

Research Article

Impact of COVID-19 on Menstrual Cycle Pattern

Hanan Altaee* , Ban Jaber Edan , Manal Kahtan Altaher

Department of Medical Physiology, University of Babylon, Hillah, Iraq

Abstract

Background: The coronavirus disease 2019 (COVID-19) pandemic is continuously exerting a significant effect on health care systems globally, causing extreme mortality and morbidity. As time passes our knowledge about this novel respiratory virus increase, it is clearly that its effects go behind that of the respiratory system. In recent years, there have been many reports; that there are a considerable menstrual changes in females infected with COVID-19. Data regarding the effect of COVID-19 on reproductive outcomes is limited, conflicting and only few reports from the literature reported the association between COVID-19 infection and menstrual cycle disturbances and fertility. Some studies have reported the effects of COVID-19 on fertility and menstrual cycles, but the results remain inconclusive. The *aim* of this study was to see if infection with COVID-19 had impacted cycle pattern in a group of young female studying at college of medicine/second stage. **Method:** This retrospective cross sectional study was performed on female volunteers of university medical college students; all were second stage (n = 200), who were invited to fill-out the study questionnaire programmed in a google form. **Results:** Twenty eight percent of case group had irregular cycle after infection which was significant different from those who didn't get the infection ($p < 0.05$). The relative risk of irregular cycle of participants in case group who were admitted to the hospital is higher when compared with those who did not need hospitalization (odds ratio = 3.76, CI; (1.29-10.97). More over the relative risk of irregularity increased in patients who needed CPAP at admission (Odds ratio = 6.01; CI (1.56-13.17). **Conclusion:** this study revealed that COVID-19 infection could affect the menstrual cycle for the studied females. Further prospective studies should be done to confirm these findings and evaluate how long these menstrual irregularities lasted.

Keywords

Post COVID-19, Coronavirus Disease-2019 and Menstrual Cycle, Coronavirus and Menstrual Cycle, Hormonal Change

1. Introduction

Severe acute respiratory coronavirus 2 (SARS-CoV-2) infection, which causes coronavirus disease 2019 (COVID-19), was first announced on December 31, 2019, in Wuhan, China; and have been declared as pandemic on March 11, 2020 by the World Health Organization (WHO) [1, 2].

In May 2023 the WHO announced the end of the coronavirus disease 2019 (COVID-19) as a global health emergency, and its transmission into an endemic health problem, but

it remains an ambiguous cause of sickness around the world. COVID -19 was the cause of more than 15 million deaths in 2020 and 2021 alone [3]. The WHO has monthly updating epidemiology of the disease regarding SARS-CoV-2 test positivity, morbidity and mortality trends, and hospital and Intensive Care Unit admissions in different regions in the world.

The sudden emergence of COVID-19 disease has globally

*Corresponding author: hanantace@uobabylon.edu.iq (Hanan Altaee)

Received: 17 July 2025; **Accepted:** 11 August 2025; **Published:** 25 September 2025



Copyright: © The Author(s), 2025. Published by Science Publishing Group. This is an **Open Access** article, distributed under the terms of the Creative Commons Attribution 4.0 License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution and reproduction in any medium, provided the original work is properly cited.

changed economic and social activities [4], many officials have announced the importance of limitations in these activities in addition to the fear of getting the infection [5].

The main symptoms of the SARS-CoV-2 infection include Fever, respiratory problems which may be associated with gastrointestinal symptoms, anosmia, loss of taste sensation and others. Severe illness may be triggered by increasing age, comorbidities and being a male [6]. Viral transmission is often by respiratory droplets.

During the previous three years when the COVID-19 pandemic caused millions of human loss and long-term effects; people were anxious about the loss of smell, taste and appetite, in addition to other symptoms, but nowadays the reports are increasing in regards to changes in the menstrual cycle and fertility [7-9]. Recently, there have been scientific reports and even discussions on the social media that there are a considerable number of females infected with COVID-19 suffering from menstrual changes.

The virus usually requires both (ACE2) angiotensin-converting enzyme 2 receptor and TMPRSS2 transmembrane serine protease 2 (TMPRSS2) (10). The presence of these two receptors in both male and female reproductive organ cells has raised concerns that the SARS-CoV-2 infection may compromise human fertility and pregnancy [1]. Many available review evidence have concluded that the virus have long-term effects on the human body and the female reproductive system [10-12].

Menstrual blood loss may be impacted by COVID-19's potential to influence endothelial cell function and systemic hemostasis. Hypothalamic amenorrhea may be brought on by severe COVID-19 disease. COVID-19 infection may harm oocyte quality [13], ovaries and uterine endometrium and even hypothalamus-pituitary-ovary axis, and sex hormones, including estrogen, progesterone, and the anti-Müllerian hormone, consequently the menstrual cycle.

Data regarding the effect of COVID-19 on reproductive outcomes is limited and only few reports from the literature reported the association between COVID-19 infection and menstrual cycle disturbances and fertility [14-17]. Some studies have reported the effects of COVID-19 on fertility and menstrual cycles, but the results remain inconclusive.

The aim of this study was to see if infection with COVID-19 has any impact on cycle pattern in a group of young female studying at college of medicine/second stage.

2. Materials and Methods

2.1. Study Design and Participants

This retrospective cross sectional study was performed on female volunteers of university medical college students; from April through August 2024, all were second stage ($n = 200$), to observe any changes in menstrual cycle pattern after COVID-19 infection.

2.2. Inclusion Criteria

- 1) Agree to participate in the survey.
- 2) Regular periods before the pandemic.
- 3) ($BMI \leq 25 \text{ kg/m}^2$).
- 4) Didn't take vaccine for corona virus.
- 5) No history of medical diseases or medications for chronic disease.
- 6) Non-smoker.
- 7) Not married.

2.3. Data Collection Tools and Procedures

A google form was designed in English language, through which respondents could access the survey and send their answers. Volunteers were free to fill in the questionnaire form and forward it to their colleagues.

The survey form included the following information: age, BMI, state of infection with the virus, and method of treatment (any needs for hospitalization, oxygen therapy, or C-PAP). The survey also inquired about any changes in smell or taste (which may reflects the severity of the disease) and if any acne or hirsutisms have developed after the infection. Participants were also requested to provide menstrual history both prior and after the infection. It is to be noted that volunteers could reply only once to the survey.

2.4. Definitions

All the following definitions were considered:

Normal menstrual cycle—menstruation occurring at intervals of 24-38 days, with a duration of 4-8 days and normal flow.

Menstrual cycle irregularities include:

1. Amenorrhea—the absence of menstruation for >90 days.
2. Infrequent cycle—menstruation occurring at an interval of >38 day.
3. Heavy bleeding—compared to her previous cycles.
4. Scanty bleeding—compared to her previous cycles.

Participants with a history of COVID-19 were included in the *case group* ($n = 82$), while those with no infection were considered the *control group* ($n = 118$).

To validate the results, participants were asked to provide their electronic consent before filling the survey. If they wanted to participate in the survey, they would choose agree option.

3. Results

This retrospective cross-sectional study shows after completing the questionnaire of 200 female medical students that 82 (41%) of them had been infected with COVID-19 as shown in Figure 1; they were labeled as *case group*, and 118 (59%) didn't get the infection, they were labeled as *control group*.

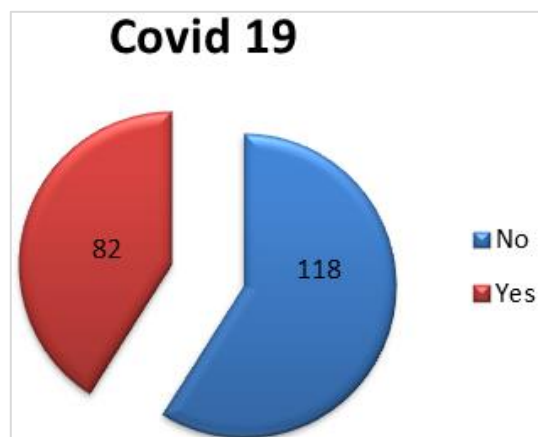


Figure 1. COVID 19 percentage in studied group.

The mean age and BMI of studied groups was shown in [Table 1](#), there was insignificant difference between case and control group ($P>0.05$).

Table 1. Comparison of Age and BMI in case and control group.

Parameters	Case (N=82)	Control (N=118)	P value
Age/yrs	18.79±0.79	18.73±0.73	0.56
BMI/kg/m ²	23.91±6.38	23.94±5.82	0.95

$p>0.05$: insignificant difference from corresponding group
BMI: Body Mass Index

From the case group only 20 participants (24.4%) needed admission to ICU while the rest have been managed by simple measures at home. As shown in [Figure 2](#). All admitted patients required the use of oxygen and 11 of them (55%) needed C-PAP.

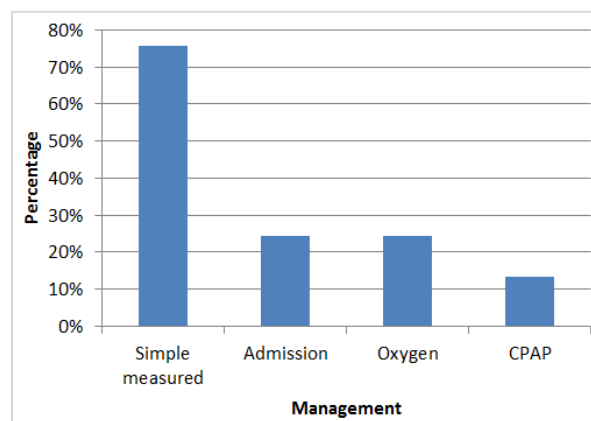


Figure 2. Percentage of line of Management of case group (n=82).

Twenty eight percent of case group had irregular cycle after infection and there was significant differences between case and control ($p<0.05$), [Figure 3](#).

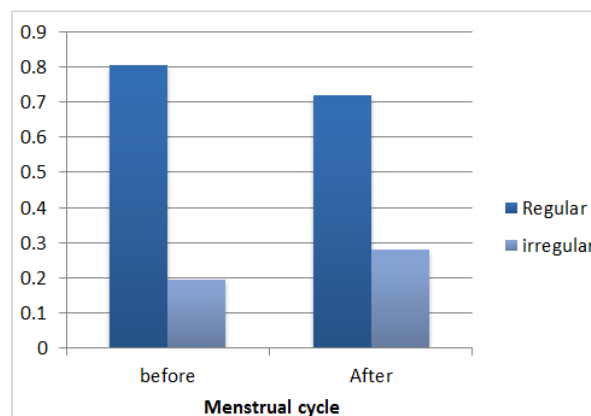


Figure 3. Menstrual cycle patterns before and after COVID 19 infection in case group (n=82).

The relative risk of irregular cycle of participants in case group who were admitted to the hospital is higher when compared with those who did not need hospitalization (odds ratio = 3.76, CI; 1.29-10.97) ([Table 2](#)). More over the relative risk of irregularity increased in patients who needed CPAP at admission (Odds ratio =6.01; CI 1.56-13.17).

Table 2. The relative risk of irregular cycle of participants in case group (n=81) who admitted to hospital, the relative risk of irregularity increase in patients who needed C-PAP at admission.

Management	Odds ratio (confidence interval) for irregular cycle in Patients group		
Simple measured	1.23 (0.43-3.26)	-	-
Admission	3.76 (1.29-10.97)	Oxygen	3.76 (1.29-10.97)
		C-PAP	6.01 (1.56-13.17)

Statistical Analysis

All statistical analyses were performed using SPSS software (version 23). Categorical variables were described by numbers and percent, whereas continuous variables described by mean and SD. χ^2 -Test was used to compare between categorical variables. Student t-test was used to compare between continuous variables. The Binomial logistic regression analysis was used to get odds ratio. A two-tailed P value less than 0.05 was considered statistical significant.

4. Discussion

This study was conducted to explore the effects of SARS-CoV-2 infection on menstrual cycle pattern and if it cause any menstrual irregularities in a group of young female at second stage medical college. After interrupting the survey and statistical analysis only 41% of the surveyed population was infected with COVID- 19. The case and control group were at the same age and BMI and there was no significant difference between them (Table 1).

From the case group only 20 patients (24.4%) needed admission while the rest have been managed by simple measures at home as shown in (Figure 2). All admitted patients needed oxygen and 11 of them (55%) needed C-PAP. Since our case group are young, non-smokers and have no co morbidities by history we can assume that the need of each measure depend on their own defense mechanism and the severity of the infection they got at that time.

Twenty eight percent of case group had irregular cycle after infection and there was significant differences between case and control group ($p < 0.05$).

Studies regarding menstrual abnormalities and ovarian reserve post COVID -19 are conflicting. A research team work done in Iraq, Jordan and United Arab Emirates reveal no significant changes between case and control group regarding menstrual abnormalities when infected with COVID [18-20]. Egyptian and Iranian research centers, didn't find any significant difference in ovarian reserve of women have been infected by COVID-19 when they compared hormone, including Anti-mullerian Hormone, before and after infection [21, 22].

on reviewing research works in different research places regarding post COVID-19 menstrual irregularities we found that our survey have approved other research works [23-26].

The diversity of results with those who concluded different results may be attributed to the methodology, sample size, selection criteria and the severity of the disease at time of infection, even to the line of management during the pandemic.

The complexity of menstrual cycle cascade from the hypothalamus through the pituitary to the ovaries and uterus and interaction of this axis with prostaglandins, and neuro-endocrine factors, makes menstrual disturbance very easy [22]. It can be affected by illness, stress, nutrition, drugs, life style, or vitamin deficiency [27-29]. Low levels of these

vitamins can cause menstrual cycle irregularities because of their role in hormones and sex steroid synthesis [30-32].

The virus usually requires both (ACE2) angiotensin-converting enzyme 2 receptor and transmembrane serine protease 2 (TMPRSS2) [10-12]. The presence of these two receptors in both male and female reproductive organ cells has raised concerns that the SARS-CoV-2 infection may compromise human fertility and pregnancy [1]. The virus usually may hinder many aspect of female reproductive functions, including follicular development, sex steroid synthesis, endometrial shedding, and repair [33]. These receptors are highly prevalent in the female reproductive system including the uterus [34, 35]. The binding of COVID-19 to the ACE2 receptor in the endometrium may be the cause of menstrual cycle irregularities [36]. Infection leads to elevated reactive oxygen species and oxidative stress, which can disturb ovarian function by triggering inflammatory reactions [37].

The initiation of menstrual bleeding in the human uterus requires vasoconstriction of the spiral artery by Ang II, so a normal menstrual cycle depends on the accurate function of Ang II and its receptors in endometrial tissue. Any disturbance in this receptor expression leads to abnormal uterine bleeding [38, 39].

Unfortunately, most large-scale COVID-19 investigations have ignored menstrual cycle changes, leaving questions about how many women experienced menstrual changes and the duration of these changes [40].

The fact that the disease itself have been shown to have impact on the psychological aspect of the infected subject which adds another cause for this menstrual irregularities, this has been documented by many studies during and after the pandemic [7, 41, 42]. Stress, whether physical or psychological, have direct effect on both axes - the hypothalamic-pituitary-gonadal (HPG) and hypothalamic-adrenal axes [43]. The role of cortisol in stress is documented by many studies; cortisol has inhibitory effects on the HPG axis. Cortisol and stress affect this axis, as increasing levels of cortisol inhibit GnRH secretion. This action helps to explain why high stress can lead to irregular menses and amenorrhea [9].

The relative risk of irregular cycle of participants in case group who underwent simple measures was higher when compared with subjects who didn't require any treatment (odds ratio = 1.23, CI; 0.43-3.26), (Table 2) and this risk was even higher in the participants who needed C-PAP at admission.

This indicates that the lack of oxygen increases the likelihood of developing irregular cycle.

In normal conditions there is a temporal physiological hypoxia in the upper endometrial zones during menstruation [44, 45], and that has been shown in mean time to enhance endometrial repair [46]. Endometrial hypoxia inducible factor (HIF)-1 α protein is also needed during the luteal phase for angiogenesis and tissue building [47, 48].

It has been found by Devaux; and Kadhim that 20-40% of

patients have some sort of hypoxia termed as ‘silent’ or asymptomatic hypoxia and Acute COVID-19 can result in very low oxygen saturation [49, 50], the activation of HIF-1 protein outside the physiological luteal phase and changes of endometrial hypoxic pathways, may make endometrial angiogenesis/metabolism unbalanced and lead to irregular uterine bleeding [51].

One important point to be mentioned about this survey is that it was carried on young female, the same age, BMI, not married, non-smoker and at the same educational level, which make confounders very minimal or negligible.

5. Conclusion

This study revealed that COVID-19 infection could affect the menstrual cycle for the studied females. Further prospective studies should be done to confirm these findings and evaluate how long these menstrual irregularities lasted.

Abbreviations

ACE2	Angiotensin-Converting Enzyme 2
BMI	Body Mass Index
COVID-19	Coronavirus Disease 2019
CPAP	Continuous Positive Airway Pressure
HPG	Hypothalamic-Pituitary-Gonadal
HIF	Hypoxia Inducible Factor
TMPRSS2	Transmembrane Serine Protease 2
WHO	World Health Organization

Acknowledgments

The authors would like to thank all the students participating in this study.

Author Contributions

Hanan Altaee: Methodology, Resources, Writing – original draft, Writing – review & editing

Ban J Edan: Data curation, Formal Analysis, Methodology, Writing – original draft, Writing – review & editing

Ethical Approval and Consent to Participate

The study protocol and all materials received approval from the Ethics Committee of College of medicine -University of Babylon. Data were handled with strict confidentiality, ensuring the privacy of the participants; following the participants consent by choosing agree option in the survey.

Conflicts of Interest

The authors declare no conflicts of interest.

References

- [1] Tur-Kaspa, I., Tur-Kaspa, T., Hildebrand, G., Cohen, D.: COVID-19 may affect male fertility but is not sexually transmitted: a systematic review. *F S Rev* 2021; 2(2): 140-9. <https://doi.org/10.1016/j.xfnr.2021.01.0022>
- [2] Singh, B., Gornet, M., Sims, H., Kisanga, E., Knight, Z., Segars, J.: Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) and its effect on gametogenesis and early pregnancy. *Am J Reprod Immunol* 2020; 84(5): e13351. <https://doi.org/10.1111/aji.13351>
- [3] Hashem, N. M., Gonzalez-Bulnes, A., Rodriguez-Morales, A. J.: Animal welfare and livestock supply chain sustainability under COVID-19 outbreak: an Overview. *Front Vet Sci* 2020; <https://doi.org/10.1016/j.sjbs.2020.12.012>
- [4] Msemburi, W., Karlinsky, A., Knutson, V., Aleshin-Guende, S. I., Chatterji, S. J.: The WHO estimates of excess mortality associated with the COVID-19 pandemic *Nature*, 2023: 613, 130-137 <https://doi.org/10.1038/s41586-022-05522-2>
- [5] Ibarra, F. P., Mehrad, M., Di Mauro, M. D., Godoy, M. F. P., Cruz, E. G., Nilforoushzadeh, M. A., et al.: Impact of the COVID-19 pandemic on the sexual behavior of the population. The vision of the east and the west. *Int Braz J Urol* 2020; 46: 104-12. <https://doi.org/10.1590/S1677-5538.IBJU.2020.S116>
- [6] Segars, J., Katler, Q., McQueen, D. B., Kotlyar, A., Glenn, T., Knight, Z., et al.: American Society for Reproductive Medicine Coronavirus/COVID-19 Task Force. Prior and novel coronaviruses, Coronavirus Disease 2019 (COVID-19), and human reproduction: what is known? *Fertil Steril* 2020; 113(6): 1140-9. <https://doi.org/10.1016/j.fertnstert.2020.04.025>
- [7] Li, K., Chen, G., Hou, H., Liao, Q., Chen, J., Bai, H., et al.: Analysis of sex hormones and menstruation in COVID-19 women of child-bearing age. *Reproductive biomedicine online* 2021; 42(1): 260-7. <https://doi.org/10.1016/j.rbmo.2020.09.020>
- [8] Edelman, A., Boniface, E. R., Benhar, E., Han, L., Matteson, K. A., Favaro, C., et al.: Association Between Menstrual Cycle Length and Coronavirus Disease 2021; (COVID-19) Vaccination: A U. S. Cohort. *Obstetrics and gynecology* 139(4): 481-9. <https://doi.org/10.1097/AOG.0000000000004695>
- [9] Ozimek, N., Velez, K., Anvari, H., Butler, L., Goldman, KN., Weitowich, N. C.: Impact of stress on menstrual cyclicity during the coronavirus disease 2019 pandemic: a survey study. *Journal of Women's Health* 2022; 31(1): 84-90. <https://doi.org/10.1089/jwh.2021.0158>
- [10] Pourmasumi, S., G Kounis, N., Naderi, M., Hosseiniadat, R., Khoradmehr, A., et al.: Effects of COVID-19 Infection and Vaccination on the Female Reproductive System: A Narrative Review. *Balkan Med J* 2023; 40(3): 153-164 <https://doi.org/10.4274/balkanmedj.galenos.2023.2023-3-4>

- [11] Li, S., Liu, H., Li, D., and Chen, F.: Female reproductive health during the COVID-19 pandemic: latest evidence and understanding. *Arch Gynecol Obstet* 2023; 1: 1-6
<https://doi.org/10.1007/s00404-023-06976-z>
- [12] Patel, D. P., Punjani, N., Guo, J., Alukal, J. P., Li, P. S., Hotaling, J. M.: The impact of SARS-CoV-2 and COVID-19 on male reproduction and men's health. *Fertil Steril* 2021; 115(4): 813-23. <https://doi.org/10.1016/j.fertnstert.2020.12.033>
- [13] Maham, S., and Yoon, M.: Clinical Spectrum of Long COVID: Effects on Female Reproductive Health *Viruses* 2024; 16: 1142. <https://doi.org/10.3390/v16071142>
- [14] Luongo, F., Dragon, F., Boccuto, A., Paccagnini, E., Gentile, M.: SARS-CoV-2 Infection of Human Ovarian Cells: A Potential Negative Impact on Female Fertility Cells 2022; 23; 11(9): 1431.
- [15] Stanly KE, Thomas E, Wells D (2020) Coronavirus disease-19 and fertility: viral host entry protein expression in male and female reproductive tissues. *Fertility Sterility* 114(1): 33-43.
- [16] Sharp, G. C., Fraser, A., Sawyer, G., Kountourides, et al.: The COVID-19 pandemic and the menstrual cycle: research gaps and opportunities. *International journal of epidemiology*. *Int J Epidemiol* 2022; 13; 51(3): 691-700.
<https://doi.org/10.1093/ije/dyab239>
- [17] Male, V.: Menstrual changes after covid-19 vaccination. *BMJ* 2021; 374 <https://doi.org/10.1136/bmj.n2211>
- [18] Al-Najjar, M. A., Al-alwany, R. R., Al-Rshoud, F. M., Abu-Farha, R. K., Zawiah, M.: Menstrual changes following COVID-19 infection: A cross-sectional study from Jordan and Iraq *PLoS ONE* 17(6): e0270537
<https://doi.org/10.1371/journal.pone.0270537>
- [19] Abu-Lubad, M. A., Abu-Helalah, M. A., QawaQzeh, M. S.: Impact of COVID-19 infections and vaccination on menstrual cycle symptoms in the south of Jordan: a cross-sectional study *Egypt Public Health Assoc* 2024; 10; 99(1): 8.
<https://doi.org/10.1186/s42506-024-00153-z>
- [20] Afta, N., Fahad A, Al Hammadi S., Tahlak M., Badawi, F et al.: Effects of the COVID-19 Infection on Women's Menstrual Cycle: A Retrospective Study at Latifa Hospital, Dubai, s *Cureus* 2024; 15(12): e51391.
- [21] Etman, K. M., Sofy, M. S., Abd El-Samie, A. A: COVID-19 disease effect on ovarian reserve in women of reproductive age: an analytical STUDY before and- after COVID- Egypt *J Fertil Steril* 2023M 27: 5.
- [22] Nazari, M., Pajokh M.: The Evaluation of Post-COVID-19 Effects on Ovarian Reserve and Menstruation in Reproductive-Aged Women in 2022: A Single-Centered Observational Study. *Middle East J Rehabil Health Stud* 2024; 11(3): e145630.
- [23] Alvergne, A., Kountourides G., Argentieri M. A., et al.: A retrospective case-control study on menstrual cycle changes following COVID-19 vaccination and disease. *iScience* 2023; 26: 106401.
- [24] Mitra, A., Verbakel J. Y., Kasaven, L.S., Tzafetas, M., Grewal K., Jones B., Bennett PR., Kyrgiou M., Saso, S.: menstrual cycle and the COVID-19 pandemic *PLOS ONE* 2023;
<https://doi.org/10.1371/journal.pone.02904131-20>
- [25] Halime S. K., Tuğçe D. Ö.: Evaluation of menstrual irregularities following COVID-19 infection or vaccination: The impact of COVID anxiety and associated risk factors *Medicine* 2024L 103(26): p e38771.
- [26] Błażejowski G., Witkoś, J.: The Impact of COVID-19 on Menstrual Cycle in Women *Faculty of Medicine and Health Science J Clin Med* 2023 12(15): 4991.
- [27] Sakurada, Y., Matsuda Y., Motohashi K., Hasegawa, T., Otsuka Y., Nakano, Y.: Clinical characteristics of female long COVID patients with menstrual symptoms: a retrospective study from a Japanese outpatient clinic *Journal of Psychosomatic Obstetrics & Gynecology Psychosom Obstet Gynaecol* 2024; 45(1): 2305899.
<https://doi.org/10.1080/0167482X.2024.2305899>
- [28] Mayo JL: A healthy menstrual cycle. *Clin Nutr Insights* 1997; 5(9): 1-8. <https://acudoc.com/Healthy%20Cycle.PDF>
- [29] Im, J. H., Je, Y. S., Baek J., Chung M-H, Kwon HY, Lee JS (2020) Nutritional status of patients with COVID-19. *International Journal of Infectious Diseases* 100: 390-3.
- [30] Gorji, A., Ghadiri MK (2021) Potential roles of micronutrient deficiency and immune system dysfunction in the coronavirus disease 2019 (COVID-19) pandemic. *Nutrition* 82: 111047.
- [31] Smolders J, Ouweland, V. J., Geven, C., Pickkers, P., Kox., M: Letter to the Editor: Vitamin D deficiency in COVID-19: Mixing up cause and consequence. *Metabolism: clinical and experimental* 2021; 115: 154434.
- [32] Shakoor, H., Feehan, J., Mikkelsen, K., Al Dhaheri, A. S., Ali, H. I., Platat, C., et al.: Be well: A potential role for vitamin B in COVID-19. *Maturitas* 2021; 144: 108-11.
<https://doi.org/10.1016/j.maturitas.2020.08.007>
- [33] Kumrungsee, T., Zhang, P., Chartkul, M., Yanaka, N, Kato, N.: Potential role of vitamin B6 in ameliorating the severity of COVID-19 and its complications. 2020; *Frontiers in nutrition*.
<https://doi.org/10.3389/fnut.562051>
- [34] Luck, M. R., Jeyaseelan, I., Scholes, R. A.: Ascorbic acid and fertility. *Biology of Reproduction* 1995; 52(2): 262-6.
- [35] Al-Katib, S. R., Al-Kaabi, MM., Al-Safi, WG., Al-Bderi, AJ.: Effect of the relationship between vitamin C and serum ferritin on fertility. *Al-Kufa University Journal for Biology* 2018; 10(1).
<https://journal.uokufa.edu.iq/index.php/ajb/article/view/8207>
- [36] Zafari, Z. F: Interaction of SARS-CoV-2 With RAS / ACE2 in the Female Reproductive System. *J Family Reprod Health* 2022; 16(1): 1-8.
- [37] Wrapp, D., Wang N., Corbett KS., Goldsmith JA., Hsieh C-L., Abiona O., et al: Cryo-EM structure of the 2019-nCoV spike in the prefusion conformation. *Science* 2020; 367(6483): 1260-1263.

- [38] Dhaundiyal, A., Kumari P., Jawalekar SS., Chauhan G., Kalra S., Navik U.: Is highly expressed ACE 2 in pregnant women “a curse” in times of COVID-19 pandemic? *Life Sci* 2021; 264: 118676. <https://doi.org/10.1016/j.lfs.2020.118676>
- [39] Li, XF., Ahmed, A.: Expression of angiotensin II and its receptor subtypes in endometrial hyperplasia: a possible role in dysfunctional menstruation. *Lab Invest* 1996; 75(2): 137-45.
- [40] Rajak P., Roy S., Dutta M., Podder S., Sarkar S., Ganguly A., et al.: Understanding the cross-talk between mediators of infertility and COVID-19. *Reprod Biol* 2021; 21(4): 100559.
- [41] Fernando, SR., Chen X., Cheng KW., Wong BP., Qi S., Jiang L., et al.: ACE inhibitors on ACE1, ACE2, and TMPRSS2 expression and spheroid attachment on human endometrial Ishikawa cells. *Reprod Biol* 2022; 22(3): 100666.
- [42] Jain P., Chauhan AK., Kavita, G. R., Jain N, Singh, R.: Correlation of perceived stress with monthly cyclical changes in the female body *J Family Med Prim Care* 2023; 12(11): 2927-2933.
- [43] Bucciarelli V., Nasi M., Bianco F., Seferovic J., Ivkovic V., Gallina S., et al.: Depression pandemic and cardiovascular risk in the COVID-19 era and long COVID syndrome: gender makes a difference. *Trends in cardiovascular medicine* 2022; 32(1): 12-17. <https://doi.org/10.1016/j.tcm.2021.09.009>
- [44] Orta, OR., Hatch EE., Regan AK., Perkins R., Wesselink AK., Willis SK., et al.: A prospective study of influenza vaccination and time to pregnancy. *Vaccine* 2020; 38(27): 4246-4251. <https://doi.org/10.1016/j.vaccine.2020.04.054.51>
- [45] Matsumoto T, Ushiroyama T, Morimura M, Moritani T, Hayashi T, Suzuki T, et al.: Autonomic nervous system activity in the late luteal phase of eumenorrheic women with premenstrual symptomatology. *J Psychosom Obstet Gynaecol* 2006; 27: 131-9.
- [46] Cousins F. L, Murray AA., Scanlon JP., Saunders P. T.: Hypoxyprobe reveals dynamic spatial and temporal changes in hypoxia in a mouse model of endometrial breakdown and repair. *BMC Res Notes*; 2016; 9: 30.
- [47] Maybin JA., Murray AA., Saunders PT., Hirani N., Carmeliet P., Critchley, H. O.: Hypoxia and hypoxia inducible factor-1 alpha are required for normal endometrial repair during menstruation. *Nat. Commun* 2018; 9: 295. <https://www.nature.com/articles/s41467-017-02375-6>
- [48] Couzin-Franke, J.: The mystery of the pandemic’s ‘happy hypoxia’. *Science* 2020; 368: 455-456. 2020; 1; 368(6490): 455-456. <https://doi.org/10.1126/science.368.6490.455>
- [49] Devaux CA., Lagier, J. C.: Unraveling the Underlying Molecular Mechanism of ‘Silent Hypoxia’ in COVID-19 Patients Suggests a Central Role for Angiotensin II Modulation of the AT1R-Hypoxia-Inducible Factor Signaling Pathway. *J. Clin. Med* 2023; 12: 2445-2465. <https://doi.org/10.3390/jcm12062445>
- [50] Kadhim, H., Edanb, B., Baayb, A., Kadhum A., Al-Amiery, A.: Exploring the clinical implications of silent hypoxia in COVID-19 *J. Med. Pharm. Chem. Res* 2024; 6 690-700 2024; 22; 12(6): 2445 <https://doi.org/10.48309/jmpcr.2024.427528.1042>
- [51] Schwartz, D. A., Avvad-Portari, E., Babal, P., Baldewijns, M., Blomberg, M., Bouachba, A. et al.: Placental Tissue Destruction and Insufficiency From COVID-19 Causes Stillbirth and Neonatal Death From Hypoxic-Ischemic Injury. *Arch. Pathol. Lab. Med* 2022; 146: 660-676. <https://doi.org/10.5858/arpa.2022-0029-SA>