Manifestations of COVID-19 in pregnant women with focus on gastrointestinal symptoms: a systematic review

Somayeh Makvandi1, Sara Ashtari2, Amir Vahedian-Azimi3
1Department of Midwifery, School of Nursing and Midwifery, Islamic Azad University AhvazBranch, Ahvaz, Iran
2Gastroenterology and Liver Diseases Research Center, Research Institute for Gastroenterology and Liver Diseases, Shahid Beheshti University of Medical Sciences, Tehran, Iran
3Trauma Research Center, Nursing Faculty, Baqiyatallah University of Medical Sciences, Tehran, Iran

ABSTRACT
Aim: This review study was conducted to evaluate the symptoms of COVID-19 in pregnant women with a focus on gastrointestinal symptoms.

Background: COVID-19 is a fatal respiratory disease caused by a novel coronavirus that quickly became a pandemic. Although the main symptoms of this disease include respiratory symptoms, gastrointestinal manifestations have also been observed in some patients suffering from COVID-19. Pregnant women are among the most vulnerable groups in the community to infectious diseases.

Methods: Scientific databases were searched for articles published up to May 8, 2020. Any type of study investigating the manifestations of COVID-19 in pregnant women was included. Symptoms of the disease in pregnant women with an emphasis on gastrointestinal symptoms were assessed.

Results: The search resulted in 852 titles and abstracts, which were narrowed down to 43 studies involving 374 women. The most common symptoms of patients were fever (59.1%) and cough (48.4%), respectively. Gastrointestinal symptoms included diarrhea (4.5%), abdominal pain (1.6%), nausea (0.8%), and loss of appetite (0.3%), respectively. In studies on pregnant women with gastrointestinal symptoms, 13 fetal abortions occurred, most of which were induced abortions due to the risks posed by COVID-19. In thirty cases, and infected pregnant women reported a history of chronic pregnancy-related diseases.

Conclusion: COVID-19 in pregnant women, similar to the general population, can present with gastrointestinal manifestations. The gastrointestinal tract can be a potential route for infection with the novel coronavirus.

Keywords: COVID-19, Novel Coronavirus Infection, Pregnancy, Diarrhea, Gastrointestinal Tract.

Introduction
Coronaviruses comprise a large family of viruses that, according to evidence, can cause diseases such as the common cold, to more severe diseases such as the Middle East respiratory syndrome (MERS), or even more severe, such as severe acute respiratory syndrome (SARS) (1). In December 2019, a new type of coronavirus that had not previously been seen in humans was identified in Wuhan, China. The novel virus, called SARS-CoV-2, has been linked to a new respiratory syndrome called COVID-19 (2). This disease spread rapidly, resulting in epidemics in China and reports of multiple cases worldwide, and has been declared by the World Health Organization as a pandemic situation and the sixth public health emergency of international concern (3). The knowledge and understanding of COVID-19 are advancing rapidly, but evidence specifically focused on pregnant women is limited. They appear to be one of the most vulnerable groups to COVID-19. Physiological changes during pregnancy in the pulmonary system, such as increased oxygen consumption, increased minute ventilation, and decreased lung capacity, increase the risk of developing severe respiratory diseases in pregnant
women. In addition, suppression of immune responses during pregnancy increases the risk of infections (4, 5).

Although the main symptoms of this disease include respiratory symptoms such as fever, dry cough, fatigue, and shortness of breath(3, 6), according to the evidence, gastrointestinal manifestations have also been observed in some patients suffering from COVID-19. One hypothesis in this regard is the use by the coronavirus of human angiotensin-converting enzyme 2 (ACE-2) receptors located on intestinal cells, hepatocytes, and cholangiocytes (7). Sellevoll et al. presented a woman with suspected cholecystitis who was admitted with acute abdominal pain and had no symptoms of respiratory infection, but eventually, a coronavirus test was positive (8). Findings from some studies on pregnant women infected by SARS-CoV-2 have indicated gastrointestinal symptoms such as abdominal pain, nausea, vomiting, and diarrhea in addition to respiratory symptoms (9, 10).

This review study was conducted to evaluate the symptoms of COVID-19 in pregnant women with a focus on gastrointestinal symptoms.

### Methods

Two investigators searched the Cochrane Library, Cochrane Central Register of Controlled Trials (CENTRAL), MEDLINE/PubMed, and SCOPUS for articles published up to May 8, 2020. The search strategy was: (coronavirus OR “coronavirus disease-19” OR “COVID-19” OR “2019-nCoV disease” OR “2019 novel coronavirus infection” OR “2019-nCoV infection” OR “COVID-19 pandemic” OR “2019 novel coronavirus disease”) AND (pregnant* OR Childbearing OR Prenatal).

Any type of study with original data involving pregnant women infected by SARS-CoV-2 in any trimester of pregnancy was included in the study. Articles in languages other than English, those that did not have enough data to answer the research question, and those that were only abstract were excluded. Our outcomes were any type of symptoms of COVID-19, mode of delivery, history of chronic basic diseases, vertical transmission, and maternal complications.

In the first step, two researchers independently examined the search output on each database. They...
reviewed the titles and abstracts of the articles and removed irrelevant studies. In the second step, the full text of the remaining articles was carefully reviewed. Any disagreement was resolved through discussion. The data retrieval tool was a researcher-made form that included data such as the name of the first author; country; sample size; pregnancy characteristics; general, respiratory, and gastrointestinal symptoms at the time of hospitalization or in the days following; mode of delivery; the history of chronic basic diseases; rate of vertical transmission; and maternal complications.

Throughout the preparation of this article, the researchers adhered to the ethical principles in research; they never manipulated data to achieve their advantages and avoided plagiarism.

**Results**

Figure 1 shows the PRISMA flowchart for study inclusion and exclusion. A total of 852 studies corresponding to our search strategy were identified. Throughout data reduction, 563 irrelevant records were excluded based on the title and abstract review. The full-text articles for the remaining 58 articles were retrieved. After review of the full-text articles, 15 articles were excluded and 43 met our inclusion criteria for the review. The characteristics of these studies are presented in Table 1.

**Participants and settings**

A total of 374 samples were involved, ranging from 1 to 118 per study. In general, the gestational age in most women was 37 weeks or more (n=161, 62.9%). Twenty-three studies were undertaken in China (9, 11-32), seven studies were conducted in the USA (33-39), four studies in Italy (40-43), three in Iran (10, 44, 45), and one study each in Peru (46), Portugal (47), Turkey (48), Sweden (49), Central America (50), and Korea (51).

**Manifestations of COVID-19**

The symptoms of COVID-19 were classified into three categories: general, respiratory, and gastrointestinal. The most common general symptoms of COVID-19 in the studied pregnant women were fatigue (n=36, 9.6%) and myalgia (n=23, 6.1%), respectively. The most common respiratory symptoms in pregnant women included fever (n=221, 59.1%), cough (n=181, 48.4%), and dyspnea or shortness of breath (n=47, 12.5%), respectively. Among the gastrointestinal symptoms associated with novel coronavirus infection, diarrhea (n=17, 4.5%) and abdominal pain (n=6, 1.6%) were more common than others.

Focus on studies of pregnant women with gastrointestinal symptoms of COVID-19:

In 12 studies (n=259), pregnant women reported gastrointestinal symptoms caused by COVID-19 (Table 2). Most of these studies were conducted in China (66.6%). Gastrointestinal symptoms included diarrhea, abdominal pain, nausea, and loss of appetite. In studies of pregnant women with gastrointestinal symptoms, 159 cesarean sections (61.4%) and 40 vaginal deliveries (15.4%) were performed. There were also 13 abortions, most of which were induced abortions due to the risks posed by COVID-19.

In thirty cases, infected pregnant women reported a history of chronic or pregnancy-related diseases. In order of frequency, they were gestational diabetes mellitus (26.6%), anemia (16.6%), diabetes mellitus (13.3%), hypothyroidism (13.3%), obesity (10%), high blood pressure (6.6%), polycystic ovarian disease (6.6%), and hepatitis B (6.6%). The vertical transmission rate was 7.6%. No maternal deaths were reported. The need for mechanical ventilation was 0.9%.

**Discussion**

To the best of our knowledge, this is the first study that focused on the gastrointestinal symptoms of COVID-19 in pregnant women. We did not find any similar study on pregnant women focusing on gastrointestinal symptoms of COVID-19 to compare with our findings. In the present study, the most common gastrointestinal symptoms of COVID-19 in pregnant women were diarrhea (4.5%) and abdominal pain (1.6%), respectively. Evidence suggests that approximately 2% to 33% of patients suffered from diarrhea as one of the symptoms of COVID-19 (53, 54). Chan et al. stated that 10.6% of patients with SARS and 30% of patients with MERS complained of diarrhea (55). It has been shown that MERS coronavirus can survive in simulated gastrointestinal juice and can cause intestinal infections (55). Some studies have shown the presence...
of SARS-CoV-2 in the stool of patients suffering from COVID-19 (54, 56). Such evidence suggests that the gastrointestinal tract may be one of the potential routes of SARS-CoV-2 invasion and transmission, and there is also the possibility of oral-fecal transmission, indicating the need for effective revision of diagnostic and diagnostic guidelines.

According to our results, the second most common gastrointestinal symptom in infected pregnant women was abdominal pain (1.6%). Studies on non-pregnant populations have shown that abdominal pain as one of the symptoms of COVID-19 was rated from 2.2% to 5.8% (55, 57). In some studies, liver damage caused by SARS-CoV-2, impaired liver function tests, and increased bilirubin levels have also been reported in
intestinal flora, which could result in gastrointestinal SARS-CoV-2, like SARS-CoV, to bind to ACE-2 receptors, which are abundantly expressed in the gastrointestinal tract (57). Pan et al. stated that SARS-CoV-2 itself may cause disorders of the intestinal flora, which could result in gastrointestinal manifestations (59). Another possible mechanism is that changes in the composition and function of the gastrointestinal tract and respiratory tract flora can affect each other. This effect is called the “gut-lung axis” and can help explain why patients with COVID-19 often have gastrointestinal symptoms (60).

A significant number of pregnant women in whom gastrointestinal symptoms caused by COVID-19 were predisposed to underlying chronic diseases. According to increasing evidence, the risk of developing COVID-19 and

**Table 2. Characteristics of Studies with Gastrointestinal Symptoms of COVID-19 in Pregnant Women**

| Author's Name | Country | GA (weeks) | Symptoms of COVID-19 | Method of Birth | History of Chronic Basic Diseases | Maternal Complications |
|---------------|---------|------------|----------------------|-----------------|-----------------------------------|------------------------|
| Chen, L (9)   | China   | 118        | Preterm              | Gastrointestinal | Preterm                          |                       |
| Chen, R (12)  | China   | 17         | Term                 | Abdominal pain   | Term                             |                       |
| Ferrazza, E (42) | Italy  | 42         | Nausea               | Vaginal          | Cesarcan                         |                       |
| Juusela, A (37) | USA    | 2          | Loss of appetite     | Cesarcan         | Cesarcan at End                  |                       |
| Kelly, JC (38) | USA    | 1          | Abortion             | Abortion         | Abortion                         |                       |
| Khan, S-2 (17) | China  | 17         | Preterm              | Gastrointestinal | Preterm                          |                       |
| Liu, D (21)   | China   | 15         | Term                 | Vaginal          | Cesarcan                         |                       |
| Qiancheng, X (25) | China | 9          | Loss of appetite     | Cesarcan         | Cesarcan at End                  |                       |
| Wang, S (26)  | China   | 1          | Abortion             | Abortion         | Abortion                         |                       |
| Yu, N (31)    | China   | 7          | Preterm              | Gastrointestinal | Preterm                          |                       |
| Zamanian, M (10) | Iran   | 1          | Term                 | Term             | Term                             |                       |
| Zhu, H (32)   | China   | 10         | Abortion             | Abortion         | Abortion                         |                       |

**DM**: Diabetes Mellitus; **GMM**: Gestational Diabetes Mellitus; **PCOD**: Polycystic Ovarian Disease; **NM**: Not Mentioned
worsening of the condition of those with a chronic disease such as high blood pressure, lung disease, kidney problems, diabetes, or heart disease is higher than it is in healthy people (61). Therefore, it is recommended that pregnant women suffering from underlying diseases quarantine at home, because the weakening of their immune system and specific physiological changes related to pregnancy in interaction with the underlying disease increase the risk of infection by SARS-CoV-2 and its serious complications.

The current study found that COVID-19 gastrointestinal symptoms were lower in pregnant women than in the non-pregnant populations reported in some studies (59). It seems that because the disease first appeared with respiratory symptoms, these have been the focus of most studies, and gastrointestinal symptoms have been neglected in some lower quality studies. Non-English language studies were also excluded from the current study, which may be a factor in this finding. To achieve more reliable and accurate results, more original, higher quality studies should be conducted.

COVID-19 in pregnant women, similar to the general population, can present with gastrointestinal manifestations. The gastrointestinal tract can be a potential route for infection with the novel coronavirus. According to the evidence, there is also the possibility of oral-fecal transmission. In pregnant women, as in the non-pregnant population, gastrointestinal symptoms in addition to the respiratory symptoms of COVID-19 should be considered.

Acknowledgment

The authors thank the reviewers for their valuable comments that improved the quality of the article.

Conflict of interests

The authors declare that they have no conflict of interest.

References

1. Qiao J. What are the risks of COVID-19 infection in pregnant women? The Lancet 2020;395:760-2.
2. Breslin N, Baptiste C, Gyamfi-Bannerman C, Miller R, Martinez R, Bernstein K, et al. 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.
3. Huang C, Wang Y, Li X, Ren L, Zhao J, Hu Y, et al. Clinical features of patients infected with 2019 novel coronavirus in Wuhan, China. The lancet 2020;395:497-506.
4. Wong SF, Chow KM, Leung TN, Ng WF, Ng TK, Shek CC, et al. Pregnancy and perinatal outcomes of women with severe acute respiratory syndrome. AJOG2004;191:292-7.
5. Dashraath P, Jeslyln WJL, Karen LMX, Min LL, Sarah L, Biswas A, et al. Coronavirus Disease 2019 (COVID-19) Pandemic and Pregnancy. AJOG 2020;222:521-31
6. Rajkumar RP. COVID-19 and mental health: A review of the existing literature. Asian J Psychiatr2020;52:102066.
7. Agarwal A, Chen A, Ravindran N, To C, Thuluvath PJ. Gastrointestinal and Liver Manifestations of COVID-19. J ClinExpHepatol2020;10:263-65.
8. Sellevoll HB, Saeed U, Young VS, Sandbek G, Gundersen K, Mala T. Acute abdomen as an early symptom of COVID-19. Tidsskr Nor Legeforen 2020;10:4045.
9. Chen L, Li Q, Zheng D, Jiang H, Wei Y, Zou L, et al. Clinical Characteristics of Pregnant Women with Covid-19 in Wuhan, China: N Engl J Med 2020;382:e100.
10. Zamaniyan M, Ebadi A, Aghajanpoor Mir S, Rahmani Z, Haghshenas M, Azizi S. Preterm delivery in pregnant woman with critical COVID-19 pneumonia and vertical transmission. Prenat Diagn2020;10:1002.
11. Cao D, Yin H, Chen J, Tang F, Peng M, Li R, et al. Clinical analysis of ten pregnant women with COVID-19 in Wuhan, China: A retrospective study. Int J Infect Dis 2020;23:30263-70.
12. Chen R, Zhang Y, Huang L, Cheng BH, Xia ZY, Meng QT. Safety and efficacy of different anesthetic regimens for parturients with COVID-19 undergoing Cesarean delivery: a case series of 17 patients. Can J Anesth2020;67:655-63.
13. Chen S, Liao E, Cao D, Gao Y, Sun G, Shao Y. Clinical analysis of pregnant women with 2019 novel coronavirus pneumonia. J Med Virol2020;92:1556-61.
14. Chen Y, Peng H, Wang L, Zhao Y, Zeng L, Gao H, et al. Infants Born to Mothers With a New Coronavirus (COVID-19). Front Pediatr 2020;8:1-5.
15. Fan C, Lei D, Fang C, Li C, Wang M, Liu Y, et al. Perinatal Transmission of COVID-19 Associated SARS-CoV-2: Should We Worry? Clin Infect Dis2020;10:1093.
16. Khan S, Peng L, Siddique R, Nabi G, Nawsherwan, Xue M, et al. 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;41:748-50.
17. Khan S, Jun L, Nawsherwan, Siddique R, Li Y, Han G, et al. Association of COVID-19 with pregnancy outcomes in health-care workers and general women. Clin Microbiol Infect2020;26:788-90.
18. Li J, Wang Y, Zeng Y, Song T, Pan X, Jia M, et al. Critically ill pregnant patient with COVID-19 and neonatal death within two hours of birth. Int J Gynaecol Obstet 2020;5:13189.

19. Li Y, Zhao R, Zheng S, Chen X, Wang J, Sheng X, et al. Lack of Vertical Transmission of Severe Acute Respiratory Syndrome Coronavirus 2, China. Emerg Inf Dis 2020;26.

20. Liao J, He X, Gong Q, Yang L, Zhou C, Li J. Analysis of vaginal delivery outcomes among pregnant women in Wuhan, China during the COVID-19 pandemic. Int J Gynaecol Obstet 2020;29:13188.

21. Liu D, Li L, Wu X, Zheng D, Wang J, Yang L, et al. Pregnancy and Perinatal Outcomes of Women With Coronavirus Disease (COVID-19) Pneumonia: A Preliminary Analysis. AJR Am J Roentgenol 2020;1-6.

22. Liu Y, Chen H, Tang K, Guo Y. Clinical manifestations and outcome of SARS-CoV-2 infection during pregnancy. J Infect 2020.

23. Lu D, Sang L, Du S, Li T, Chang Y, Yang XA. Asymptomatic COVID-19 infection in late pregnancy indicated no vertical transmission. J Med Virol 2020;24:25927.

24. Peng Z, Wang J, Mo Y, Duan W, Xiang G, Yi M, et al. Unlikely SARS-CoV-2 vertical transmission from mother to child: A case report. Journal of Infection and Public Health 2020;13:818-20.

25. Qiancheng X, Jian S, Lingling L, Xi He, Xiaogang J, Weihua L, et al. Coronavirus disease 2019 in pregnant women. Int J Infect Dis 2020;95:376-83.

26. Wang S, Guo L, Chen L, Liu W, Cao Y, Zhang J, et al. A case report of neonatal COVID-19 infection in China. Clin Infect Dis 2020.

27. Wang X, Zhou Z, Zhang J, Zhu F, Tang Y, Shen X. A case of 2019 Novel Coronavirus in a pregnant woman with preterm delivery. Clin Infect Dis 2020;71:844-6.

28. Wu C, Yang W, Wu X, Zhang T, Zhao Y, Ren W, et al. Clinical Manifestation and Laboratory Characteristics of SARS-CoV-2 Infection in Pregnant Women. VirolSin 2020;1-6.

29. Xu W, Sun R, Chen J, Xie Y, Zhang S, Wang X. Radiological findings and clinical characteristics of pregnant women with COVID-19 pneumonia. Int J Gynaecol Obstet 2020;150:58-63.

30. Xiong X, Wei H, Zhang Z, Chang J, Ma X, Gao X, et al. Vaginal Delivery Report of a Healthy Neonate Born to a Convalescent Mother With COVID-19. J Med Virol 2020.

31. Yu N, Li W, Kang Q, Xiong Z, Wang S, Lin X, et al. 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 2020;20:559-64.

32. Zhu H, Wang L, Fang C, Peng S, Zhang L, Chang G, et al. Clinical analysis of 10 neonates born to mothers with 2019-nCoV pneumonia. Transl Pediatr 2020;9:51-60.

33. Browne PC, Linfert JB, Perez-Jorge E. Successful Treatment of Preterm Labor in Association with Acute COVID-19 Infection. Am J Perinatol 2020;37:866-8.

34. De Castro A, Abu-Hishme M, El Husseini I, Paul L. Haemophilus parainfluenzae endocarditis with multiple cerebral emboli in a pregnant woman with coronavirus. ID Cases 2019;18:e00593.

35. Hirshberg A, Korn-Goldberger AR, Levine LD, Pierce-Williams R, Short WR, Parry S, et al. Care of critically ill pregnant patients with COVID-19: a case series. Am J Obstet Gynecol 2020;223:286-90.

36. Iqbal SN, Overcash R, Mokhtari N, Saeed H, Gold S, Auguste T, et al. An Uncomplicated Delivery in a Patient with Covid-19 in the United States: N Engl J Med 2020;382:e34.

37. Juusela A, Nazir M, Gimovsky M. Two cases of coronavirus 2019-related cardiomyopathy in pregnancy. Am J Obstet Gynecol MFM 2020;2:100113.

38. Kelly JC, Dombrowski M, ONEil-Callahan M, Kernberg AS, Frolova AI, Stout MJ. False-Negative COVID-19 Testing: False-negative testing for severe acute respiratory syndrome coronavirus 2: consideration in obstetrical care. Am J Obstet Gynecol MFM 2020;2:100130.

39. Schnettler WT, Al Ahwel Y, Suhag A. Severe ARDS in COVID-19-infected pregnancy: obstetric and intensive care considerations. Am J Obstet Gynecol MFM 2020;2:100120.

40. Buonsenso D, Raffaelli F, Tamburrini E, Biasucci DG, Salvi S, Smargiassi A, et al. Clinical role of lung ultrasound for the diagnosis and monitoring of COVID-19 pneumonia in pregnant women. Ultrasound Obstet Gynecol 2020;56:106-9.

41. Carosso A, Cosma S, Borella F, Marozio L, Coscia A, Ghisetti V, et al. Pre-labor anorectal swab for SARS-CoV-2 in COVID-19 pregnant patients: is it time to think about it? Eur J Obstet Gynecol Reprod Biol 2020;249:98-9.

42. Ferrazzi E, Frigerio L, Savasi V, Vergani P, Prefumo F, Bjog 2020;127:1116.

43. Martinelli I, Ferrazzi E, Ciavarella A, Erra R, Iurlaro E, Ossola M, et al. Pulmonary embolism in a young pregnant woman with COVID-19. Thromb Res 2020;191:36-7.

44. Hantoushzadeh S, Shamshirsaz AA, Aleyasin A, Seferovic MD, Aski SK, Arian SE, et al. Maternal Death Due to COVID-19 Disease. Am J Obstet Gynecol 2020;223:109.e1-16.

45. Karami P, Naghavi M, Feyzi A, Aghamohammadi M, Novin MS, Mobaian A, et al. Mortality of a pregnant patient diagnosed with COVID-19: A case report with clinical, radiological, and histopathological findings. Travel Med Infect Dis 2020;101665.

46. Alzamora MC, Paredes T, Caceres D, Webb CM, Valdez LM, La Rosa M. Severe COVID-19 during Pregnancy and Possible Vertical Transmission. Am J Perinatol 2020;37:861-5.
Manifestations of COVID-19 in pregnant women

47. Lyra J, Valente R, Rosario M, Guimaraes M. Cesarean Section in a Pregnant Woman with COVID-19: First Case in Portugal. Acta Med Port 2020;33:429-31.

48. Kalafat E, Yapra E, Cinar G, Varli B, Ozisik S, Uzun C, et al. Lung ultrasound and computed tomographic findings in pregnant woman with COVID-19. Ultrasound Obstet Gynecol 2020;55:835-7.

49. Sidlóf S, Savchenko J, Brune T, Josefsson H. COVID-19 in pregnancy with comorbidities: More liberal testing strategy is needed. Acta Obstetricia et Gynecologica Scandinavica 2020;99:948-9.

50. Zambrano LI, Fuentes-Barahona IC, Bejarano-Torres DA, Bustillo C, Gonzales G, Vallecello-Chinchilla G, et al. A pregnant woman with COVID-19 in Central America. Travel Med Infect Dis 2020:101639.

51. Lee DH, Lee J, Kim E, Woo K, Park HY, An J. Emergency cesarean section on severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) confirmed patient. Korean J Anesthesiol 2020;73:347-351.

52. Novel Coronavirus Pneumonia Emergency Response Epidemiology Team. Vital surveillances: the epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19)-China. China CDC Wkly 2020;2:113-22.

53. Liang W, Feng Z, Rao S, Xiao C, Xue X, Lin Z, et al. Diarrhoea may be underestimated: a missing link in 2019 novel coronavirus. BMJ 2020;69:1141-3.

54. Holshue ML, DeBlolt C, Lindquist S, Lofty KH, Wiesman J, Bruce H, et al. First case of 2019 novel coronavirus in the United States. N Engl J Med 2020;382:929-36.

55. Wang D, Hu B, Hu C, Zhu F, Liu X, Zhang J, et al. Clinical characteristics of 138 hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. JAMA 2020;323:1061-9.

56. Gu J, Han B, Wang J. COVID-19: gastrointestinal manifestations and potential fecal–oral transmission. Gastroenterology 2020;158:1518-9.

57. Guan G, Gao L, Wang J, Wen X, Mao T, Peng S, et al. Exploring the mechanism of liver enzyme abnormalities in patients with novel coronavirus-infected pneumonia. Zhonghua Gan Bing Za Zhi 2020;28:E002.

58. Chen H, Guo J, Wang C, Luo F, Yu X, Zhang W, et al. Clinical characteristics and intrauterine vertical transmission potential of COVID-19 infection in nine pregnant women: a retrospective review of medical records. Lancet 2020;395:809-15.

59. Pan L, Mu M, Yang P, Sun Y, Wang R, Yan J, et al. Clinical characteristics of COVID-19 patients with digestive symptoms in Hubei, China: a descriptive, cross-sectional, multicenter study. Am J Gastroenterol 2020;115:766-73.

60. Budden KF, Gellatly SL, Wood DL, Cooper MA, Morrison M, Hugenholtz P, et al. Emerging pathogenic links between microbiota and the gut–lung axis. Nat Rev Microbiol 2017;15:55-63.

61. Guo W, Li M, Dong Y, Zhou H, Zhang Z, Tian C, et al. Diabetes is a risk factor for the progression and prognosis of COVID-19. Diabetes Metab Res Rev 2020;e3319.