Hakan Golbasi*, Ibrahim Omeroglu, Burak Bayraktar, Ceren Golbasi, Duygu Adiyaman and Atalay Ekin

How COVID-19 pandemic is changing the practice of prenatal screening and diagnosis?

<https://doi.org/10.1515/jpm-2021-0343>

Received July 22, 2021; accepted November 11, 2021;

published online December 7, 2021

Abstract

Objectives: To evaluate the impact of the COVID-19 pandemic on prenatal screening and diagnostic tests.

Methods: We conducted a retrospective study with pregnant women attending to the perinatology department of a tertiary referral center. The pre-COVID-19 period between 11 March 2019 and 10 March 2020 and COVID-19 period between 11 March 2020 and 10 March 2021 were evaluated. Both periods were compared in terms of outpatient visits, ultrasound examinations, prenatal screening and diagnostic tests. The correlation of deaths related to COVID-19 pandemic on these parameters was also assessed.

Results: A total of 38,918 patients were examined and 28,452 ultrasound examinations, 26,672 prenatal screening tests and 1,471 prenatal diagnostic tests were performed over two years. During COVID-19 pandemic, number of outpatient visits decreased by 25.2%, ultrasound examinations decreased by 44.2%, prenatal screening tests decreased by 36.2% and prenatal diagnostic tests decreased by 30.7%. Statistically significant correlation was not observed between deaths related to COVID-19 and outpatient visits ($p=0.210$), ultrasound examinations ($p=0.265$), prenatal screening ($p=0.781$) and diagnostic tests ($p=0.158$). Among

indications of prenatal diagnostic tests, maternal anxiety was significantly higher in COVID-19 period ($p=0.023$). There was significant decrease in the detection of fetuses with trisomy 21 ($p=0.047$) and a significant increase in the detection of fetuses with Turner syndrome ($p=0.017$) during COVID-19 period.

Conclusions: The COVID-19 pandemic has severely impacted antenatal care. Prenatal fetal screening and diagnosis was adversely affected by the pandemic in terms of detecting genetic and structural anomalies.

Keywords: antenatal care; COVID-19; pregnancy; prenatal diagnosis; prenatal screening.

Introduction

The World Health Organization declared the COVID-19 outbreak a worldwide pandemic on March 11, 2020, because of the number of cases, deaths, and affected countries [1]. The first case reported in Turkey was on March 11, 2020. After that, severe restrictions were imposed to limit the spread of the disease [2]. Despite restrictions, the coronavirus outbreak has caused more than 180 million cases and more than four million deaths [3]. Although vaccination has been carried out worldwide, viral mutations have made it difficult to control the pandemic [4].

COVID-19 has a poor clinical course and high morbidity and mortality in susceptible individuals, including pregnant women. Pregnant women are more likely admitted to an intensive care unit, require invasive ventilation, receive extracorporeal membrane oxygenation, and die than non-pregnant women [5]. Studies have reported COVID-19 fetal complications such as abortion, preterm delivery, stillbirth, and intrauterine growth retardation [6–8]. Although there is insufficient data, COVID-19 during pregnancy could be associated with fetal structural anomalies [9, 10].

Routine antenatal care for pregnant women is essential to identify high-risk pregnant women as soon as possible. However, there have been great difficulties in maternal antenatal care during the COVID-19 pandemic due to limited access to medical services, restrictions, and the risk of viral transmission [11]. The restrictions that interrupted routine care were the suspension of all non-urgent services

*Corresponding author: Hakan Golbasi, MD, Division of Perinatology, Department of Obstetrics and Gynecology, University of Health Sciences Tepecik Training and Research Hospital, Izmir, Turkey, E-mail: drhkgolbasi@gmail.com. <https://orcid.org/0000-0001-8682-5537>

Ibrahim Omeroglu, Duygu Adiyaman and Atalay Ekin, Division of Perinatology, Department of Obstetrics and Gynecology, University of Health Sciences Tepecik Training and Research Hospital, Izmir, Turkey. <https://orcid.org/0000-0001-9200-0208> (I. Omeroglu). <https://orcid.org/0000-0002-5307-8149> (D. Adiyaman). <https://orcid.org/0000-0002-4712-3927> (A. Ekin)

Burak Bayraktar, Department of Obstetrics and Gynecology, University of Health Sciences Tepecik Training and Research Hospital, Izmir, Turkey. <https://orcid.org/0000-0001-6233-4207>

Ceren Golbasi, Department of Obstetrics and Gynecology, Izmir Tınaztepe University Faculty of Medicine, Izmir, Turkey. <https://orcid.org/0000-0002-1844-1782>

to provide treatment to COVID-19 patients and the limitation of public transport, which caused difficulty in reaching hospitals. Healthcare systems revised the antenatal care procedures, expanding telehealth to provide adequate prenatal care without increasing healthcare professionals' risk of maternal viral transmission [12]. Nevertheless, face-to-face visits of pregnant women are required for ultrasound examination and genetic screening. Although genetic consultation with telehealth is carried out in many countries, even during the pre-COVID-19 period, face-to-face visits are required for genetic consultation in Turkey due to the Ministry of Health policy [13, 14]. It is important to screen high-risk pregnant women to detect fetal structural and chromosomal anomalies because fetal morbidity and mortality may affect the continuation of pregnancy [15].

For this reason, this study was conducted to examine the changes in prenatal screening and diagnostic tests that occurred in the first year of the COVID-19 pandemic to develop strategies to provide prenatal care.

Materials and methods

This retrospective observational study was conducted with pregnant women attending to University of Health Sciences Tepecik Training and Research Hospital, Department of Perinatology between the dates of 11 March 2019 and 10 March 2021. To compare the impact of COVID-19 pandemic, the time schedule was divided into two equal periods. 11 March 2020 was accepted as cut-off point due to confirmation of the first case with COVID-19 at that date by Turkish Government. Therefore, the date between 11 March 2019 and 10 March 2020 was defined as pre-COVID-19 period and the date between 11 March 2020 and 10 March 2021 was defined as COVID-19 period. Data regarding outpatient visits, ultrasound examinations, prenatal screening and diagnostic tests were collected from the medical records of the patients in hospital. Additionally, the information about maternal age, gravida, parity, gestational week at the diagnostic test, indications of diagnostic tests, type of diagnostic tests (chorionic villus sampling, amniocentesis, cordocentesis) and fetal karyotype results of pregnancies were also investigated.

The double screening test was performed between 11 and 14 weeks of gestation, triple and quadruple screening tests were performed between 16 and 20 weeks of gestation and the cell-free DNA test was performed between 10 and 20 weeks of gestation. All chorionic villus sampling procedures were performed transabdominally between 11 and 14 weeks of gestation, amniocenteses were between 16 and 24 weeks, and cordocentesis were at ≥ 20 weeks of gestation. The number of deaths related to COVID-19 pandemic was obtained from the database of Turkish Ministry of Health [16]. Ethics committee approval was obtained from University of Health Sciences Tepecik Training and Research Hospital Ethics Committee (Approval Number: 2021/04-07).

Results

Over two years, a total of 38,918 patients visited our perinatology department, and 28,452 ultrasound examinations, 26,672 prenatal screening tests, and 1,471 prenatal diagnostic tests were performed. The distribution of outpatient visits, ultrasound examinations, prenatal screening, and diagnostic tests for pre-COVID-19 and COVID-19 periods are shown according to months of the year in Table 1. During the COVID-19 pandemic, outpatient visits decreased by 25.2%, ultrasound examinations decreased by 44.2%, prenatal screening tests decreased by 36.2%, and prenatal diagnostic tests decreased by 30.7%. Compared to the pre-COVID-19 period, there was a decrease in outpatient visits, ultrasound examinations, prenatal screening, and diagnostic tests in all months during the COVID-19 period. The highest decrease in all parameters was observed at the beginning of the COVID-19 pandemic (April and May 2020). However, there was no significant correlation between deaths related to COVID-19 and outpatient visits ($p=0.210$), ultrasound examinations ($p=0.265$), prenatal screening ($p=0.781$) and diagnostic tests ($p=0.158$) (Figures 1 and 2). The clinical characteristics of patients who had prenatal diagnostic tests are in Table 2. The number of prenatal invasive procedures, including chorion villus sampling ($p<0.001$), amniocentesis ($p<0.001$), and cordocentesis ($p<0.001$), were significantly lower during the COVID-19 period compared to the pre-COVID-19 period. The gestational week of the prenatal invasive procedures was significantly later for the COVID-19 period (17.4 ± 3.2 weeks vs. 17.8 ± 3 weeks; $p=0.011$).

Prenatal diagnostic test indications for both periods are presented in Table 3. The most common indications were prenatal screening tests and fetal structural anomalies on ultrasound for both pre-COVID-19 (58.6 and 34.1%, respectively) and COVID-19 periods (56.4 and 32.5%, respectively). Among the indications, prenatal screening tests ($p=0.332$), a fetal anomaly on ultrasound ($p=0.578$), a history of fetal anomaly ($p=0.559$), fetal infection ($p=0.051$), and parental genetic abnormalities ($p=0.591$) did not significantly differ between the two periods. However, maternal anxiety was significantly higher in pregnant women during the COVID-19 period ($p=0.023$). There was no significant difference between the two periods in terms of fetal chromosome abnormalities (Table 4). Trisomy 21 was the most detected fetal chromosomal abnormality for both COVID-19 periods (6.4 and 5.4%, respectively). Interestingly, when we compared the difference of fetal chromosomal abnormalities one by one, we found that there was a significant decrease in the detection of fetuses with trisomy 21 ($p=0.047$) and a

Table 1: Distribution of characteristics of prenatal care for pre-COVID-19 and COVID-19 periods.

	11–31 March	April	May	June	July	August	September	October	November	December	January	February	1–10 March	Total
Outpatient visits (n=38,918)														
Pre-COVID 19	378	2,347	2,336	1,678	2,190	1,502	1,825	1,950	1,728	1,978	2,115	1,740	500	22,267
COVID 19	794	417	550	1,050	1,342	1,237	1,849	1,715	1,923	1,425	1,734	1,705	910	16,651
Change, %	110.1	-82.2	-76.5	-37.4	-38.7	-17.6	1.3	-12.1	11.3	-28.0	-18.0	-2.0	82.0	-25.2
Ultrasound examination (n=28,452)														
Pre-COVID 19	298	1,895	1,979	1,365	1,694	1,285	1,544	1,656	1,527	1,545	1,694	1,299	485	18,266
COVID 19	394	299	404	768	1,006	932	1,007	869	970	1,046	1,034	612	845	10,186
Change, %	32.2	-84.2	-79.6	-43.7	-40.6	-27.5	-34.8	-47.5	-36.5	-32.3	-39.0	-52.9	74.2	-44.2
Prenatal screening tests (n=26,672)														
Pre-COVID 19	1,160	1,344	1,656	1,133	1,380	1,074	1,249	1,215	1,263	1,378	1,674	1,307	449	16,282
COVID 19	707	352	661	1,014	894	902	926	885	876	807	927	1,031	408	10,390
Change, %	-39.1	-73.8	-60.1	-10.5	-35.2	-16.0	-25.9	-27.2	-30.6	-41.4	-44.6	-21.1	-9.1	-36.2
Prenatal diagnostic tests (n=1,471)														
Pre-COVID 19	42	69	60	63	84	65	63	69	54	69	69	130	32	869
COVID 19	35	36	23	49	40	40	43	39	54	59	57	106	21	602
Change, %	-16.7	-47.8	-61.7	-22.2	-52.4	-38.5	-31.7	-43.5	0.0	-14.5	-17.4	-18.5	-34.4	-30.7

significant increase in the detection of fetuses with Turner syndrome ($p=0.017$) during the COVID-19 period (Table 5).

Discussion

Our study demonstrated that the COVID-19 pandemic had a significant impact on antenatal care. We found that outpatient visits, ultrasound examinations, prenatal screening, and diagnostic tests decreased significantly in pregnancies in the COVID-19 period. The COVID-19 pandemic has had a huge impact worldwide. Many countries have had difficulties maintaining health care, and thus, antenatal care has been affected. A study from Israel determined that the rate of ruptured ectopic pregnancy increased significantly during the COVID-19 pandemic [17]. Another study from the United States showed that the rate of home births increased due to the risk of COVID-19 transmission, and one-third of women (32.5%) avoided routine antenatal visits [18]. Similarly, Goyal et al. [19] reported that pregnant women in India delayed antenatal visits to protect themselves from the epidemic or economic problems caused by the pandemic. They also emphasized that home births increased, and maternal mortality increased rapidly during the pandemic.

We found that the number of outpatient visits and ultrasound examinations drastically decreased during the COVID-19 period. Ghesquière et al. [20] showed that diabetes was less controlled in pregnancy during the pandemic lockdown, even with follow-up. They attributed this association to decreased physical activity, altered eating habits, and anxiety during the COVID-19 pandemic. Outpatient visits are important in providing routine antenatal care and the diagnosis of pregnancy-related diseases such as gestational diabetes and preeclampsia. Ultrasound examination is also important in detecting conditions that may cause fetal distress, such as intrauterine growth retardation and oligohydramnios. However, not enough studies have explored the effects of disruption of these restrictions on maternal and fetal outcomes.

Due to decreased admission of pregnant women, the number of prenatal screening tests during the COVID-19 pandemic decreased substantially. Therefore, difficulties in maintaining antenatal care have led to the need to revise antenatal care for the COVID-19 pandemic. The Royal College of Obstetricians and Gynecologists published guidelines for prenatal screening in pregnancy during the evolving COVID-19 pandemic. These guidelines instructed physicians to provide medical care online or by phone whenever possible [17]. Due to the COVID-19 outbreak in China, online medical care counseling for pregnant women has begun. As a result, pregnant women have refused

Figure 1: The relationship between the monthly number of deaths from COVID-19 infection and the number of prenatal diagnostic tests.

admission for routine antenatal care in regions where disease severity is high, and more than 90% of the problems of pregnant women were resolved with this practice. However, the effect of hospital admission on perinatal outcomes was not included in the mentioned study [11]. A study conducted in the United States showed that antenatal visits could be compensated by performing video and image recordings and fetal telecardiography in patients who require fetal anomaly screening. This practice can also help reduce the risk of transmission for clinicians and pregnant women [21].

Limited studies are investigating the effect of the COVID-19 pandemic on prenatal screening and diagnostic tests in antenatal care. The COVID-19 pandemic may affect pregnant women's access and use of prenatal genetic testing and may cause delays in admission for prenatal screening tests due to anxiety about viral transmission [22]. Prenatal screening tests are very important in detecting fetal genetic and structural anomalies and may affect the continuation of pregnancy, accurate and timely counseling of families, and mode of delivery. The most common prenatal diagnostic test

indications in this study were abnormal prenatal screening and fetal structural anomalies in both eras. On the other hand, maternal anxiety was the only statistically significant change in indications of invasive prenatal diagnosis. We believe that the restrictions caused by the pandemic and the anxiety of viral transmission in pregnant women significantly affected prenatal screening tests and, thus, diagnostic tests (Figures 1 and 2). The effect on diagnostic tests might have been related to the fact that pregnant women did not visit the hospital or could not reach the hospital rather than the delay.

Furthermore, there have been other contributing factors that have worsened antenatal care during the pandemic. Our government reduced patient volume across hospital departments and services to allow social distancing and streaming pandemic requirements. As the pandemic progressed, it was impossible to maintain appropriate staffing in healthcare facilities due to COVID-19 exposure, illness, stress, anxiety, and the need to care for family members. We already know that many pregnant women delayed or avoided medical care, including screening and diagnostic tests,

Figure 2: Relationship between monthly COVID-19 infection deaths and prenatal screening tests, outpatient visits, and ultrasound examinations.

Table 2: Comparison of clinical characteristics of patients who had prenatal diagnostic tests according to two periods.

	Pre-COVID-19 (n=869)	COVID-19 (n=602)	p- Value
Maternal age, years	32.2 ± 6.6	32.2 ± 6.5	0.954
≤19 years	30 (3.45%)	15 (2.5%)	0.292
≥35 years	371 (42.7%)	245 (40.7%)	0.445
Gestational age at diagnostic testing (week) (mean ± SD)	17.4 ± 3.2	17.8 ± 3	0.011
Gravida median (min–max)	3 (1–8)	3 (1–8)	0.431
Parity median (min–max)	2 (0–5)	2 (0–5)	0.004
Chorionic villus sampling, n (%)	132 (15.2%)	45 (7.5%)	<0.001
Amniocentesis, n (%)	553 (63.6%)	479 (79.6%)	<0.001
Cordocentesis, n (%)	184 (21.2%)	78 (13%)	<0.001

because of concerns about COVID-19. Supporting this view, the prenatal screening and diagnostic tests were significantly reduced in the months when the disease was most prevalent (Figures 1 and 2). Previous studies have proposed

the mental impact of COVID-19 on pregnant women, indicating that the anxiety level and the need for psychological support of pregnant women increased during the pandemic [23, 24]. Besides, Ozalp et al. [25] reported that the acceptance rate of the invasive procedures increased at the time of the first visit during the pandemic period, although the total number of invasive procedures decreased. They also emphasized that the patients referred from different cities had higher rates of having the procedure at the first visit when patients' residence was compared [25]. Ozalp et al. [25] thought that both transportation restrictions and avoidance of the need for re-admission due to anxiety are involved in patients' decision-making process during the pandemic.

Furthermore, the mean gestational age of the pregnant women who had prenatal diagnostic tests was significantly higher in the COVID-19 pandemic. The significant change in the number of women who underwent chorionic villus sampling could be the reason for the increase in the time of prenatal invasive testing. Compared with the non-pandemic era, there was a 65.9% decrease in cases undergoing

Table 3: Indications of prenatal diagnostic tests during pre-COVID-19 and COVID-19 periods.

	Pre-COVID-19 (n=869)		COVID-19 (n=602)		p-Value
	n	%	n	%	
High risk in prenatal screening test	510	58.6	338	56.4	0.332
Double screening test	365	42.0	233	38.8	
Triple screening test	102	11.7	74	12.3	
Quadruple screening test	25	2.9	24	4.0	
Cell-free DNA	18	2	7	1.3	
Fetal anomaly on ultrasound	295	34.1	196	32.5	0.578
Soft markers	168	19.4	95	15.7	
Major anomaly	127	14.7	101	16.8	
Maternal anxiety	27	3.1	33	5.5	0.023
History of fetal anomaly	19	2.2	16	2.7	0.559
Fetal infection	10	1.1	15	2.5	0.050
Cytomegalovirus	2	0.2	4	0.7	
Toxoplasma	8	0.9	11	1.8	
Parental genetic abnormality	8	0.9	4	0.7	0.591

Table 4: Results of prenatal diagnostic tests during pre-COVID-19 and COVID-19 periods.

	Pre-COVID 19 (n=869)		COVID-19 (n=602)		p-Value
	n	%	n	%	
Normal	780	89.8	537	89.2	0.732
Abnormal	89	10.2	65	10.8	
Trisomy 21	56	6.4	32	5.4	
Trisomy 18	13	1.5	8	1.3	
Translocation	8	0.9	4	0.7	
Trisomy 13	3	0.3	3	0.5	
Triploidy 69,XXX	2	0.2	2	0.3	
45,X0 (Turner syndrome)	1	0.1	6	1	
47XXY (Klinefelter syndrome)	1	0.1	3	0.5	
46,...,22pstk+	1	0.1	0	0.0	
46,...,der(20)	1	0.1	0	0.0	
46,XY,add(Y)(p11.2)	1	0.1	0	0.0	
Partial trisomy 5p	1	0.1	0	0.0	
Triploidy 69,XXY	1	0.1	0	0.0	
Trisomy 2	0	0.0	2	0.3	
Trisomy 8	0	0.0	1	0.2	
Trisomy 21 + 48XXY (Down-Klinefelter syndrome)	0	0.0	2	0.4	
Paracentric inversions on the q arm of chromosome 12	0	0.0	1	0.2	
Fragile X	0	0.0	1	0.2	

chorionic villus sampling, whereas the decrease in cases undergoing amniocentesis was 13.3%. Like our findings, Ozalp et al. [25] showed that amniocentesis and chorionic

Table 5: Types of fetal chromosome abnormalities in fetuses with abnormal prenatal genetic tests during pre-COVID-19 and COVID-19 periods.

	Pre-COVID-19 (n=89)		COVID-19 (n=65)		p-Value
	n	%	n	%	
Trisomy 21	58	65.2	32	49.3	0.047
Trisomy 18	12	13.6	8	12.3	0.830
Translocation	7	7.9	4	6.2	0.683
Trisomy 13	3	3.4	3	4.6	0.693
Triploidy 69,XXX	2	2.2	2	3.1	0.749
45,X0 (Turner syndrome)	1	1.1	6	9.2	0.017
47XXY (Klinefelter syndrome)	1	1.1	3	4.6	0.178
46,...,22pstk+	1	1.1	0	0.0	0.391
46,...,der(20)	1	1.1	0	0.0	0.391
46,XY,add(Y)(p11.2)	1	1.1	0	0.0	0.391
Partial trisomy 5p	1	1.1	0	0.0	0.391
Triploidy 69,XXY	1	1.1	0	0.0	0.391
Trisomy 2	0	0.0	2	3.1	0.095
Trisomy 21+48XXY (Down-Klinefelter syndrome)	0	0.0	2	3.1	0.095
Trisomy 8	0	0.0	1	1.5	0.240
Paracentric inversions on the q arm of chromosome 12	0	0.0	1	1.5	0.240
Fragile X	0	0.0	1	1.5	0.240
Total	89	100	65	100	0.732

villus sampling decreased significantly, but cordocentesis increased during the pandemic period. It was stated that this change might be related to the delay in patient admissions due to the pandemic, but the change in screening tests during the pandemic period was not examined, and the number of pregnant women who underwent cordocentesis was not sufficient for evaluation. However, the significant increase in the mean gestational week of diagnostic testing in the COVID-19 period may not be significant in clinical practice. The mean gestational age of women who underwent invasive diagnostic testing in the COVID-19 period (17.8 ± 3 weeks) was only 0.4 weeks (about three days) later than those in the pre-COVID-19 period (17.4 ± 3.2 weeks). This brief delay probably does not preclude the management options and patients' decisions following the evaluation of fetal tissue cultures.

We did not reveal any difference in the total rate of chromosomal abnormalities between the two eras. However, an interesting finding is a significant decrease in the detection of pregnancies with trisomy 21 during the COVID-19 pandemic. In addition, prenatal diagnosis of pregnancies with Turner syndrome significantly increased in the COVID-19 period. It is already known that some fetuses with

trisomy 21 show no abnormalities on routine ultrasound. Therefore, the decrease in prenatal screening tests for trisomy 21 may lead to the underdiagnosis of pregnancies with trisomy 21 in the COVID-19 pandemic. Although the rate of all anomalies detected on ultrasound decreased by 1.6%, the rate of major fetal anomalies detected on ultrasound increased by 1.9% compared to the pre-COVID 19 period. This change could be associated with a significant increase in the rate of pregnancies diagnosed with Turner syndrome. Accordingly, Khan et al. [9] reported that COVID-19 infection in pregnancy might cause congenital birth defects such as neural tube defects due to placental crossing of coronavirus. Although the rate of fetal major structural anomalies increased during the COVID-19 period in this study, there was not enough data to associate this increase with maternal–fetal coronavirus transmission. The study's main limitations are its retrospective design and lack of information regarding the impact of the COVID-19 pandemic on other adverse maternal and fetal outcomes, including pre-eclampsia, gestational diabetes, and fetal growth retardation. However, one of the key strengths of our study is that the data was obtained from a large sample size in a high-volume tertiary referral center. Furthermore, our findings will fill the gap in the literature with limited information by promoting awareness and understanding of antenatal care during the COVID-19 pandemic.

In conclusion, the COVID-19 pandemic has adversely affected antenatal care by decreasing patient admissions, ultrasound examinations, prenatal screening, and diagnostic tests. However, antenatal care services during the pandemic have great importance for managing pregnancy-related diseases, diagnosis of fetal structural and chromosomal anomalies, and adequate and timely patient counseling. Therefore, the findings of this study may provide new strategies for the most accurate antenatal care during the current COVID-19 pandemic.

Research funding: None declared.

Author contributions: All authors have accepted responsibility for the entire content of this manuscript and approved its submission.

Competing interests: Authors state no conflict of interest.

Informed consent: Informed consent is not required as it is a retrospective study.

Ethical approval: The study was approved by the University of Health Sciences Tepecik Training and Research Hospital Local Ethics Committee (Approval Number: 2021/04-07). The research was conducted in accordance with the 1964 Helsinki Declaration. Informed consent is not required as it is a retrospective study.

References

1. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed* 2020;91:157–60.
2. Cakir B. COVID-19 in Turkey: lessons learned. *J Epidemiol Glob Health* 2020;10:115–7.
3. Coronavirus disease (COVID-19) World Health Organization; n.d. Available from: <https://covid19.who.int/> [Accessed 5 Nov 2021].
4. Callaway E. Delta coronavirus variant: scientists brace for impact. *Nature* 2021;595:17–8.
5. Zambrano LD, Ellington S, Strid P, Galang RR, Oduyebo T, Tong VT, et al. Update: characteristics of symptomatic women of reproductive age with laboratory-confirmed SARS-CoV-2 infection by pregnancy status - United States, January 22–October 3, 2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1641–7.
6. Allotey J, Stallings E, Bonet M, Yap M, Chatterjee S, Kew T, et al. Clinical manifestations, risk factors, and maternal and perinatal outcomes of coronavirus disease 2019 in pregnancy: living systematic review and meta-analysis. *BMJ* 2020;370:m3320.
7. Rasmussen SA, Smulian JC, Lednický JA, Wen TS, Jamieson DJ. Coronavirus Disease 2019 (COVID-19) and pregnancy: what obstetricians need to know. *Am J Obstet Gynecol* 2020;222:415–26.
8. Dashraath P, Wong JIJ, Lim MXK, Lim LM, Li S, Biswas A, et al. Coronavirus disease 2019 (COVID-19) pandemic and pregnancy. *Am J Obstet Gynecol* 2020;222:521–31.
9. Khan MSI, Nabeka H, Akbar SMF, Al Mahtab M, Shimokawa T, Islam F, et al. Risk of congenital birth defects during COVID-19 pandemic: draw attention to the physicians and policymakers. *J Glob Health* 2020;10:020378.
10. Muldoon KM, Fowler KB, Pesch MH, Schleiss MR. SARS-CoV-2: is it the newest spark in the TORCH? *J Clin Virol* 2020;127:104372.
11. Chen M, Liu X, Zhang J, Sun G, Gao Y, Shi Y, et al. Characteristics of online medical care consultation for pregnant women during the COVID-19 outbreak: cross-sectional study. *BMJ Open* 2020;10:e043461.
12. Zork NM, Aubey J, Yates H. Conversion and optimization of telehealth in obstetric care during the COVID-19 pandemic. *Semin Perinatol* 2020;44:151300.
13. Terry AB, Wylie A, Raspa M, Vogel B, Sanghavi K, Djurdjinovic L, et al. Clinical models of telehealth in genetics: a regional telegenetics landscape. *J Genet Counsel* 2019;28:673–91.
14. Rhoads S, Rakes AL. Telehealth technology: reducing barriers for rural residents seeking genetic counseling. *J Am Assoc Nurse Pract* 2020;32:190–2.
15. Practice Bulletin No. 162. Prenatal diagnostic testing for genetic disorders. *Obstet Gynecol* 2016;127:e108–22.
16. COVID-19 information platform: republic of Turkey Ministry of Health; n.d. Available from: <https://covid19.saglik.gov.tr/> [Accessed 1 Oct 2021].
17. Dvash S, Cuckle H, Smorgick N, Vaknin Z, Padoa A, Maymon R. Increase rate of ruptured tubal ectopic pregnancy during the COVID-19 pandemic. *Eur J Obstet Gynecol Reprod Biol* 2021;259:95–9.
18. Davis-Floyd R, Gutschow K, Schwartz DA. Pregnancy, birth and the COVID-19 pandemic in the United States. *Med Anthropol* 2020;39:413–27.
19. Goyal M, Singh P, Singh K, Shekhar S, Agrawal N, Misra S. The effect of the COVID-19 pandemic on maternal health due to delay

- in seeking health care: experience from a tertiary center. *Int J Gynaecol Obstet* 2021;152:231–5.
20. Ghesquiere L, Garabedian C, Drumez E, Lemaitre M, Cazaubiel M, Bengler C, et al. Effects of COVID-19 pandemic lockdown on gestational diabetes mellitus: a retrospective study. *Diabetes Metab* 2021;47:101201.
21. Schwartz BN, Klein JH, Barbosa MB, Hamersley SL, Hickey KW, Ahmadzia HK, et al. Expanding access to fetal telecardiology during the COVID-19 pandemic. *Telemed J E Health* 2021;27:1235–40.
22. Farrell RM, Pierce M, Collart C, Craighead C, Coleridge M, Chien EK, et al. The impact of the emergence of COVID-19 on women's prenatal genetic testing decisions. *Prenat Diagn* 2021; 41:1009–17.
23. Durankus F, Aksu E. Effects of the COVID-19 pandemic on anxiety and depressive symptoms in pregnant women: a preliminary study. *J Matern Fetal Neonatal Med* 2020;18:1–7.
24. Mirzadeh M, Khedmat L. Pregnant women in the exposure to COVID-19 infection outbreak: the unseen risk factors and preventive healthcare patterns. *J Matern Fetal Neonatal Med* 2020;7:1–2.
25. Ozalp M, Demir O, Akbas H, Kaya E, Celik C, Osmanagaoglu MA. Effect of COVID-19 pandemic process on prenatal diagnostic procedures. *J Matern Fetal Neonatal Med* 2021;34:3952–7.