiological changes such as cell-mediated immunity, immaturity of the adaptive immune system, and dysregulation of cytokines [4–7].

The vertical transmission of SARS-CoV-2 virus and its impact on neonatal clinical outcome has yet to be confirmed [8], however, several newborns have tested positive for SARS-CoV-2 [9–11]. Perinatal COVID-19 infection may not have the same adverse effects on neonatal outcome, including problems such as respiratory distress, thrombocytopenia accompanied by abnormal liver function, and even death in contrast to SARS and MERS [12,13]. Moreover, no severe adverse pregnancy outcomes, such as gestational hypertension, intrauterine growth restrictions, fetal distress, or stillbirth have been consistently reported in COVID-19 positive pregnancy cases [14–16]. Additional data needs to be accumulated to examine clinical outcomes of women infected with SARS-CoV-2 and their babies [12].

Given the inconclusive clinical findings, it is appropriate to conduct a systematic review on the evidence around placental pathology and SARS-CoV-2 to help contribute to the understanding of this disease and its impact on pregnancy. At present, relevant literature has relatively small sample sizes and results are diverse, inhibiting generalizability. As such, we aimed to conduct a systematic review of available literature to illustrate findings in a narrative fashion pertaining to SARS-CoV-2 on placental pathology, maternal, and neonatal outcomes.

Methods

Search Strategy and Selection Criteria

This is a systematic review only. The following databases were searched: MEDLINE including Epub Ahead of Print, In-Process & Other Non-Indexed Citations (1946- April 17, 2020) and Embase (1947 – April 17, 2020) using the Ovid interface and Global Health (from inception) using the CAB Direct interface. Searches were developed and conducted by librarian experienced in systematic reviews, using a method designed to optimize term selection [17] and the MEDLINE search was peer reviewed by a second librarian before being translated for the other databases.

A search of Google Scholar (April 8th, 2020) through Publish or Perish was screened until 50 consecutive apparently irrelevant citations were found. Results to that point were saved as an RIS file and edited to remove patents, reports, and books. The WHO database on COVID-19 as

of April 17, 2020 was downloaded and searched within Reference Manager. Disaster Lit: Database for Disaster Medicine and Public Health, MedRxiv and OSF Preprints were searched April 19th, 2020 and relevant publications were selected and downloaded. Search strategies are presented in the supplementary file. Search alerts for MEDLINE, Embase and Google Scholar were in place throughout the review to identify newly emerging research.

After duplicate records were removed online, records retrieved by the electronic search were downloaded and imported into a Reference Manager database, and then uploaded to InsightScope [(www.insightscope.ca)] for title and abstract screening and full text review. Prior to gaining access to the full set of citations, each reviewer (JT, BR, CB, and YN) screened a test set of 50 citations (containing 5 true positives, 45 true negatives) requiring accuracy of $\geq 80\%$ to qualify as a reviewer. At both the title/abstract and full text review stages, citations were excluded only if both reviewers agreed to exclude; disagreements were reviewed and resolved by the study leads, where necessary (DD and IO). Citation screening for titles/abstract and full-text review was conducted independently and in duplicate by a team of seven reviewers recruited from the University of Ottawa and Children's Hospital of Eastern Ontario (CHEO) to allow for rapid completion. The study co-lead (IO) reviewed all eligible citations to identify potential duplicates and confirm eligibility. Consensus and/or resolution of conflicts were managed between reviewers and a third reviewer was not necessary.

Inclusion Criteria

Case series, case reports, case-control, and comparative studies on COVID-19 infection among pregnant women and/or neonates as validated by positive antibody testing or viral testing using Polymerase Chain Reaction (PCR) were included. Studies included both asymptomatic carriers and patients with symptomatic infection. The endpoints were: pregnancy outcomes (e.g., still birth), radiology (e.g., pulmonary consolidation), laboratory findings (e.g., lymphopenia) and signs and placental pathology syndromes as identified by the Amsterdam placental workshop group consensus in addition to documented neonatal and maternal death or survival [18].

Exclusion Criteria

Studies were excluded if the population of interest was non-pregnant mothers, general patients, or children older than one month. There were no language restrictions since we had language specialists who worked in the medical profession available to translate foreign findings (JT, JD, NZ, MK). Systematic reviews, literature reviews, editorials, letters to the editor, conference abstracts, and commentaries were omitted.

Data analysis

Four authors (DD, IO, JT, and BR) extracted summary estimates using a pre-designed, piloted, and modified data abstraction sheet in Excel version 14.7.7. The data abstraction form was piloted against a total of five eligible studies. The extracted information included: citation details (title of the article and the year of publication); study details including study design; location of the study and its sample size; patient demographics including age, sex, gestational

age (in weeks), maternal body mass index (BMI), asthma, signs and symptoms of COVID-19 in mothers and neonates, mode of delivery, type of pregnancy, and neonatal outcomes. The Methodological Index for Non-Randomized Studies (MINORS) criteria was used to assess study quality [19]. A meta-analysis will be conducted in a prospective version of this systematic review examining the role of maternal comorbidity, multiple versus singleton pregnancy, and elevated CRP on neonatal clinical outcome. The study protocol has been registered in PROSPERO (CRD42020180538).

Results

837 articles were identified through the initial database search, resulting in 525 records for level I (title and abstract) screening, of which 292 were excluded according to title, abstract, and research question relevance. 233 were selected for full-text review, of which 192 were excluded due to an ineligible population (n=39), study design (n=141), no mention of our outcomes of interest (n=6), or inability to locate text (n=6). After full-text screening, there were 41 eligible studies remaining (Figure 1).

Most studies were conducted in Wuhan, China (n=26). Eighteen of the included studies were case reports, 11 case series, eight retrospective cohort studies, one prospective cohort study, and three case control studies (Table 1). A total of 315 women with laboratory confirmed SARS-CoV-2 by PCR were included in the selected 41 articles with a mean age from 30 to 32 years of age. Most of them were in their third trimester of pregnancy (e.g., 35-38 gestational weeks). Their average body mass index (BMI) varied from 22 to 30.9 kg/m². There were six cases of maternal intensive care admission (1.9%). Overall, the most prevalent complications on admission or during pregnancy were gestational hypertension (2.5%), gestational diabetes (3.5%), and type II diabetes (2.2%). There were two cases of abnormal cord insertion and abnormal amniotic fluid volume with oligohydramnios and polyhydramnios (0.63% each) (Table 1). Upon admission, fever and cough were the most common maternal symptoms reported (55.2% and 40.3%, respectively). There were twenty cases of documented intrauterine foetal distress (7.6%) and fifteen cases of premature ruptures of membranes (5.7%) (Table 2). Typical symptoms of neonates after birth were similar to that of mothers, including cough (2.3%), fever (4.2%), shortness of breath (2.7%), and respiratory difficulties or distress (2.3%) (Table 3).

Table 4 illustrates neonatal outcomes with the most data coverage. When reported, the majority (56.1%) of neonates born to SARS-CoV-2 positive mothers tested negative; however, there were 8 positive cases validated by RT-PCR (3.1%). 21% of neonates were born preterm (Table 4). There were two cases of rashes and one neonatal death; however, they were occasional overall (0.8% and 0.4%, respectively).

Preeclampsia was the most frequent disease of the placenta (eight cases; 2.5%) (Table 5). An equal number of pregnant women experienced placental abruption or abnormal placenta/placenta previa (three cases each; 0.95%).

More than half of infected pregnant women had viral pneumonia (160 cases; 50.8%). When examining the lungs on computer tomography (CT), pregnant women with SARS-CoV-2 were

frequently classified as demonstrating pure (18 cases; 5.7%), bilateral (12 cases; 3.8%) or patchy ground-glass opacities (GGO) (15 cases; 4.8%) (Table 6). There were 87 (30%) cases of elevated C-reactive protein, 21 cases of leukocytosis (6.7%), and 25 cases of lymphopenia (7.9%) (Table 6).

Table 7 displays the results from the critical appraisal for 39 studies written in the English language. We achieved substantial or almost perfect agreement between two independent reviewers on half of the domains from the MINORS 2015 criteria (Table 6). MINORS scores for comparative studies (n=9) ranged from 20-23, with mean 22 ± 1.0 . MINORS scores for non-comparative studies (n=32) ranged from 13-16, with a mean of 15 ± 0.7 . The ideal global score is 16 for non-comparative studies and 24 for comparative studies, which indicates excellent studies based on this definition [19].

Discussion

Given the evolving nature of the virus, understanding the potential implications of SARS-CoV-2 in vulnerable populations such as pregnant women is warranted worldwide. This review summarizes the findings from 315 women confirmed to have SARS-CoV-2 and 262 neonates who underwent PCR testing.

In our systematic review, similar symptoms (e.g., fever, cough, and shortness of breath) were reported among pregnant women and their neonates [8,20–22]. The maternal symptomology findings align with prior literature reporting fever, cough, breathing difficulties, malaise, chills, and rigors as common symptoms of SARS during pregnancy [23].

We found six cases of maternal ICU admission [20–22,24] representing 1.9% of total SARS-CoV-2 laboratory confirmed pregnancies. In contrast, the ICU admission rate for pregnant or postpartum women admitted to Canadian hospitals in 2019 was 0.32 per 100 pregnancies [25]. Therefore, the rate of ICU admission in this systematic review is six times higher than in healthy pregnant women from the general population. ICU admission is also associated with maternal comorbidity [OR 1.88 (1.86, 1.99)][25]. Thus, the potential reasons for admission to the ICU could be as a result of underlying conditions during pregnancy such as gestational hypertension or pre-existing conditions like chronic hypertension [26], type II diabetes [27], and high body mass index (BMI)[26]. Similarly, the presence of pre-existing comorbid conditions is more common in an older population with severe SARS-CoV-2 than among those with nonsevere disease (38.7% vs. 21.0%)[28,29]. As such, a deeper examination into the role of comorbidities in pregnant women with SARS-CoV-2 is warranted [30].

Seven pregnant women with SARS-CoV-2 had type II diabetes (2.2%). Gestational diabetes was the most frequent complication during pregnancy (3.5% of SARS-CoV-2 laboratory confirmed pregnancies) [26,31,32]. This result is 1.3 times higher than in a population of pregnant women without SARS-CoV-2 in Japan, where 2.7% were diagnosed with gestational diabetes [33]. Prior

literature has established a relationship between elevated BMI and gestational weight gain on the presence of gestational diabetes; however, lack of reporting on BMI in women with gestational diabetes in this review inhibits us from inferring the same in SARS-CoV-2 positive pregnant women [34,35].

A considerable percentage (i.e., 5-7%) of pregnant women with SARS-CoV-2 experienced premature rupture of membranes. This particular finding is unique in that prior research on the SARS-CoV-1 outbreak from 2002 to 2003 described adverse outcomes such as miscarriages in the first trimester of pregnancy and intrauterine growth restriction in the second and third trimesters but nothing explicitly on premature rupture of membranes or preterm birth [36–38]. It remains unclear as to how SARS-CoV-2 may influence timing of delivery (e.g., preterm versus term), maturity, or membrane rupture. However, viral infection influences pregnancy and foetal growth by penetrating the placenta and decidua via the lower reproductive tract contributing to the presence of such adverse outcomes [39]. The rate of preterm birth (i.e., 21%) was high in our review. Whether premature labour is evidence of increased psychological stress in expectant mothers with SARS-CoV-2 or a direct effect of the virus, remains to be investigated [40,41]. It is possible that pregnancy outcome is influenced by elective premature delivery in attempts to improve maternal symptoms. In general, neonatal complications were found to be more prevalent after elective preterm delivery in hypertensive mothers versus low risk controls (i.e., uneventful pregnancies delivered due to spontaneous preterm labour or premature membrane rupture) [42]. Elective caesarean sections due to worsening dyspnea in pregnant women with SARS-CoV-2 may also increase the proportion of adverse neonatal outcome like preterm birth [43].

Preeclampsia was also common (i.e., 2-5%) in our systematic review and is an indicator for preterm birth [44]. The rate of preeclampsia in a population-based retrospective study on women admitted to hospital for delivery from 1980 to 2010 in the United States was 3-4%, higher by 1-36 times than the rate reported in this review [45]. When compared to a large cohort study in China, the incidence of preeclampsia among healthy pregnant women was 2-28%, 1-1 times lower than we have found in the COVID positive population [46]. Both preeclampsia and premature membrane rupture can precipitate a preterm birth [47,48], and it is unknown whether SARS-CoV-2 directly influences preterm birth alone or in conjunction with elevated late gestational hypertension and membrane rupture. Therefore, a more detailed analysis and longitudinal approach that controls for various confounders and pre-existing conditions is needed to discern the true impact of SARS-CoV-2 on preterm birth.

Caesarean Sections (C-section) were disproportionally performed in pregnant COVID-19 positive women (i.e., 79-0%). In some cases, emergent caesarean sections were attributed to foetal distress [15,30,49]. C-section is normally recommended to prevent adverse neonatal

outcomes in the presence of elevated maternal viral infection; as such, when women tested positive for SARS-CoV-2, the clinical recommendation may have been to undergo an elective C-section to prevent possible vertical transmission of infection to the neonate [50]. Moreover, Li and colleagues determined a lower rate of C-section among controls without SARS-CoV-2 (47.1%)[51].

As mentioned, a significant percentage (21%) of neonates born to SARS-CoV-2 positive mothers were born preterm. However, Zhang and colleagues found that preterm birth and neonatal asphyxia were not statistically different between cases and controls without SARS-CoV-2 [16]. In this review, nearly three quarters of neonates (74.8%) born to mothers who tested positive were admitted to the NICU. However, admission protocols in some areas of the world, such as China, may immediately separate neonates from their mothers, with neonates admitted to a neonatal quarantine observation ward as a safety precaution, not necessarily because neonates require NICU admission due to abnormalities [52,53]. There was one case of neonatal death in our systematic review. Zhu and colleagues reported a neonate who developed thrombocytopenia complicated by abnormal liver function, and later died from refractory shock and multiple organ failure but did not test positive for SARS-CoV-2 despite being born to a SARS-CoV-2 positive mother [8]. Many autopsies on non-pregnant adults with SARS-CoV-2 also demonstrate thrombocytopenia as well as disseminated intravascular coagulation [54]. The preliminary case fatality rate in asymptomatic and symptomatic patients hospitalized with SARS-CoV-2 also appears to be around 1% (95% CI: 0.5-4%) in contrast to MERS (35-40%) and SARS (9.6%)[55]. Literature describes high viral load of SARS-CoV-2 in patients' respiratory tracts as a positive predictor of lung disease severity and subsequent lung injury [56,57]. Thus, the impact of viral load on neonatal respiratory outcomes or overall adverse clinical outcomes (e.g., stillbirth, intrauterine fetal demise (IUFD) etc.) should be explored further.

There were two cases of rashes, described as skin ulcerations on the forehead or scattered rashes over the body. Chen and colleagues propose that a maternal inflammatory toxin might be the cause [58]. Recent literature has raised concerns about potential post-viral severe inflammatory reactions, specifically Kawasaki disease (KD) (i.e., rare acute pediatric vasculitis), in children infected with SARS-CoV-2. KD can have detrimental complications such as coronary artery aneurysms requiring intensive care support [59–61]. At present, KD has not yet been described in neonates with SARS-CoV-2.

With respect to laboratory findings, there were three SARS-CoV-2 positive pregnant women with thrombocytopenia (0.95%). Based on a recent meta-analysis, a low platelet count is associated with enhanced risk of severe SARS-CoV-2 [62]. Furthermore, a study examining 138 SARS-CoV-2 positive non-pregnant patients reported about a third of patients (i.e., 46) had this condition ($<150\,000 \times 10^6/L$) regardless of severity of illness [63]. In another systematic review,

thrombocytopenia was reported in 2 pregnant patients without preeclampsia (platelet counts of 81,000 and 91,000 $\times 10^6/L$, respectively)[64]. In comparison, our study reported one additional patient with thrombocytopenia whose neonate died of multiple organ failure. The percentage of lymphopenia was high in this review (7.9%). Lymphocytes below the normal range ($<1.1 \times 10^9 /L$) and cases of lymphopenia ($<1.0 \times 10^9 /L$) have been reported in mothers infected with SARS-CoV-2 [15,58]. A systematic review also reported significantly lower lymphocyte count in severe SARS-CoV-2 patients [65]. Unlike the normal laboratory investigations reported in this systematic review, prior studies report lower counts of WBC, neutrophils, and CRP in pregnant women on admission in comparison to non-pneumonia controls [63]. However, increased CRP has been documented in postpartum blood tests, which supports our finding of elevated CRP [51]. Elevated CRP can be used as an indicator of SARS-CoV-2 disease progression; thus, it is worthwhile to examine how it may predict deteriorating maternal and fetal outcomes associated with this virus [66].

In terms of placental pathology findings, there were three cases each of placental abruption and abnormal placenta/placenta previa in SARS-CoV-2 women (6 cases total; 2.0%). Li and colleagues reported two cases of preterm delivery due to gestational hypertension/preeclampsia, and one suspected case due to placenta previa but a connection between placental abruption and preeclampsia was not directly mentioned [51]. Current risk factors of placental abruption include smoking and trauma, suggesting an interplay of complex factors dependent on maternal lifestyle behaviours in addition to chorioamnionitis and decidual vascular lesion [67]. Rodrigues and colleagues also found one instance of placental abruption in their systematic review [68]; therefore, although not a regular occurrence, future monitoring of placental abruption may be encouraged. In another study, placental abnormalities such as placenta previa, placenta accrete, and placental abruption were also prevalent in 2% of pregnant women with COVID-19 [69]. The total percentage of placenta previa reported among pregnant women without SARS-CoV-2 in Japan was 0.3-0.5% [70]. Globally, placental abruption of various degrees of severity occurs in around 1% of all pregnancies [71]. Thus, rates of placental abruption and placenta previa were higher in this review. Additional investigation of the potential relationship between SARS-CoV-2 and placental abruption and placenta previa is recommended for management strategies.

Radiology findings from this systematic review suggest the presence of viral pneumonia (50.8%) and pure, patchy or bilateral ground-glass opacities (GGOs) (14.3%) in pregnant women with SARS-CoV-2. These results are supported by a study conducted in the general population of patients with SARS-CoV-2 pneumonia, which demonstrated nearly half of patients had ground glass opacities and lung abnormalities on chest CT [72]. The presence of lesions like pure GGO was more prevalent in age-matched non-pregnant women with SARS-CoV-2 pneumonia (57 cases; 62%) versus pregnant women with SARS-CoV-2 (141 cases; 57%). Interestingly, pure

consolidation increased to 95% and 82% from 27% and 24%, respectively, after baseline chest CT for pregnant and non-pregnant groups with significant differences [73].

The main limitations of this review pertain to the fact that several studies had missing outcome data (i.e., poor coverage) although being assessed as high-quality evidence. There was also a potential for selective reporting and misclassification bias when reporting data on certain outcomes (e.g., myalgia versus muscle soreness overlap). There is the potential for double covering since certain studies may have reported on clinical outcomes from patients in the same hospital institution; however, secondary studies like systematic reviews were omitted to minimize this risk. Six studies could also not be obtained for inclusion due to accessibility issues. Moreover, most studies included are case studies or case series with small sample sizes; thus, there is a lack of generalizability to all pregnant women with SARS-CoV-2 and their neonates. Despite this, we included studies of pregnant women or their neonates with laboratory confirmed SARS-CoV-2 to ensure clinical assessments of maternal and neonatal outcomes and precise estimates. There was no language barrier during the screening stages, as we had experienced language specialists fluent in multiple languages. All available evidence was reviewed; as such, it is unlikely to have missed studies with relevant study designs at this time of submission for publication.

Results from this review suggest elevated rates of ICU admission, gestational diabetes, preeclampsia, placental abruption, placental previa, c-sections, pre-term birth, and CRP in comparison to pregnant women without SARS-CoV-2. When compared to non-pregnant patients with SARS-CoV-2, rates of viral pneumonia, lung abnormalities, and lower lymphocyte counts were similar while fewer cases of thrombocytopenia were reported in this review. This work advances current, limited knowledge around maternal and neonatal outcomes regarding placental pathology, radiology, and laboratory findings in the context of a global pandemic. This review could serve to inform future protocols for managing women with SARS-CoV-2 and their neonates as further evidence is generated. A compelling area of study is to examine clinical outcomes of SARS-CoV-2 positive women during their first and second trimester of pregnancy. In the future, longitudinal studies can examine development (i.e., cognitive and neurological) of infants older than one month born to SARS-CoV-2 positive mothers as well as the effect of maternal stress on prematurity.

Contributors

IO wrote the manuscript, performed data collection (level I and II screening and data extraction), generated the figures, tables, performed the data analysis, and interpreted the data. JT aided in data collection (level I and II screening and data extraction), translation of foreign language articles, and quality appraisal. SL revised the manuscript and verified the tabulated data. BR aided in data collection (level I and II screening and data extraction) and

quality appraisal. NZ also performed data collection (level I and II screening and data extraction), translation, and quality appraisal of articles in Chinese. CB, YN, and JDN assisted with level I and II screening while JDN aided with translation. DD conceptualized the study, revised the manuscript, and verified the tabulated data.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgements

We thank Katie O'Hearn, MSc, (Children's Hospital of Eastern Ontario Research Institute) for methodological assistance, Margaret Sampson, MLIS, PhD, AHIP (Children's Hospital of Eastern Ontario) for developing the electronic search strategies, Lindsey Sikora, MSt (University of Ottawa) for peer review of the MEDLINE search strategy, and Vid Bigelic, MSc, for determining inter-rater reliability using the MINORS instrument.

Table 1. Study Characteristics (n=41)

Author	Study location	n (pregnant women with laboratory confirmed SARS-CoV-2)	n (neonates)	Maternal and Neonatal Interventions	Comparator	Maternal Medication Treatment	Fetal Medication Treatment	Follow-up after delivery (days)	MINORS Score
Case report									
Diaz et al 2020 [20]	Spain	1	1	Chest radiography; RT-PCR; chest x-ray; C-reactive protein assessment	N/A ¹	Mechanical ventilation	Continuous nasal pressure device	6, 8, and 13	15
Wang et al 2020 [74]	Wuhan, China	1	1	Two throat-swab samples; RT-PCR; and chest tomography scan (CT)	N/A	Arbitol tablets; lopinavir and ritonavir tablets; cefoperazone sodium; sulbactam sodium; and human serum albumin	Dexamethasone and magnesium sulfate as prophylaxis	10, 15, and 18	15
Wang et al 2020 [75]	Wuhan, China	1	1	CT scan; rPT-PCR ²	N/A	Recombinant human interferon; sterilization injection; ganciclovir. Abipenem; moxifloxacin; methylprednisolone	Not mentioned	4	15
Iqbal et al 2020 [76]	Washington, United States of America	1	1	Chest radiographs; nonstress test; ultrasound; nasopharyngeal and oropharyngeal swabs	N/A	Oxytocin	Not mentioned	6	15

Song et al 2020 [77]	Wuhan, China	1	1	Throat swabs and fecal samples by rPT-PCR; viral respiratory test; chest CT; pinprick test	N/A	CSEA ³ ; hyperbaric ropivacaine; oxytocin; dolasetron; tramadol; sodium chloride	Not mentioned	1	16
Zhao et al 2020 [78]	Wuhan, China	1	1	Serum biochemical test; CT scan; B-ultrasound; throat swabs by PCR	N/A	Azithromycin; oseltamivir; moxifloxacin; ganciclovir	Not mentioned	4	15
Lowe et al 2020 [79]	Southport, Australia	1	1	COVID-19 testing	N/A	Artificial rupture of membranes; oxytocin infusion; CTG ⁴ ; epidural; gentamicin; metronidazole; cephazolin	Not mentioned	10	16
Lee et al 2020 [80]	Republic of Korea	1	1	Chest radiographs; CT scans; blood and urine tests; RT-PCR for placenta, amniotic fluid, and cord blood	N/A	Spinal anesthesia; Marcaine; fentanyl; phenylephrine; Hartmann solution; colloid; carbetocin; oxytocin; crystalloid; colloid; analgesia pump	Not mentioned	Unknown	16
Kalafat et al 2020 [24]	Turkey	1	1	RT-PCR for throat, nasal, and breast milk; fetal ultrasound; lung ultrasound; CT angiography	N/A	Azithromycin; hydroxychloroquine; oseltamivir; favipiravir; steroids	Not mentioned	2	15
Karami et al 2020 [22]	Iran	1	1	Fern test; chest CT; chest X-ray; echocardiography; RT-PCR; lung	N/A	Oseltamivir, azithromycin, ceftriaxone, lopinavir/ritonavir/hy	Not mentioned	2	16

				autopsy		droxychloroquine, meropenem, vancomycin			
Kamali et al 2020 [21]	Tehran, Iran	1	1	Pharyngeal swab via RT-PCR; chest X-ray; echocardiography	N/A	Not mentioned.	Proper fluid therapy; oxygen therapy; vancomycin; amikacin, oseltamivir	14	16
Zeng et al 2020 [81]	Wuhan, China	1	1	Pharyngeal and nasal swabs; COVID-19 nucleic acid test; pulmonary imaging; blood tests; suction pharyngeal swabs; immunofluorescence tests; echocardiogram	N/A	Not mentioned.	Vitamin K1 and fluid replacement	Unknown	15
Wang et al 2020 [82]	Wuhan, China	1	1	Nucleic acid test; lung CT; chest imaging; abdominal X-ray; adenovirus antigen test	N/A	Not mentioned	Interferon treatment; nasal spray; fluid replacement	Unclear	15
Schnettler et al 2020 [83]	Cincinnati, Ohio	1	1	Chest x-ray; vital assessment; respiratory viral laboratory analysis; nasopharyngeal swab via RT-PCR; chest X-ray; lung	N/A	Intubation with mechanical ventilation; antenatal corticosteroids; magnesium sulphate; benzodiazepines and narcotics; ceftriaxone;	Electronic monitoring	5	15

Peng et al 2020 [84]	Chongqing, China	1	1	ultrasound imaging; Chest CT; throat swab via RT-PCR;	N/A	azithromycin; oseltamivir; hydroxychloroquine Interferon nebulization; oral lopinavir; intravenous antibiotics; oxygen supplements; demethasone	Nasal continuous positive airway pressure; pulmonary surfactant; gentamycin; ampicillin; procalcitonin Not mentioned.	1,2,3,7 and 14	15
Xiong et al 2020 [85]	Beijing, China	1	1	Chest X-ray; throat swab via RT-PCR test; chest CT	N/A	Antiviral; anti- infection; corticosteroid therapies	Not mentioned.	3	16
Han et al 2020 [86]	Seoul, Korea	1	1	Chest radiograph; physical examination; laboratory examination; nasopharyngeal and oropharyngeal swabs via RT-PCR	N/A	Not mentioned.	No antiviral or antibacterial agents	29	16
Shojaei et al 2020 [87]	Tehran, Iran	1	1	Spiral lung and mediastinal CT scan; portable chest X-ray; echocardiography ; nasopharyngeal swab via RT-PCR	N/A	Oseltamivir; ceftriaxone; hydroxychloroquine; azithromycin; lopinavir/ritonavir; O ₂ therapy with mask; fentanyl and propofol injection and mechanical ventilation;	Not mentioned	Terminated pregnancy.	16

						vancomycin; meropenem; fresh frozen plasma; norepinephrine infusion			
Case series									
Chen et al 2020 [88]	Wuhan, China	5	5	Serum testing; chest imaging; RT-PCR	N/A	Ceased breastfeeding (n=5); oseltamivir (n=5); azithromycin (n=5)	Not mentioned	Not mentioned	14
Zhu et al 2020 [8]	Wuhan, China	9	10	Chest CT; ultrasound; ⁵ NAT testing	N/A	Oseltamivir (n=3); nebulized inhaled interferon (n=1)	Symptomatic supportive treatments (n=10); transfusion of platelets (n=1); oxygen therapy (n=1)	7,9	14
Liu et al 2020 [89]	Wuhan, China	10	19	Chest CT; chest x- ray; RT-PCR in urine, throat and feces	N/A	No mother received prenatal steroids; antiviral drugs (n=6)	Not mentioned	Not mentioned	15
Liu et al 2020 [90]	Wuhan, China	3	3	CT scans; oropharyngeal swabs, breast milk, placenta, vaginal mucus and feces testing via RT-PCR;	N/A	Oxygen therapy (n=3), antiviral (n=2)(i.e., atomized inhalation of interferon and ganciclovir), and anti- inflammatory treatment (n=2); oral arbidol hydrochloride (n=2)	Not mentioned	2,6	15
Breslin et al 2020 [27]	New York, United	7	2	Chest X-ray; PCR	N/A	Ampicillin (n=1); gentamicin (n=1); acetaminophen	Not mentioned	2,4,5	15

	States of America					(n=1); endotracheal intubation (n=1); hydroxychloroquine (n=2); furosemide (n=1); azithromycin (n=1); ceftriaxone (n=1); ongoing oxygen supplementation (n=1)			
Khan et al 2020 [31]	Wuhan, China	3	3	Nasopharyngeal swab; CT scan	N/A	Azithromycin (n=1); Lianhua Qingwen capsules (n=2); oseltamivir (n=1); antibiotics (n=2); antiviral drugs (n=2); oxygen inhalation (n=2)	Not mentioned	Not mentioned	16
Chen et al 2020 [58]	Wuhan, China	4	4	Throat swab via RT-PCR; laboratory examination; CT scans; chest radiograph	N/A	Respiratory support (n=1)	Nasal-continuous positive airway pressure (n=1)	3,5	16
Chen et al 2020 [14]	Wuhan, China	3	3	Pharyngeal swabs via nucleic acid test; tissue and lung CT; laboratory examination	N/A	Not mentioned	Not mentioned	Not mentioned	13
Fan et al 2020 [32]	Wuhan, China	2	2	Nasopharyngeal swab, maternal serum, placenta tissue, umbilical cord blood,	N/A	Lianhua qingwen capsule (n=2); cefaclor (n=1); beclomethasone (n=1); calamine	Antibiotic therapy (n=2)	3,4,8,18,19	16

				amniotic fluid, vaginal swabs, and breast milk via RT-PCR; laboratory examination; CT chest scan; CT of thorax		tropical (n=1); azithromycin (n=1); oseltamivir (n=2); methylprednisolone (n=1); cefotiam hydrochloride (n=1); ornidazole (n=1); diclofenac sodium (n=1); ceftazidime (n=1);			
Liu et al 2020 [91]	Wuhan, China	15	15	RT-PCR; CT scan	N/A	Oxygen support via nasal cannula (n=14); antibiotic treatment (n=15); antiviral treatment (n=11);	Not mentioned	4,6	15
Chen et al 2020 [92]	Wuhan, China	17	17	RT-PCR; general anaesthesia (n=3); epidural anaesthesia (n=14)	General anaesthesia group	Not mentioned	Not mentioned	6,13	20
Retrospective cohort									
Yue et al 2020 [93]	Wuhan, China	14	13	Chest CT; throat swabs via RT-PCR; CSEA	Patients with suspected COVID-19 infection	Intraspinal anaesthesia (n=30); dezocine and morphine via epidural catheter (n=30)	Not mentioned	N/A	21
Chen et al 2020 [15]	Wuhan, China	9	6	Chest CT; throat swab samples via RT-PCR; amniotic fluid samples; cord blood and neonatal throat swabs; breast milk samples	N/A	Oxygen support via nasal cannula (n=9); antibiotic treatment (n=9); antiviral therapy (n=6)	Not mentioned	N/A	14

Yu et al 2020 [94]	Wuhan, China	7	7	Throat swab samples via RT- PCR; chest CT; laboratory examinations; sputum or endotracheal aspirates; CSEA; general anaesthesia	N/A	Oxygen therapy via nasal catheter (n=7); antiviral therapy (i.e., oseltamivir, ganciclovir, interferon, arbidol)(n=7); Jinyebaidu and Lianhuaqingwen capsules (n=7); antibiotic treatment (i.e., cephalosporins, quinolones, macrolides)(n=7);	Not mentioned	28	15
Nie et al 2020 [95]	Wuhan, China	33	28	RT-PCR; clinical presentation; laboratory examination; chest CT information; chest X-ray	N/A	Oxygen supplementation via nasal cannula or mask (n=29); noninvasive mechanical ventilation (n=1); antibiotic treatment (n=29); glucocorticoids (n=11); traditional Chinese medicine (n=12)	No treatment (n=1)	4, 8, 15	15
Breslin et al 2020 [26]	New York, USA	43	18	Nasopharyngeal swab via RT-PCR; imaging; and treatment; chest X-ray; neuraxial anesthesia;	Asymptomatic patients on presentation	No supplemental oxygen (n=29); hydroxychloroqui ne (n=2); ceftriaxone (n=2); supportive therapy	Not mentioned	14	21

				intraoperative conversion		with intravenous hydration (n=2); azithromycin (n=1); oxygen support via nasal cannula (n=1); antibiotics (ampicillin and gentamicin)(n=5); misoprostol (n=3)			
Zhang et al 2020 [96]	Wuhan, China	4	4	Nasopharyngeal or anal swabs via RT-PCR; CT scans	N/A	Not mentioned	Supportive treatment (n=4); mechanical ventilation (n=0)	Not mentioned	15
Zhang et al 2020 [16]	Wuhan, China	16	10	Biochemical tests; pharyngeal swab collection via RT-PCR; chest radiographs; laboratory examinations	Pregnant women without SARS-CoV-2	Dexamethasone (n=1)	Not mentioned	Not mentioned	21
Yin et al 2020 [97]	Wuhan, China	31	17	Amniotic fluid; placenta; neonatal throat and anal swab samples; breastmilk samples via RT-PCR; laboratory and radiology examinations	Non-pregnant women with SARS-CoV-2	Antiviral therapy (n=30); glucocorticoid therapy (n=16); oxygen therapy (n=35)	Not mentioned	9-40	22
Prospective cohort									
Yang et al 2020 [98]	Wuhan, China	7	7	Umbilical cord blood, amniotic	N/A	Not mentioned	nCAP ⁶ treatment	2-5, 7	15

				fluid, and pharyngeal swabs via RT-PCR; chest X-ray; laboratory examination			(n=2); no respiratory support or oxygen therapy (n=0); piperacillin tazobactam (n=4); feeding and nursing care (n=3)			
Case-control										
Zhang et al 2020 [99]	Wuhan, China	89	90	SARS-CoV-2 nucleic acid test; CT imaging; spinal anaesthesia; epidural anaesthesia; general anaesthesia; inhalational anaesthesia	Pregnant women without SARS-CoV-2	Intraoperative oxytocin (n=94)	Not mentioned	Not mentioned		23
Yang et al 2020 [11]	Wuhan, China	13	20	CT scan; throat swab test via RT-PCR; routine blood test; laboratory and radiology examination	Pregnant women without laboratory confirmed SARS-CoV-2 infection	Not mentioned	Not mentioned	Unclear		23
Li et al 2020 [51]	Wuhan, China	11	17	CT scan; laboratory examination; throat swabs via RT-PCR	Pregnant women without SARS-CoV-2	Antibiotics (n=34); antivirals (n=4)	Not mentioned	4,14		21

¹Not applicable to the study design.

²Real-time reverse transcription polymerase chain reaction.

³Combined spinal and epidural anesthesia.

⁴Continuous cardiotocography.

⁵Nucleic acid testing.

⁶Non-invasive continuous positive airway pressure ventilation.

Table 2. Maternal Characteristics from 315 women with confirmed SARS-CoV-2 Infection

	Case reports Diaz et al 2020 [20], Wang et al 2020 [74], Wang et al 2020 [75], Iqbal et al 2020 [76], Song et al 2020 [77], Zhao et al 2020 [78], Lowe et al 2020 [79], Lee et al 2020 [80], Kalafat et al 2020 [24], Karami et al 2020 [22], Kamali et al 2020 [21], Zeng et al 2020 [81], Wang et al 2020 [82], Schnettler et al 2020 [83], Peng et al 2020 [84], Xiong et al 2020 [85], Han et al 2020 [86], Shojaei et al 2020 [87] (N = 18 studies)	Case series Chen et al 2020 [88], Zhu et al 2020 [8], Liu et al 2020 [89], Liu et al 2020 [90], Breslin 2020 [27], Khan et al 2020 [31], Chen et al 2020 [58], Chen et al 2020 [14] Fan et al 2020 [32], Liu et al, 2020 [91], Chen et al, 2020 [92] (N = 11 studies)	Retrospective cohort Yue et al 2020 [93], Chen et al 2020 [15], Yu et al 2020 [94], Nie et al 2020 [95], Breslin et al 2020 [26], Zhang et al 2020 [96], Zhang et al 2020 [16], Yin et al 2020 [97] (N = 8 studies)	Prospective cohort Yang et al 2020 [98] (N =1 study)	Case control Zhang et al 2020 [99], Yang et al 2020 [11], Li et al 2020 [51] (N = 3 studies)	Total, n/N (%)
Maternal Characteristics						
Age (y) (mean $\pm$ SD)	31.5	30.7 $\pm$ 5	30.0 $\pm$ 13	N/A	31.2 $\pm$ 3	
Gestational age (mean $\pm$ SD) or range in weeks	35.0 $\pm$ 6	35.3 $\pm$ 5	38.1 $\pm$ 0.9	36-37	38.1 $\pm$ 2	
Body mass index (BMI) (kg/m ²) (mean $\pm$ SD)	24.7	¹ N/A	30.9 $\pm$ 5	N/A	22.7	
Maternal Intensive Care Unit (ICU) admission	4	0	2	0	0	6/315, 1.9%
Complications						
Gestational hypertension	0	N/A	3	2	3	8/315, 2.5%
Chronic hypertension	0	1	3	N/A	2	6/315, 1.9%
Hypothyroidism	1	1	1	N/A	2	5/315, 1.6%
Gestational diabetes	0	3	5	N/A	3	11/315, 3.5%
Type II diabetes	0	4	3	N/A	0	7/315, 2.2%
Abnormal amniotic fluid	0	2	0	0	0	2/315, 0.63%
Abnormal cord insertion	0	2	0	0	0	2/315, 0.63%
Delivery Characteristics						
Total number of deliveries	14	58	94	7	116	289/315, 91.7%
Delivery by caesarean section	9	46	75	7	112	249/315, 79.0%

Vaginal delivery	5	12	19	0	4	40/315, 12.7%
Spontaneous preterm delivery	1	0	0	0	0	1/315, 0.3 %
Pregnancy type						
Singleton	11	35	46	7	70	169/315, 53.7%
Twin	2	2	0	0	5	10/315, 3.2%
Multiple	0	0	0	0	88	88/315, 27.9%
Presenting signs and symptoms						
Fever on admission	11	40	69	6	48	174/315, 55.2%
Cough	10	27	52	6	32	127/315, 40.3%
Dyspnea	3	4	15	6	9	37/315, 11.7%
Shortness of breath	4	0	9	6	0	19/315, 6.0%
Myalgia	3	6	17	6	8	40/315, 12.7%
Muscular soreness	1	0	5	6	0	12/315, 3.8%
Sore throat	2	2	5	6	0	15/315, 4.8%
Diarrhea	0	4	9	6	7	26/315, 8.3%
Clinical Outcomes						
Intrauterine fetal distress	0	7	9	2	2	20/262, 7.6%
Premature rupture of membranes	1	3	9	0	2	15/262, 5.7%

¹indicates the lack of data collected on this outcome.

Table 3. Neonatal Characteristics from 262 neonates who underwent PCR laboratory testing for SARS-CoV-2

	Case reports	Case series	Retrospective cohort	Prospective cohort	Case control	Total, n/N (%)
	Diaz et al 2020 [20], Wang et al 2020 [74], Wang et al 2020 [75], Iqbal et al 2020 [76], Song et al 2020 [77], Zhao et al 2020 [78], Lowe et al 2020 [79], Lee et al 2020 [80], Kalafat et al 2020 [24], Karami et al 2020 [22], Kamali et al 2020 [21], Zeng et al 2020 [81], Wang et al 2020 [82], Shnettler et al 2020 [83], Peng et al 2020 [84], Xiong et al 2020 [85], Han et al 2020 [86], Shojaei et al, 2020 [87] (N = 18 studies)	Chen et al 2020 [88], Zhu et al 2020 [8], Liu et al 2020 [89], Liu et al 2020 [90], Breslin 2020 [27], Khan et al 2020 [31], Chen et al 2020 [58], Chen et al 2020 [14], Fan et al 2020 [32], Liu et al, 2020 [91], Chen et al, 2020 [92](N = 11 studies)	Yue et al 2020 [93], Chen et al 2020 [15], Yu et al 2020 [94], Nie et al 2020 [95], Breslin et al 2020 [26], Zhang et al 2020 [96], Zhang et al 2020 [16], Yin et al 2020 [97] (N = 8 studies)	Yang et al 2020 [98] (N =1 study)	Zhang et al 2020 [99], Yang et al 2020 [11], Li et al 2020 [51] (N = 3 studies)	
Neonatal Characteristics						
Neonatal sex						
Males	6	24	16	¹ N/A	8	54/262, 20.6%
Females	2	10	10	N/A	6	28/262, 10.7%
Mean birth weight (g)	3196.4	3117	3063.5	2096	3129.1	
Signs and symptoms after birth						
Respiratory difficulties or distress	5	0	1	N/A	N/A	6/262, 2.3%
Cough	2	4	0	N/A	N/A	6/262, 2.3%
Fever	7	4	0	N/A	N/A	11/262, 4.2%
Shortness of breath	1	6	0	N/A	N/A	7/262, 2.7%
Apnea	0	0	N/A	N/A	N/A	0/262, 0%
Vomiting	3	0	0	N/A	N/A	3/262, 1.1%
No symptoms	0	5	0	N/A	N/A	5/262, 1.9%

¹ indicates the lack of data collected on this outcome.

Table 4. Neonatal Outcomes from 262 neonates who underwent PCR laboratory testing for SARS-CoV-2

	Case reports	Case series	Retrospective cohort	Prospective cohort	Case control	Total, n/N (%)
Neonatal Intensive Care Unit (NICU) admission	3	37	4	5	147	196/262, 74.8%
Preterm	4	11	27	6	7	55/262, 21.0%
Full term	1	0	1	3	1	6/262, 2.3%
Low birth weight (e.g., <2500g)	0	1	9	0	3	13/262, 5.0%
Neonatal death	0	1	0	0	0	1/262, 0.38%
Mean Apgar Score						
1 min (mean)	8.17	8.45	8.19	¹ N/A	9.6	
5 min (mean)	9.15	9.35	9.22	N/A	10	
Fetal tachycardia	0	2	0	0	1	3/262, 1.1%
Rashes	0	2	0	0	0	2/262, 0.8%

¹indicates the lack of data collected on this outcome

Table 5. Placental Pathology outcomes in 315 SARS-CoV-2 confirmed pregnant women

Author and Study ID	Zhu et al., 2020 [8]	Yang et al., 2020 [98]	Schettler et al., 2020 [83]	Chen et al., 2020 [88]	Liu et al., 2020 [90]	Chen et al., 2020 [14]	Liu et al., 2020 [89]	Iqbal et al., 2020 [76]	Li et al., 2020 [51]	Diaz et al., 2020 [20]	Chen et al., 2020 [15]	Zhang et al., 2020 [16]	Chen et al., 2020 [58]	Kalafat et al., 2020 [24]	Total, n/N (%)
	174620	174628	174968	174619	174662	174527	174625	174572	174856	174520	174627	174510	174821	174581	
Chorioamnionitis	..	..	..	0	1	0	..	..	..	..	..	..	..	..	1/315, 0-32%
Meconium stained amniotic fluid (MSAF)	..	..	..	..	1	..	..	..	..	..	..	..	..	..	1/315, 0-32%
Placental abruption	..	..	..	..	..	1	..	..	2	..	..	..	..	..	3/315, 0-95%
Preeclampsia	..	2	..	1	..	..	..	..	1	1	2	1	..	..	8/315, 2-5%
Abnormal placenta/placenta previa	1	..	..	..	..	1	..	..	..	..	..	..	1	..	3/315, 0-95%

Table 6. Radiology and Laboratory findings across all studies (n=41) for 315 women confirmed with SARS-CoV-2

Radiology results	Total n/N, (%)
Bilateral/viral pneumonia	160/315, 50.8%
Pneumonia aggravation	1/315, 0.32%
Pulmonary consolidation	4/315, 1.3%
Lesions	5/315, 1.6%
Pure ground-glass opacity (PGO)	18/315, 5.7%
Bilateral ground-glass opacities (GGO)	12/315, 3.8%
Patchy GGO	15/315, 4.8%
Patch like shadows	8/315, 2.5%
Pleural effusion	7/315, 2.2%
Pleural thickening	4/315, 1.3%
Increased vascular marking	2/315, 0.63%
Laboratory results	
Mean number of white blood cells (WBC) ($\times 10^9$ /L)	9.1
Mean number of neutrophils ($\times 10^9$ /L)	7.0
Elevated Procalcitonin	7/315, 2.2%
Leukopenia	1/315, 0.32%
Leukocytosis ($> 10 \times 10^9$ /L)	21/315, 6.7%
Lymphopenia ($< 1 \times 10^9$ /L)	25/315, 7.9%
Thrombocytopenia	3/315, 0.95%
Mean number of Lymphocytes ($\times 10^9$ / L)	2.1
Mean albumin (g/L)	25.7
Mean haemoglobin (Hb)(g/L)	98.4
Mean C-reactive protein (CRP) (mg/L)	33.1
Elevated CRP (> 4.0 mg/L)	87/315, 27.6%
Elevated alkaline phosphatase	7/315, 2.2%
Elevated alanine aminotransferase (ALT) and aspartate aminotransferase (AST)	12/315, 3.8%

Table 7. Quality Appraisal of Eligible Articles in English using MINORS 2015 criteria (n=39)

Domain	Inter-rater reliability coefficient (Kappa)	^a Interpretation
Clearly stated aim	*Not estimable	N/A
Inclusion of patients	0.55	Moderate
Prospective collection	0.79	Substantial
Appropriate endpoints	1.00	Almost perfect
Unbiased endpoint	*Not estimable	N/A
Follow up period	0.23	Fair
Follow up loss	*Not estimable	N/A
Study size calculation	*Not estimable	N/A
Adequate control	1.00	Almost perfect
Contemporary groups	1.00	Almost perfect
Baseline equivalence	1.00	Almost perfect
Statistical analyses	1.00	Almost perfect

^aKappa was interpreted as follows: <0 “poor”, 0-0.2 “slight”, 0.21-0.4 “fair”, 0.41-0.6 “moderate”, 0.61-0.8 “substantial”, 0.81-0.99 “almost perfect”. *Not estimable: Kappa could not be estimated

References

- [1] WHO (World Health Organisation), Q&A on coronavirus (COVID-19), (n.d.). <https://www.who.int/news-room/q-a-detail/q-a-coronaviruses> (accessed April 13, 2020).
- [2] M.M.A. Khan, M.N. Khan, M.G. Mustagir, J. Rana, M.R. Haque, M.M. Rahman, COVID-19 infection during pregnancy: a systematic review to summarize possible symptoms, treatments, and pregnancy outcomes, *MedRxiv*. (2020) 2020.03.31.20049304. <https://doi.org/10.1101/2020.03.31.20049304>.
- [3] A.J. Rodriguez-Morales, J.A. Cardona-Ospina, E. Gutiérrez-Ocampo, R. Villamizar-Peña, Y. Holguin-Rivera, J.P. Escalera-Antezana, L.E. Alvarado-Arnez, D.K. Bonilla-Aldana, C. Franco-Paredes, A.F. Henao-Martinez, A. Paniz-Mondolfi, G.J. Lagos-Grisales, E. Ramírez-Vallejo, J.A. Suárez, L.I. Zambrano, W.E. Villamil-Gómez, G.J. Balbin-Ramon, A.A. Rabaan, H. Harapan, K. Dhama, H. Nishiura, H. Kataoka, T. Ahmad, R. Sah, Clinical, laboratory and imaging features of COVID-19: A systematic review and meta-analysis, *Travel Med. Infect. Dis.* (2020) 101623. <https://doi.org/10.1016/j.tmaid.2020.101623>.
- [4] W.H. Goodnight, D.E. Soper, Pneumonia in pregnancy, *Crit. Care Med.* 33 (2005). <https://doi.org/10.1097/01.CCM.0000182483.24836.66>.
- [5] S. Stone, C. Nelson-Piercy, Respiratory disease in pregnancy, *Obstet. Gynaecol. Reprod. Med.* 20 (2010) 14–21. <https://doi.org/10.1016/j.ogrm.2009.10.003>.
- [6] G.T.J. van Well, L.A. Daalderop, T. Wolfs, B.W. Kramer, Human perinatal immunity in physiological conditions and during infection, *Mol. Cell. Pediatr.* 4 (2017) 1–11. <https://doi.org/10.1186/s40348-017-0070-1>.
- [7] V. Agrawal, E. Hirsch, Intrauterine infection and preterm labor, *Semin. Fetal Neonatal Med.* 17 (2012) 12–19. <https://doi.org/10.1016/j.siny.2011.09.001>.
- [8] H. Zhu, L. Wang, C. Fang, S. Peng, L. Zhang, G. Chang, S. Xia, W. Zhou, Clinical analysis of 10 neonates born to mothers with 2019-nCoV pneumonia, *Transl. Pediatr.* 1 (2020) 51–60. <https://doi.org/10.21037/tp.2020.02.06>.
- [9] L. Zeng, S. Xia, W. Yuan, K. Yan, F. Xiao, J. Shao, W. Zhou, Neonatal Early-Onset Infection with SARS-CoV-2 in 33 Neonates Born to Mothers with COVID-19 in Wuhan, China, *JAMA Pediatr.* 23 (2020) 4–6. <https://doi.org/10.1001/jamapediatrics.2020.0878>.
- [10] L. Dong, J. Tian, S. He, C. Zhu, J. Wang, C. Liu, J. Yang, Possible Vertical Transmission of SARS-CoV-2 From an Infected Mother to Her Newborn, *JAMA*. (2020) 2–4. <https://doi.org/10.1001/jama.2020.4621>.
- [11] H. yang, G. Sun, F. Tang, M. Peng, Y. Gao, J. Peng, H. Xie, Y. Zhao, Z. Jin, Clinical

features and outcomes of pregnant women suspected of coronavirus disease 2019, *J. Infect.* (2020). <https://doi.org/10.1016/j.jinf.2020.04.003>.

- [12] D.A. Schwartz, An Analysis of 38 Pregnant Women with COVID-19, Their Newborn Infants, and Maternal-Fetal Transmission of SARS-CoV-2: Maternal Coronavirus Infections and Pregnancy Outcomes., *Arch. Pathol. Lab. Med.* (2020). <https://doi.org/10.5858/arpa.2020-0901-SA>.
- [13] J. Sankar, Thrombocytopenia, *Indian J. Pract. Pediatr.* 19 (2017) 338–341. https://doi.org/10.5005/jp/books/12854_148.
- [14] S. Chen, B. Huang, D.J. Luo, X. Li, F. Yang, Y. Zhao, X. Nie, B.X. Huang, [Pregnant women with new coronavirus infection: a clinical characteristics and placental pathological analysis of three cases]., *Zhonghua Bing Li Xue Za Zhi = Chinese J. Pathol.* 49 (2020) E005. <https://doi.org/10.3760/cma.j.cn112151-20200225-00138>.
- [15] H. Chen, J. Guo, C. Wang, F. Luo, X. Yu, W. Zhang, J. Li, D. Zhao, D. Xu, Q. Gong, J. Liao, H. Yang, W. Hou, Y. Zhang, Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records, *Lancet.* 395 (2020) 809–815. [https://doi.org/10.1016/S0140-6736\(20\)30360-3](https://doi.org/10.1016/S0140-6736(20)30360-3).
- [16] L. Zhang, Y. Jiang, M. Wei, B.H. Cheng, X.C. Zhou, J. Li, J.H. Tian, L. Dong, R.H. Hu, Analysis of the pregnancy outcomes in pregnant women with COVID-19 in Hubei Province, *Zhonghua Fu Chan Ke Za Zhi.* 55 (2020) E009. <https://doi.org/10.3760/cma.j.cn112141-20200218-00111>.
- [17] W.M. Bramer, G.B. de Jonge, M.L. Rethlefsen, F. Mast, J. Kleijnen, A systematic approach to searching: An efficient and complete method to develop literature searches, *J. Med. Libr. Assoc.* 106 (2018) 531–541. <https://doi.org/10.5195/jmla.2018.283>.
- [18] T.Y. Khong, E.E. Mooney, I. Ariel, N.C.M. Balmus, T.K. Boyd, M.A. Brundler, H. Derricott, M.J. Evans, O.M. Faye-Petersen, J.E. Gillan, A.E.P. Heazell, D.S. Heller, S.M. Jacques, S. Keating, P. Kelehan, A. Maes, E.M. McKay, T.K. Morgan, P.G.J. Nikkels, W.T. Parks, R.W. Redline, I. Scheimberg, M.H. Schoots, N.J. Sebire, A. Timmer, G. Turowski, J.P. Van Der Voorn, I. Van Lijnschoten, S.J. Gordijn, Sampling and definitions of placental lesions Amsterdam placental workshop group consensus statement, *Arch. Pathol. Lab. Med.* 140 (2016) 698–713. <https://doi.org/10.5858/arpa.2015-0225-CC>.
- [19] K. Slim, E. Nini, D. Forestier, F. Kwiatkowski, Y. Panis, J. Chipponi, Methodological index for non-randomized studies (Minors): Development and validation of a new instrument, *ANZ J. Surg.* 73 (2003) 712–716. <https://doi.org/10.1046/j.1445-2197.2003.02748.x>.

- [20] C. Alonso Díaz, M. López Maestro, M.T. Moral Pumarega, B. Flores Antón, C.R. Pallás Alonso, First case of neonatal infection due to SARS-CoV-2 in Spain, *An. Pediatr.* 92 (2020) 237–238. <https://doi.org/10.1016/j.anpedi.2020.03.002>.
- [21] M. Kamali Aghdam, N. Jafari, K. Eftekhari, Novel coronavirus in a 15-day-old neonate with clinical signs of sepsis, a case report, *Infect. Dis. (Auckl)*. 52 (2020) 427–429. <https://doi.org/10.1080/23744235.2020.1747634>.
- [22] P. Karami, M. Naghavi, A. Feyzi, M. Aghamohammadi, M.S. Novin, A. Mobaien, M. Qorbanisani, A. Karami, A.H. Norooznezhad, Mortality of a pregnant patient diagnosed with COVID-19: A case report with clinical, radiological, and histopathological findings, *Travel Med. Infect. Dis.* (2020) 101665. <https://doi.org/10.1016/j.tmaid.2020.101665>.
- [23] M.L. Chui, F.W. Shell, N.L. Tse, M.C. Kam, C.Y. Wai, Y.W. Tin, T.L. Sik, C.H. Lau, A case-controlled study comparing clinical course and outcomes of pregnant and non-pregnant women with severe acute respiratory syndrome, *BJOG An Int. J. Obstet. Gynaecol.* 111 (2004) 771–774. <https://doi.org/10.1111/j.1471-0528.2004.00199.x>.
- [24] E. Kalafat, E. Yaprak, G. Cinar, B. Varli, S. Ozisik, C. Uzun, A. Azap, A. Koc, Lung ultrasound and computed tomographic findings in pregnant woman with COVID-19, *Ultrasound Obstet. Gynecol.* (2020). <https://doi.org/10.1002/uog.22034>.
- [25] K. Aoyama, R. Pinto, J.G. Ray, A.D. Hill, D.C. Scales, S.E. Lapinsky, M. Hladunewich, G.R. Seaward, R.A. Fowler, Variability in intensive care unit admission among pregnant and postpartum women in Canada: A nationwide population-based observational study, *Crit. Care.* 23 (2019) 1–12. <https://doi.org/10.1186/s13054-019-2660-x>.
- [26] N. Breslin, C. Baptiste, C. Gyamfi-Bannerman, R. Miller, R. Martinez, K. Bernstein, L. Ring, R. Landau, S. Purisch, A.M. Friedman, K. Fuchs, D. Sutton, M. Andrikopoulou, D. Rupley, J.-J. Sheen, J. Aubey, N. Zork, L. Moroz, M. Mourad, R. Wapner, L.L. Simpson, M.E. D’Alton, D. Goffman, COVID-19 infection among asymptomatic and symptomatic pregnant women: Two weeks of confirmed presentations to an affiliated pair of New York City hospitals, *Am. J. Obstet. Gynecol. MFM.* (2020) 100118. <https://doi.org/10.1016/j.ajogmf.2020.100118>.
- [27] N. Breslin, C. Baptiste, R. Miller, K. Fuchs, D. Goffman, C. Gyamfi-Bannerman, M. D’Alton, COVID-19 in pregnancy: early lessons, *Am. J. Obstet. Gynecol. MFM.* (2020) 100111. <https://doi.org/10.1016/j.ajogmf.2020.100111>.
- [28] W.J. Guan, Z.Y. Ni, Y. Hu, W.H. Liang, C.Q. Ou, J.X. He, L. Liu, H. Shan, C.L. Lei, D.S.C. Hui, B. Du, L.J. Li, G. Zeng, K.Y. Yuen, R.C. Chen, C.L. Tang, T. Wang, P.Y. Chen, J. Xiang, S.Y. Li, J.L. Wang, Z.J. Liang, Y.X. Peng, L. Wei, Y. Liu, Y.H. Hu, P. Peng, J.M. Wang, J.Y. Liu, Z. Chen, G. Li, Z.J. Zheng, S.Q. Qiu, J. Luo, C.J. Ye, S.Y.

- Zhu, N.S. Zhong, Clinical Characteristics of Coronavirus Disease 2019 in China, *N. Engl. J. Med.* (2020). <https://doi.org/10.1056/NEJMoa2002032>.
- [29] Z. Wu, J.M. McGoogan, Characteristics of and Important Lessons from the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases from the Chinese Center for Disease Control and Prevention, *JAMA - J. Am. Med. Assoc.* 323 (2020) 1239–1242. <https://doi.org/10.1001/jama.2020.2648>.
- [30] M. Zaigham, O. Andersson, Maternal and perinatal outcomes with COVID-19: A systematic review of 108 pregnancies, *Acta Obstet. Gynecol. Scand.* (2020) 1–7. <https://doi.org/10.1111/aogs.13867>.
- [31] S. Khan, L. Peng, R. Siddique, G. Nabi, Nawsherwan, M. Xue, J. Liu, G. Han, Impact of COVID-19 infection on pregnancy outcomes and the risk of maternal-to-neonatal intrapartum transmission of COVID-19 during natural birth, *Infect. Control Hosp. Epidemiol.* (2020) 1–3. <https://doi.org/10.1017/ice.2020.84>.
- [32] C. Fan, D. Lei, C. Fang, L. C, M. Wang, Y. Liu, Y. Sun, Y. Bao, J. Huang, Y. Guo, Y. Yu, S. Wang, Perinatal transmission of COVID-19 Associated SARS-CoV-2: Should we worry?, *Infect. Dis. Soc. Am.* (2020). <https://doi.org/10.1017/CBO9781107415324.004>.
- [33] L. Yang, K. Yamamoto-Hanada, K. Ishitsuka, T. Ayabe, H. Mezawa, M. Konishi, T. Shoda, H. Sago, H. Saito, Y. Ohya, Medical and surgical complications in pregnancy and obstetric labour complications in the Japan Environment and Children's Study (JECS) cohort: a birth cohort study, *J. Obstet. Gynaecol. (Lahore)*. 0 (2019) 1–7. <https://doi.org/10.1080/01443615.2019.1673709>.
- [34] S.S. Hashemi-Nazari, F. Najafi, M.A. Rahimi, N. Izadi, F. Heydarpour, H. Forooghira, Estimation of gestational diabetes mellitus and dose–response association of BMI with the occurrence of diabetes mellitus in pregnant women of the west of Iran, *Health Care Women Int.* 41 (2020) 121–130. <https://doi.org/10.1080/07399332.2018.1521812>.
- [35] X. Lan, Y.Q. Zhang, H.L. Dong, J. Zhang, F.M. Zhou, Y.H. Bao, R.P. Zhao, C.J. Cai, D. Bai, X.X. Pang, G. Zeng, Excessive gestational weight gain in the first trimester is associated with risk of gestational diabetes mellitus: A prospective study from Southwest China, *Public Health Nutr.* 23 (2020) 394–401. <https://doi.org/10.1017/S1368980019003513>.
- [36] S.F. Wong, K.M. Chow, T.N. Leung, W.F. Ng, T.K. Ng, C.C. Shek, P.C. Ng, P.W.Y. Lam, L.C. Ho, W.W.K. To, S.T. Lai, W.W. Yan, P.Y.H. Tan, Pregnancy and perinatal outcomes of women with severe acute respiratory syndrome, *Am. J. Obstet. Gynecol.* 191 (2004) 292–297. <https://doi.org/10.1016/j.ajog.2003.11.019>.
- [37] Q. tao Huang, S. shan Wei, M. Zhong, L. lin Hang, Y. yuan Xu, G. xi Cai, Q. Liu, Y.

hong Yu, Chronic hepatitis B infection and risk of preterm labor: A meta-analysis of observational studies, *J. Clin. Virol.* 61 (2014) 3–8.
<https://doi.org/10.1016/j.jcv.2014.06.006>.

- [38] Q.T. Huang, J.H. Chen, M. Zhong, Y.Y. Xu, C.X. Cai, S.S. Wei, L.L. Hang, Q. Liu, Y.H. Yu, The risk of placental abruption and placenta previa in pregnant women with chronic hepatitis B viral infection: A systematic review and meta-analysis, *Placenta*. 35 (2014) 539–545. <https://doi.org/10.1016/j.placenta.2014.05.007>.
- [39] K. Racicot, G. Mor, Risks associated with viral infections during pregnancy, *J. Clin. Invest.* 127 (2017) 1591–1599. <https://doi.org/10.1172/JCI87490>.
- [40] A. Staneva, F. Bogossian, M. Pritchard, A. Wittkowski, The effects of maternal depression, anxiety, and perceived stress during pregnancy on preterm birth: A systematic review, *Women and Birth*. 28 (2015) 179–193.
<https://doi.org/10.1016/j.wombi.2015.02.003>.
- [41] S. Wheeler, P. Maxson, T. Truong, G. Swamy, Psychosocial Stress and Preterm Birth: The Impact of Parity and Race, *Matern. Child Health J.* 22 (2018) 1430–1435. <https://doi.org/10.1007/s10995-018-2523-0>.
- [42] A. Spinillo, E. Capuzzo, M. Stronati, A. Iasci, A. Ometto, L. Solerte, Early neonatal complications after elective preterm delivery in hypertensive pregnancies, *J. Perinat. Med.* 23 (1995) 175–181. <https://doi.org/10.1515/jpme.1995.23.3.175>.
- [43] F. Parazzini, E. Ferrazzi, E. Ferrazzi, L. Frigerio, V. Savasi, P. Vergani, F. Prefumo, S. Barresi, S. Bianchi, E. Ciriello, F. Facchinetti, M.T. Gervasi, E. Iurlaro, A. Kusterman, G. Mangili, F. Mosca, D. Spazzini, A. Spinillo, G. Trojano, M. Vignali, A. Villa, G.V. Zuccotti, F. Parazzini, I. Cetin, Mode of delivery and clinical findings in COVID-19 infected pregnant women in, *Lancet*. (2020).
<file:///Users/irinaoltean/Downloads/SSRN-id3562464.pdf>.
- [44] R. Goldenberg, J. Culhane, J. Iams, R. Romero, Epidemiology and causes of preterm birth, *Lancet*. 371 (2008) 75–81.
[https://doi.org/https://doi.org/10.1016/S0140-6736\(08\)60074-4](https://doi.org/https://doi.org/10.1016/S0140-6736(08)60074-4).
- [45] C. V. Ananth, K.M. Keyes, R.J. Wapner, Pre-eclampsia rates in the United States, 1980-2010: Age-period-cohort analysis, *BMJ*. 347 (2013) 1–9.
<https://doi.org/10.1136/bmj.f6564>.
- [46] N. Li, H. An, Z. Li, R. Ye, L. Zhang, H. Li, J. Liu, Preconception blood pressure and risk of gestational hypertension and preeclampsia: a large cohort study in China, *Hypertens. Res.* (2020). <https://doi.org/10.1038/s41440-020-0438-9>.
- [47] R. Fox, J. Kitt, P. Leeson, C.Y.L. Aye, A.J. Lewandowski, Preeclampsia: Risk Factors, Diagnosis, Management, and the Cardiovascular Impact on the Offspring, *J. Clin. Med.* 8 (2019) 1625. <https://doi.org/10.3390/jcm8101625>.

- [48] H.N. Simhan, T.P. Canavan, Preterm premature rupture of membranes: Diagnosis, evaluation and management strategies, *BJOG An Int. J. Obstet. Gynaecol.* 112 (2005) 32–37. <https://doi.org/10.1111/j.1471-0528.2005.00582.x>.
- [49] H. Liu, F. Liu, J. Li, T. Zhang, D. Wang, W. Lan, Clinical and CT imaging features of the COVID-19 pneumonia: Focus on pregnant women and children, *J. Infect.* 80 (2020) e7–e13. <https://doi.org/10.1016/j.jinf.2020.03.007>.
- [50] D. Sharma, P. Spearman, The Impact of Cesarean Delivery on Transmission of Infectious Agents to the Neonate, *Clin. Perinatol.* 35 (2008) 407–420. <https://doi.org/10.1016/j.clp.2008.03.010>.
- [51] N. Li, L. Han, M. Peng, Y. Lv, Y. Ouyang, K. Liu, L. Yue, Q. Li, G. Sun, L. Chen, L. Yang, Maternal and neonatal outcomes of pregnant women with COVID-19 pneumonia: a case-control study, *Clin. Infect. Dis.* (2020). <https://doi.org/10.1017/CBO9781107415324.004>.
- [52] W. Danhua, Newborn Health Care During the Outbreak of COVID-19, Beijing, 2020. <http://www.chinacdc.cn/en/COVID19/202004/P020200421436572702166.pdf> (accessed April 13, 2020).
- [53] Chinese Centre for Disease Control and Prevention, General Questions COVID-19 Prevention and Control, 2015. <https://doi.org/10.1515/9781400824441-005>.
- [54] D. Giannis, I.A. Ziogas, P. Gianni, Coagulation disorders in coronavirus infected patients: COVID-19, SARS-CoV-1, MERS-CoV and lessons from the past, *J. Clin. Virol.* 127 (2020) 104362. <https://doi.org/10.1016/j.jcv.2020.104362>.
- [55] S.A. Rasmussen, J.C. Smulian, J.A. Lednický, T.S. Wen, D.J. Jamieson, Coronavirus Disease 2019 (COVID-19) and pregnancy: what obstetricians need to know, *Am. J. Obstet. Gynecol.* 222 (2020) 415–426. <https://doi.org/10.1016/j.ajog.2020.02.017>.
- [56] Y. Liu, Y. Yang, C. Zhang, F. Huang, F. Wang, J. Yuan, Z. Wang, J. Li, J. Li, C. Feng, Z. Zhang, L. Wang, L. Peng, L. Chen, Y. Qin, D. Zhao, S. Tan, L. Yin, J. Xu, C. Zhou, C. Jiang, L. Liu, Clinical and biochemical indexes from 2019-nCoV infected patients linked to viral loads and lung injury, *Sci. China Life Sci.* 63 (2020) 364–374. <https://doi.org/10.1007/s11427-020-1643-8>.
- [57] C. Heneghan, J. Brassey, T. Jefferson, SARS-CoV -2 viral load and the severity of COVID-19, (2020). <https://doi.org/10.1101/2020.03.15.20036707v2.full.pdf+html>.
- [58] Y. Chen, H. Peng, L. Wang, Y. Zhao, L. Zeng, H. Gao, Y. Liu, Infants Born to Mothers With a New Coronavirus (COVID-19), *Front. Pediatr.* 8 (2020) 1–5. <https://doi.org/10.3389/fped.2020.00104>.

- [59] J. Toubiana, C. Poirault, A. Corsia, F. Bajolle, Outbreak of Kawasaki disease in children during COVID-19 pandemic: a prospective observational study in Paris, France Running title :, MedRxiv. (2020) 1–21.
<https://www.medrxiv.org/content/10.1101/2020.05.10.20097394v1.full.pdf>.
- [60] A.R. Schroeder, K.M. Wilson, S.L. Ralston, COVID-19 and Kawasaki Disease : Finding the Signal in the Noise Pre-publication Release, (2020).
<https://doi.org/10.1542/hpeds.2020-000356>.
- [61] R. Viner, E. Whittaker, Kawasaki-like disease: emerging complication during the COVID-19 pandemic, *Lancet*. (2020) 19–20.
[https://doi.org/https://doi.org/10.1016/S0140-6736\(20\)31129-6](https://doi.org/https://doi.org/10.1016/S0140-6736(20)31129-6).
- [62] G. Lippi, M. Plebani, B.M. Henry, Thrombocytopenia is associated with severe coronavirus disease 2019 (COVID-19) infections: A meta-analysis, *Clin. Chim. Acta*. 506 (2020) 145–148. <https://doi.org/10.1016/j.cca.2020.03.022>.
- [63] D. Wang, B. Hu, C. Hu, F. Zhu, X. Liu, J. Zhang, B. Wang, H. Xiang, Z. Cheng, Y. Xiong, Y. Zhao, Y. Li, X. Wang, Z. Peng, Clinical Characteristics of 138 Hospitalized Patients with 2019 Novel Coronavirus-Infected Pneumonia in Wuhan, China, *JAMA - J. Am. Med. Assoc.* 323 (2020) 1061–1069.
<https://doi.org/10.1001/jama.2020.1585>.
- [64] M.E. Bauer, R. Chiware, C. Pancaro, Neuraxial procedures in COVID-19 positive parturients: a review of current reports, *Anesth. Analg.* (2020) 1–8.
<https://doi.org/10.1213/ANE.0000000000004831>.
- [65] Q. Zhao, M. Meng, R. Kumar, Y. Wu, J. Huang, Y. Deng, Z. Weng, L. Yang, Lymphopenia is associated with severe coronavirus disease 2019 (COVID-19) infections: A systemic review and meta-analysis, *Int. J. Infect. Dis.* 96 (2020) 131–135. <https://doi.org/10.1016/j.ijid.2020.04.086>.
- [66] X. Li, L. Wang, S. Yan, F. Yang, L. Xiang, J. Zhu, B. Shen, Z. Gong, Clinical characteristics of 25 death cases with COVID-19: A retrospective review of medical records in a single medical center, Wuhan, China, *Int. J. Infect. Dis.* 94 (2020) 128–132. <https://doi.org/10.1016/j.ijid.2020.03.053>.
- [67] M. Arizawa, Histologic evidences for chorioamnionitis and decidual vascular lesion as high risk causes of abruptio placentae, *Placenta*. 35 (2014) A20.
<https://doi.org/10.1016/j.placenta.2014.08.076>.
- [68] C. Rodrigues, I. Baia, R. Dominigues, H. Barros, Pregnancy and breastfeeding during COVID-19 pandemic: A systematic review of published pregnancy cases, MedRxiv. (2020). <https://doi.org/10.1016/j.sciaf.2019.e00146>.
- [69] R. Gajbhiye, D. Modi, S. Mahale, Pregnancy outcomes, newborn complications and maternal-fetal transmission of SARS-CoV-2 in women with COVID-19: A

systematic review of 441 cases, MedRxiv. (2020).
<https://doi.org/https://doi.org/10.1101/2020.04.11.20062356.t>.

- [70] S. Suzuki, Peripartum periventricular leukomalacia resulting in cerebral palsy associated with placenta previa in Japan, *F100 Res.* 9 (2020) 1–7.
<https://doi.org/https://doi.org/10.12688/f1000research.22878.2>.
- [71] T. Akhtar, S. Shaikh, A. Bhutto, Frequency of abruption placenta in grand multigravida, *Pak Armed Forces Med.* 70 (2020) S74-77.
<https://www.pafmj.org/index.php/PAFMJ/article/view/3797/2510>.
- [72] F. Pan, T. Ye, P. Sun, S. Gui, B. Liang, L. Li, D. Zheng, J. Wang, R.L. Hesketh, L. Yang, C. Zheng, Time Course of Lung Changes On Chest CT During Recovery From 2019 Novel Coronavirus (COVID-19) Pneumonia, *Radiology.* (2020) 200370.
<https://doi.org/10.1148/radiol.2020200370>.
- [73] D. Wang, Clinico-radiological features and outcomes in pregnant women with COVID-19 : compared with age-matched non-pregnant women, *Lancet.* (2020) 25.
https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3556647.
- [74] X. Wang, Z. Zhou, J. Zhang, F. Zhu, Y. Tang, X. Shen, A case of 2019 Novel Coronavirus in a pregnant woman with preterm delivery, *Clin. Infect. Dis.* (2020) 2019–2021. <https://doi.org/10.1093/cid/ciaa200>.
- [75] S. Wang, L. Guo, L. Chen, W. Liu, Y. Cao, J. Zhang, L. Feng, A case report of neonatal COVID-19 infection in China, *Clin. Infect. Dis.* (2020) 3–7.
<https://doi.org/10.1093/cid/ciaa225>.
- [76] S.N. Iqbal, R. Overcash, N. Mokhtari, H. Saeed, S. Gold, T. Auguste, M.-U. Mirza, M.-E. Ruiz, J.J. Chahine, M. Waga, G. Wortmann, An Uncomplicated Delivery in a Patient with Covid-19 in the United States, *N. Engl. J. Med.* 382 (2020) e34.
<https://doi.org/10.1056/nejmc2007605>.
- [77] S. Limin, X. Weimin, L. Ken, Y. Shanglong, C. Xiangdong, Anesthetic Management for Emergent Cesarean Delivery in a Parturient with Recent Diagnosis of Coronavirus Disease 2019 (COVID-19): A Case Report, *Transl. Perioper. Pain Med.* 7 (2020) 5–8. <https://doi.org/10.31480/2330-4871/118>.
- [78] Y. Zhao, L. Zou, M.-H. Dong, X.-X. Liu, Y.-L. Liu, J.-W. Zhu, Q.-Q. Luo, H. Gao, Challenges for Obstetricians and the Countermeasures of COVID-19 Epidemic, *Matern. Med. Latest Art* (2020).
<https://doi.org/10.1097/fm9.0000000000000046>.
- [79] B. Lowe, B. Bopp, COVID-19 vaginal delivery - a case report, *Aust. New Zeal. J. Obstet. Gynaecol.* (2020). <https://doi.org/10.1111/ajo.13173>.
- [80] D.H. Lee, J. Lee, E. Kim, K. Woo, H.Y. Park, J. An, Emergency cesarean section on

severe acute respiratory syndrome coronavirus 2 (SARS- CoV-2) confirmed patient, Korean J. Anesthesiol. (2020). <https://doi.org/10.4097/kja.20116>.

- [81] Z. Lingkong, T. Xuwei, Y. Wenhao, W. Jin, L. Xin, L. Zhisheng, First case of neonate with COVID-19 in China, *Chin J Pediatr.* 58 (2020) 1–7. <https://doi.org/10.3760/cma.j.cn112140>.
- [82] J. Wang, D. Wang, G.C. Chen, X.W. Tao, L.K. Zeng, SARS-CoV-2 infection with gastrointestinal symptoms as the first manifestation in a neonate, *Chin J Contemp Pediatr.* 22 (2020) 211–214. <https://doi.org/10.7499/j.issn.1008-8830.2020.03.006>.
- [83] W.T. Schnettler, Y. Al Ahwel, A. Suhag, Severe ARDS in COVID-19-infected pregnancy: obstetric and intensive care considerations, *Am. J. Obstet. Gynecol. MFM.* (2020) 100120. <https://doi.org/10.1016/j.ajogmf.2020.100120>.
- [84] Z. Peng, J. Wang, Y. Mo, W. Duan, G. Xiang, M. Yi, L. Bao, Y. Shi, Unlikely SARS-CoV-2 vertical transmission from mother to child: A case report, *J. Infect. Public Health.* (2020) 4–6. <https://doi.org/10.1016/j.jiph.2020.04.004>.
- [85] X. Xiong, H. Wei, Z. Zhang, J. Chang, X. Ma, X. Gao, Q. Chen, Q. Pang, Vaginal Delivery Report of a Healthy Neonate Born to a Convalescent Mother with COVID-19, *J. Med. Virol.* (2020) 0–3. <https://doi.org/10.1002/jmv.25857>.
- [86] M. Han, M. Seong, E. Heo, J. Park, N. Kim, S. Shin, S. Cho, S. Park, E. Choi, Sequential analysis of viral load in a neonate and her mother infected with SARS-CoV-2, *Infect. Dis. Soc. Am.* (2020) 1–13. <https://doi.org/doi/10.1093/cid/ciaa447/5820869>.
- [87] S. Shojaei, M. Kouчек, M.M. Miri, S. Salarian, M. Sistanizad, S. Ariana, M. Hosseini, S. Shoaee, M. Haghighi, M. Nabavi, M. Farahbakhsh, P. Ansari, M. Mirhadi, F. Hadavand, Twin pregnant woman with COVID-19: a case report, *J. Cell. Mol. Anesth.* 5 (2020) 43–46. <https://doi.org/10.22037/JCMA.V5I1.29688>.
- [88] S. Chen, E. Liao, D. Cao, Y. Gao, G. Sun, Y. Shao, Clinical analysis of pregnant women with 2019 novel coronavirus pneumonia, *J. Med. Virol.* 2019 (2020) 1–6. <https://doi.org/10.1002/jmv.25789>.
- [89] W. Liu, J. Wang, W. Li, Z. Zhou, S. Liu, Z. Rong, Clinical characteristics of 19 neonates born to mothers with COVID-19, *Front. Med.* (2020). <https://doi.org/10.1007/s11684-020-0772-y>.
- [90] W. Liu, Q. Wang, Q. Zhang, L. Chen, Coronavirus disease 2019 (COVID-19) during pregnancy: a case series, *Preprint.* 2019 (2020) 1–28. <https://www.preprints.org/manuscript/202002.0373/v1%0Awww.preprints.org>.
- [91] D. Liu, L. Li, D. Zheng, J. Wang, L. Yang, C. Zheng, D. Liu, L. Li, X. Wu, Pregnancy

and perinatal outcomes of women with coronavirus disease (COVID-19) pneumonia: A preliminary analysis, *Am. J. Roentgenol.* (2020) 1–6.
<https://doi.org/doi.org/10.2214/AJR.20.23072> D.

- [92] R. Chen, Y. Zhang, L. Huang, B. heng Cheng, Z. yuan Xia, Q. tao Meng, Safety and efficacy of different anesthetic regimens for parturients with COVID-19 undergoing Cesarean delivery: a case series of 17 patients, *Can. J. Anesth.* (2020).
<https://doi.org/10.1007/s12630-020-01630-7>.
- [93] L. Yue, L. Han, Q. Li, M. Zhong, J. Wang, Z. Wan, C. Chu, Y. Zeng, M. Peng, L. Yang, N. Li, Anaesthesia and infection control in cesarean section of pregnant women with coronavirus disease 2019 (COVID-19), *MedRxiv.* (2020) 2020.03.23.20040394. <https://doi.org/10.1101/2020.03.23.20040394>.
- [94] N. Yu, W. Li, Q. Kang, Z. Xiong, S. Wang, X. Lin, Y. Liu, J. Xiao, H. Liu, D. Deng, S. Chen, W. Zeng, L. Feng, J. Wu, Clinical features and obstetric and neonatal outcomes of pregnant patients with COVID-19 in Wuhan, China: a retrospective, single-centre, descriptive study, *Lancet Infect. Dis.* 20 (2020) 559–564.
[https://doi.org/10.1016/S1473-3099\(20\)30176-6](https://doi.org/10.1016/S1473-3099(20)30176-6).
- [95] R. Nie, S. Wang, Q. Yang, C. Fan, Y. Liu, W. He, M. Jiang, Clinical features and the maternal and neonatal outcomes of pregnant women with coronavirus disease 2019, *MedRxiv.* (2020) 1–23.
<https://doi.org/doi.org/10.1101/2020.03.22.20041061>.
- [96] Z.J. Zhang, X.J. Yu, T. Fu, Y. Liu, Y. Jiang, B.X. Yang, Y. Bi, Novel Coronavirus Infection in Newborn Babies Under 28 Days in China, *Eur. Respir. J.* (2020).
<https://doi.org/10.1183/13993003.00697-2020>.
- [97] M. Yin, L. Zhang, G. Deng, C. Han, M. Shen, H. Sun, F. Zeng, W. Zhang, L. Chen, Q. Luo, D. Yao, M. Wu, S. Yu, H. Chen, D. Baud, X. Chen, Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) Infection During Pregnancy In China: A Retrospective Cohort Study, *MedRxiv.* 2 (2020) 2020.04.07.20053744.
<https://doi.org/10.1101/2020.04.07.20053744>.
- [98] P. Yang, X. Wang, P. Liu, C. Wei, B. He, J. Zheng, D. Zhao, Clinical characteristics and risk assessment of newborns born to mothers with COVID-19, *J. Clin. Virol.* 127 (2020) 104356. <https://doi.org/10.1016/j.jcv.2020.104356>.
- [99] Y. Zhang, R. Chen, J. Wang, Y. Gong, Q. Zhou, H. Cheng, X. Zhong-yuan, X. Chen, Q. Meng, D. Ma, Anaesthetic management and clinical outcomes of parturients with COVID-19: a multicentre, retrospective, propensity score matched cohort study, *MedRxiv.* (2020). <https://doi.org/https://doi.org/10.1101/2020.03.24.20042176>.