



The prevalence of menstrual changes in COVID-19 vaccinated women: A cross-sectional study

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ABSTRACT

Background: This study aimed to examine the prevalence of menstrual cycle changes (MCs) and their patterns among healthy Syrian women following the administration of the first and second doses of a vaccine.

Methods: A cross-sectional online survey following campaigns for COVID-19 vaccines was conducted in 2022 from June 26 to August 3. Data collected included the participants' demographic characteristics, vaccination status, and multiple-choice questions for MCs changes after the first and second doses.

Results: Of 236, 89.8 % completed all shots of the vaccine. After the first dose, 36.9 % reported MCs, and 35 % after the second dose. Most women did not experience changes in menstrual cycle frequency—81.8 % after the first dose and 83.4 % after the second dose. Similarly, most women did not observe changes in cycle length, or menstrual flow quantity—5.5 % after the first dose and 8 % after the second dose reported spotting. Dysmenorrhea was reported by 15.7 % and 14.1 % of women after the first and second doses, respectively.

Conclusion: MCs are a potential symptom that a healthy woman at childbearing age could have after a different type of COVID-19 vaccine. MCs patterns do not significantly differ following vaccine doses.

1. Introduction

According to the World Health Organization (WHO), the global death toll resulting from COVID-19 has exceeded 6.9 million. On a more positive note, the WHO also reported that approximately 5.5 billion people worldwide have received at least one dose of a COVID-19 vaccine (WHO Health Emergency Dashboard: World Health Organization, 2023). The emergence of the COVID-19 infection has sparked extensive research in the field of public health, primarily due to its significant impact on various aspects of health. One area of particular concern has been the potential effects of COVID-19 on female reproductive integrity. Numerous studies reported menstrual cycle disturbance, not only after the disease but even after vaccination (Maher and Owens, 2023). The available evidence indicates that the side effects of COVID-19 vaccination are generally moderate and self-limiting, resolving without requiring medical intervention in approximately 95 % of vaccinated individuals. However, a small proportion, estimated around 5 %, may

experience side effects severe enough to warrant medical evaluation and, in some cases, hospitalization. These side effects have been reported to span a variety of organ systems, including the cardiovascular (e.g., myocarditis and pericarditis), nervous (e.g., neuropathy), and renal (e.g., nephropathy) systems (Yaamika et al., 2023).

Menstrual cyclicity is a valid indicator of women's health. However, it is not uncommon for women to experience irregular menstrual cycles. Approximately 5–30 % of adult women may experience irregular cycles (Wang et al., 2020). The characteristics of the so-called “normal Menstrual cycle” such as length and quantity differ across populations. The factors influencing menstrual cycle are numerous and complex while physical and psychological factors contribute to its irregularity. It is well-established that stress and anxiety can elicit a hormonal response in the body, which in turn can affect the menstrual cycle (Bull et al., 2019; Abdel-Moneim et al., 2022). Suggesting a linkage between vaccination and menstrual cycle changes (MCs) is not a precedent for COVID-19 vaccines. Concerns were raised regarding the potential impact of the

Abbreviations: WHO, World Health Organization; COVID-19, Coronavirus disease 2019; MENA, The Middle East and North Africa; MCs, menstrual cycle changes.

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typhoid vaccine on menstrual cycles. Reports indicated that 53 % of women experienced some form of irregularity in their cycles, after ruling out other possible causes (Alvergne et al., 2021). Moreover, the HPV vaccine was addressed with the same issue before (Male, 2021). COVID-19 vaccines have been associated with temporary menstrual cycle irregularities, likely due to vaccine-induced immune responses and cytokine signalling impacting the hypothalamic-pituitary-ovarian axis and endometrial tissue (Wesselink et al., 2023). Network biology analysis identified key transcription factors like IRF1, STAT1, NF- κ B, and biomarkers like TNF, IL-6, and LIF as causal drivers of these menstrual changes, which appear to be transient and do not raise concerns about long-term effects on fertility (Hajjo et al., 2023). Recent observational research and systematic reviews stated the occurrence of menstrual cycle alterations following COVID-19 vaccination. Still, prospective research revealed only a temporary effect. Later, in a nationwide cohort study, there is no supporting evidence of the connection between MCs and COVID-19 vaccination (Ljung et al., 2023).

Despite the mass vaccination campaigns, Syria is still among the countries with the lowest vaccination rate (WHO Health Emergency Dashboard: World Health Organization, 2023). Moreover, there was a notable level of hesitancy among the population regarding its uptake prior to the availability of the vaccine in the country (Shibani et al., 2021). The reported changes in the menstrual cycle following vaccines have the potential to contribute to the spread of myths and misconceptions surrounding the vaccine's safety. Vaccines have been widely recognized as highly effective in preventing diseases, particularly among individuals at risk of experiencing severe symptoms. However, the association between changes in menstrual cycles and vaccines can lead to vaccine hesitancy.

This study aimed to investigate the prevalence of menstrual cycle alterations and its pattern among Syrian women. The findings of this study expand the current knowledge on menstrual cycle changes by revealing previously undocumented patterns and associations within this population. Moreover, by focusing on healthy Syrian women, the study seeks to provide insights into the potential impact of vaccination on menstrual cycles in this specific population.

2. Methods

2.1. Study design and sampling

A cross-sectional online survey was conducted in 2022 from June 26 to August 3, with a self-administered questionnaire that was distributed as a Google Form on social media platforms. Chain-referral sampling method was used, online respondents were asked to send the questionnaire to their family members, friends, and colleagues. The sample size was calculated using Epi info software. According to the data from the WHO, the estimated number of Syrians who had been vaccinated at the time of the study was 1.7 million (Mathieu et al., 2021). However, data regarding the vaccination status of women was not provided. To address this, a statistical power analysis was run to determine the appropriate sample size. Considering a conservative assumption that 50 % of women would experience a return to normal menstrual cycles after vaccination, the following parameters were used for the power analysis: an alpha of 0.05, a power of 80 %, and a desired margin of error of 4.5 %. Based on these inputs, the calculated sample size required was determined to be 475 participants. 581 questionnaires were received at the end of the study time-frame.

2.2. Questionnaire and reliability

The questionnaire was adopted from a previous study (Laganà et al., 2022), and modified to fit Syrian society. The questionnaire was translated to Arabic (the local language) and re-translated into English to check consistency in the meaning of words and concepts. The questionnaire consists of two parts: the first is about socio-demographics

(age, marital status, previous pregnancies or abortions, pregnancy, chronic diseases or gynaecological disorders, used treatments, the menstrual cycle history, and the type of COVID-19 vaccine), and the second is multiple choice questions that assess menstrual cycle characteristics irregularities regarding frequency, length, quantity, and the occurrence of spotting and dysmenorrhea. The Cronbach's alpha value of the Arabic questionnaire was 0.644. The items were considered to represent an acceptable level of internal consistency. The questionnaire is available in the [supplementary materials](#).

2.3. Public involvement consent

All Syrian Women on their reproductive age who took at least one shot of any available COVID-19 vaccine were asked to fill up the questionnaire. All participants were informed that their participation was voluntary, all of their responses were recorded anonymously, response to all questions was not mandatory, and they were allowed to withdraw from participation at any time. Inclusion criteria included that the person is: (1) a Syrian woman living in Syria, (2) aged 18 years old and above, and in their reproductive age, (3) received at least one shot of the COVID-19 vaccine, (4) willing to complete the questionnaire.

2.4. Second round of exclusion

Of the 581 questionnaires that were responded to, 560 forms were fully completed with a response rate of 96.3 %. second round of exclusion was conducted for the following criteria: current pregnancy, women with gynaecological and non-gynaecological diseases, undergoing hormonal and non-hormonal treatments, women who declare an irregular cycle, or an abnormal length of period or amount of bleeding in the last 12 months before the vaccine administration. For the purposes of this study, an irregular menstrual cycle was operationally defined as exhibiting one or more of the following characteristics: (1) excessive menstrual flow, characterized by greater than 70 ml of blood loss per day; (2) scanty menstrual flow, defined as less than 10 ml of blood loss per day (oligomenorrhea); (3) abnormal cycle length, with the time between consecutive menstrual periods being less than 22 days or greater than 35 days; or (4) intermenstrual bleeding, defined as bleeding occurring between regular menstrual periods. The study also considered menstrual periods lasting less than one day or more than eight days to be indicative of an irregular cycle. The flowchart of the study sample selection is shown in [Fig. 1](#).

2.5. Statistical analysis

Data were extracted from Google Forms directly to an Excel spreadsheet, and then analyzed using the Statistical Package for Social Sciences version 26.0 (Chicago, USA) was used in our analysis. Cronbach's alpha test was applied to determine the internal consistency of the questionnaire. All categorical variable were calculated and provided as frequencies (percentages) using standard descriptive statistical parameters. Confidence interval was calculated using the following formula $[CI = p \pm z * \sqrt{p * (1 - p)/n}]$. Differences in the specific menstrual cycle changes that were reported following the first, and second doses of various COVID-19 vaccine types were compared using chi-squared test. Test were two-sided and a p-value < 0.05 was considered statistically significant.

3. Results

From June 26 to August 3, 2022, a total of 560 women responded to the online questionnaire. Following the second round of exclusion, which involved applying specific criteria to the initial responses, 236 women made up the last sample.

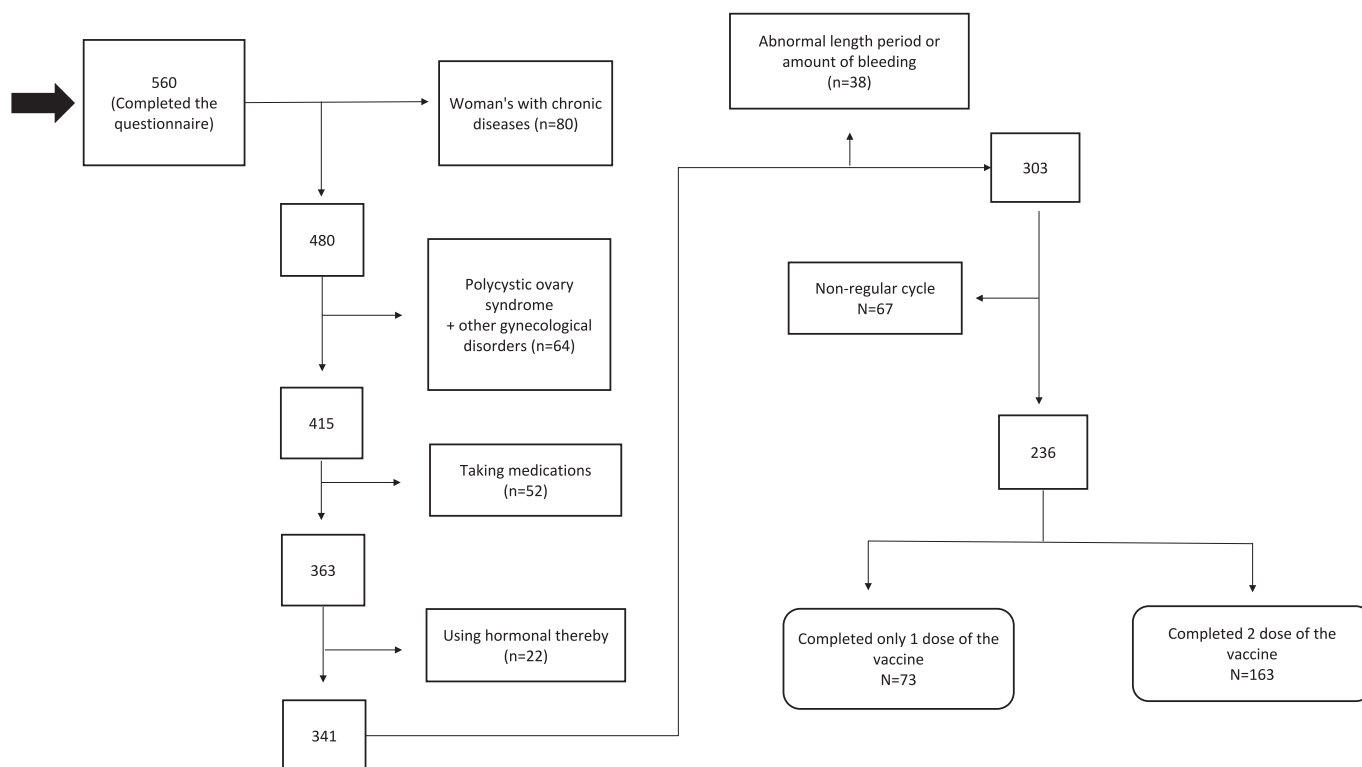


Fig. 1. Flowchart of the study population selection.

3.1. Socio-demographics

Of 236, 69 % received two doses of the COVID-19 vaccine, while 30.9 % received a single dose. Among the participants, 47 % fell into the 18–25 years age group, and the majority were unmarried 75 %. The majority of women declared no previous pregnancies (83.1 %) or abortions (91.5 %). Among the different types of COVID-19 vaccines, AstraZeneca was the most chosen, with 30.5 % of participants receiving at least one dose, followed by Sputnik (19.9 %) and Pfizer-BioNTech (16.9 %). Additionally, 33.1 % of the participants received a booster dose. (Table 1).

3.2. Reported menstrual changes in regularly menstruating healthy women

The prevalence of menstrual cycle changes (MCs) was found to be 36.9 % among the participants, with a 95 % confidence interval of [0.308, 0.430]. Among those experiencing MCs, approximately 16.5 % reported changes in more than one characteristic of their cycle. However, the prevalence of MCs slightly decreased to 35 %, with a 95 % confidence interval of [0.277, 0.423] after the administration of the second vaccine dose. In this group, 15.3 % reported changes in more than one characteristic of their menstrual cycle.

9.7 % of participants reported a missed cycle after the first dose, and this percentage further decreased to 4.9 % after the second dose. The most frequently reported change was an earlier onset of menstruation occurring 1–5 days earlier than usual as 9.3 % and 6.2 % stated this change after the first and second dose respectively. Changes in the frequency of menstrual cycles were observed in 18.2 % of participants after the first dose and in 16.6 % after the second dose, irrespective of the specific pattern of change.

Regarding menstrual cycle length, the most notable change was menstruation lasting less than 3 days occurring in 4.7 % and 4.2 % of participants after the first and second dose respectively. Overall, changes in menstrual cycle length were stated by 7.2 % of participants

Table 1

Demographic characteristics and COVID-19 vaccination details of adult women study participants in Syria, 2022: n (%).

Age group	18–25	111 (47)
	26–30	61 (25.9)
	31–48	62 (27.1)
Marital status	Single	117 (75)
	Married	54 (22.9)
	Divorced/widow	5 (2.1)
Previous pregnancies	Yes	40 (16.9)
	No	196 (83.1)
Previous abortions	Yes	20 (8.5)
	No	216 (91.5)
COVID-19 vaccine received [†]	AstraZeneca	72 (30.5)
	sputnik vaccine	47 (19.9)
	Pfizer-BioNTech	40 (16.9)
	sputnik light	38 (16.1)
	Sinopharm	26 (11)
	Johnson and johnson	24 (10.2)
Completed all vaccine doses ^{††}	Yes	212 (89.8)
	No	24 (10.2)
Received COVID-19 booster dose	Yes	78 (33.1)
	No	158 (66.9)

[†] Participants may have received more than one COVID-19 vaccine type.

^{††} One dose for Johnson & Johnson vaccine.

after the first dose and 6.7 % after the second dose. However, it is important to highlight that spotting was slightly more frequent after the second dose compared to the first dose.

Heavier menstruation was the most stated change in terms of

quantity, as 6.4 % and 8 % of participants reported that issue after the first and second doses, respectively. Changes in quantity were more prevalent after the second dose (16 %), in comparison with the first dose (11 %). Regarding dysmenorrhea, 15.7 % and 14.1 % reported the issue after the first and second doses, respectively (Table 2, Fig. 2).

3.3. Association between menstrual cycle changes following COVID-19 vaccination and participant characteristics

Menstrual cycle changes did not differ according to age, marital status, previous pregnancies, previous abortions, completing all doses of the chosen vaccine, or having a booster dose after the first. After the second dose, having menstrual changes showed a borderline correlation with having previous pregnancy experience ($P = 0.044$). However, menstrual cycle changes did not differ across the other variables (Table 3).

4. Discussion

This study contributes to the growing body of research examining the potential effects of COVID-19 vaccines on women’s reproductive health. The findings of this study revealed a prevalence rate of 36.9 % for MCs after the first dose, and a slightly lower prevalence rate of 35 % after the

Table 2
Reported changes in menstrual cycle characteristics after the first and second doses of the covid-19 vaccine: n (%).

Variable		After the first dose (N = 236)	After the second dose (N = 163)
I did not have menstrual cycle	Yes	23 (9.7)	8 (4.9)
	No	213 (90.3)	155 (95.1)
Frequency	I did not notice any variation of the frequency	193 (81.8)	136 (83.4)
	Menstruation arrived 1–5 days earlier than expected	22 (9.3)	10 (6.2)
	Menstruation arrived 5–10 days earlier than expected	6 (2.5)	8 (4.9)
	Menstruation arrived more than 10 days earlier than expected	1 (0.5)	3 (1.8)
	Menstruation arrived 1–5 days later than expected	5 (2.1)	3 (1.9)
	Menstruation arrived 5–10 days later than expected	6 (2.5)	2 (1.2)
	Menstruation arrived more than 10 days later than expected	3 (1.3)	1 (0.6)
Length	I did not notice any variation of the length	219 (92.8)	152 (93.3)
	Menstruation lasted more than 7 days	6 (2.5)	4 (2.5)
	Menstruation lasted less than 3 days	11 (4.7)	7 (4.2)
Spotting	Yes	13 (5.5)	13 (8)
	No	223 (94.5)	150 (92)
Quantity	I did not notice any variation of the quantity	210 (89)	137 (84)
	Menstruation was heavier than usual	15 (6.4)	13 (8)
	Menstruation was less heavy than usual	11 (4.6)	13 (8)
Dysmenorrhea	Yes	37 (15.7)	23 (14.1)
	No	199 (84.3)	140 (85.9)

second dose.

4.1. The prevalence rate of MCs

The prevalence of MCs following COVID-19 vaccination varies across different studies due to several factors. These factors include the instruments used to assess changes, the studied population, the methodology employed, and the timing of the study in relation to vaccination. For instance, a study conducted in Spain reported a much higher prevalence of 78 % (Baena-García et al., 2022). A systematic review that included samples from 14 studies found a prevalence of more than 50 % (Nazir et al., 2022).

In the MENA region, including Syria, it has been reported that 66.3 % experienced menstrual symptoms after vaccination, with 46.7 % following the first dose (Muhaidat et al., 2022). Several studies conducted in Saudi Arabia have further examined the occurrence of MCs after vaccination. The Riyadh Survey Study reported an overall rate of 50.9 % with the second dose being more responsible for this rate (Morsi et al., 2022). While another Saudi survey indicated an overall rate of 46.7 % (Alahmadi et al., 2022).

A study conducted among Arab women reported a prevalence rate of 38.5 % for menstrual cycle changes following vaccination, which aligns more closely with the results of the paper (Amer et al., 2022). Additionally, an Italian study reported a prevalence of greater than 50 % for MCs, regardless of the vaccine type or the menstrual cycle phase at which the vaccine was administered (Laganà et al., 2022).

A large-scale study with a similar methodology carried out by Washington University found that 31.4 % of vaccinated women noticed changes in their period after the first dose and 37 % after the second dose. (Lee et al., 2022). Although this present study reports similar rates but in contrast pattern as the rate slightly decreased after the second dose. Nonetheless, it is lower than a study in China (35.2 %) (Zhang et al., 2022), a case-control study conducted in the UK (20 %) (Alvergne et al., 2023), and a study in Türkiye (15.1 %) (Taşkaldiran et al., 2022). These variations in prevalence rates across different studies emphasize the importance of considering the specific study populations, methodologies, and other contextual factors when interpreting the findings.

Concerns for the potential effect of the COVID-19 vaccination have been expressed about various issues including menstrual symptoms, irregular bleeding, and menstrual length (Edelman et al., 2022). The primary focus of this research paper is on the reported normal menstrual cycles following COVID-19 vaccination. The findings of this paper align with a study conducted in the UK, which also highlighted the prevalence of normal menstrual cycles among vaccinated individuals (Alvergne et al., 2023). However, irregularities have been reported by small percentage of healthy women.

The findings of this study did not show any significant differences in menstrual cycle changes between sociodemographic groups following COVID-19 vaccination. This is similar to a study conducted among Saudi students that also did not find any significant difference. (Fallatah et al., 2024). Additionally, a study in the UAE reported a significant increase in menstrual symptoms, including higher pad usage and pain medication use, after COVID-19. (Ahmad et al., 2024). These consistent findings across studies suggest that the menstrual cycle changes may be driven by factors beyond the vaccination, such as the immune response or psychological distress associated with the pandemic.

4.2. Patterns of altered menstrual cycle

The most commonly noticed change in menstrual cycle following COVID-19 vaccination was altered frequency, reported by 18.2 % of participants after the first dose and 16.6 % after the second dose. However, the patterns of frequency changes between the doses were negligibly different. Earlier menstruation was reported by 12.3 % of participants after the first dose and slightly more after the second dose, 12.9 %. Late menstruation was reported by 5.9 % after the first dose and

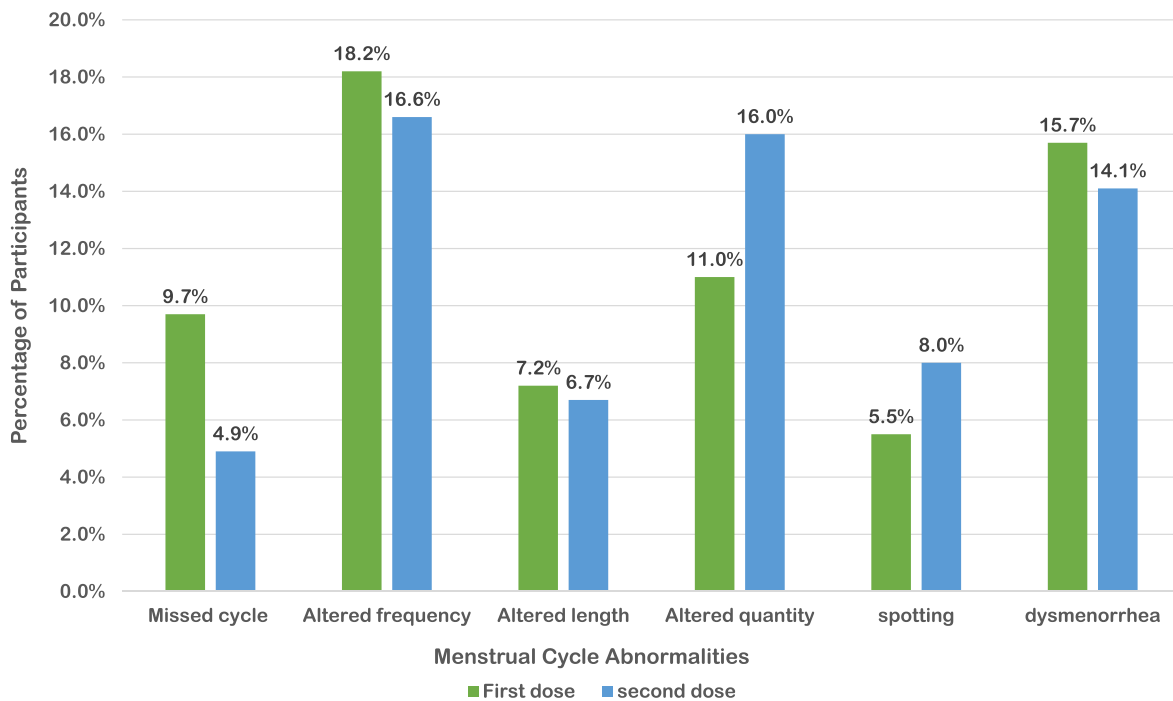


Fig. 2. Percentages of reported menstrual cycle abnormalities.

Table 3
Association between menstrual cycle changes and participant characteristics among COVID-19 vaccine recipients, 2022: n (%).

Variables		Reporting Cycle Change after First Dose (N = 236)		Reporting Cycle Change after Second Dose (N = 163)	
		Yes	P-Value	Yes	P-Value
Age	18–25	41 (36.9)	0.986	39 (31.2)	0.113
	26–30	22 (36.1)		18 (48.6)	
	31–48	24 (37.5)		0	
Marital status	Single	62 (35)	0.333	39 (31.5)	0.217
	Married	24 (44.4)		17 (47.2)	
	Divorced / widow	1 (20)		1 (33.3)	
Previous pregnancies	Yes	16 (40)	0.652	14 (51.9)	0.044*
	No	71 (36.2)		43 (31.6)	
Previous abortions	Yes	5 (25)	0.25	5 (45.5)	0.450
	No	82 (38)		52 (34.2)	
Completed all vaccine doses	Yes	77 (36.3)	0.607	50 (34.5)	0.712
	No	10 (41.7)		7 (38.9)	
Received COVID-19 booster dose	Yes	29 (40.8)	0.406	22 (44)	0.108
	No	58 (35.2)		35 (31)	

*Chi-squared test were used, and a p-value of <n0.05 was considered statistically significant.

3.7 % after the second dose. These findings are consistent with the results of a retrospectively recruited cohort study conducted in the UK (Male, 2021). However, it was lower than other studies conducted in China where 20.5 % of participants experienced delayed menstruation (Zhang et al., 2022), the Riyadh Survey Study where 30.4 % reported early onset and 60.5 % reported a delay (Morsi et al., 2022), and the previously mentioned UK study (Male, 2021).

Only 7.2 % of participants reported a variation in menstrual cycle length after the first dose, and this decreased to 6.7 % after the second dose. A US cohort study found a small change in cycle length associated with COVID-19 vaccination but not with menses length (Edelman et al., 2022). The second most common menstrual cycle change reported was altered quantity. After the first dose, 6.4 % of participants experienced heavier menses than usual, and this increased to 8 % after the second dose. These results are notably lower compared to the study conducted by Washington University, where 42 % of participants reported a heavier menstrual flow (Lee et al., 2022), and the Riyadh Survey Study, which reported a prevalence rate of 34.9 % (Morsi et al., 2022). In contrast, a Chinese study noted that only 0.2 % of vaccinated women experienced menorrhagia (Zhang et al., 2022). Spotting was reported more frequently after the second dose (8 %) compared to the first dose (5.5 %), but these results were lower than the Chinese study where 15.9 % of vaccinated women had intermenstrual bleeding (Zhang et al., 2022). Similarly, the findings of this research were lower than those of the US cohort study in all menstrual cycle characteristics (Wong et al., 2022). Unfortunately, follow-up could not be conducted due to limitations on contacting the participants. However, studies with a follow-up approach have reported the resolution of previously reported menstrual changes (Edelman et al., 2022).

The menstrual cycle is changeable due to several factors; the cause of noticing changes after COVID-19 vaccination can relate to immunization response, other factors connected to an individual’s gynaecological health, or even psychogenic causes. However, this research cannot determine if a possible linkage is present or is related to any of the causes mentioned above; therefore, further research is recommended. It is worth noting that the menstrual cycle changes even without the vaccine (Amer et al., 2022; Alvergne et al., 2023; Edelman et al., 2022). Future observational studies should take caution with what they conclude is a

normal menstrual cycle or not concerning the population's awareness and their level of knowledge.

The findings of this study, along with other studies, suggest that changes in menstrual cycle characteristics such as frequency, length, quantity, and spotting may occur after vaccination. Although the prevalence rates of these changes reported in this study were lower compared to some other studies, it is still crucial for healthcare providers to be knowledgeable about these potential effects and to address any concerns or questions that patients may have. If reported, other causes for changes should be investigated before attributing them to the vaccine alone and monitoring their course.

4.3. Strengths and limitations

This study is one of the few that assessed the menstrual cycle after both the first and second doses of different types of COVID-19 vaccines and among the Syrian population, aiming for an adequate number of participants. In addition, this research included only reported healthy women in their reproductive age using intricate inclusion criteria to eliminate any possible causes. Several limitations should be considered when interpreting the results of this study. Firstly, the small number of vaccinated women made it challenging to obtain a large-scale sample, which may limit the generalizability of the findings. Moreover, the use of chain-referral sampling through social media might introduce bias, as it may not be representative of the broader population. Finally, While a high response rate can be viewed positively as it suggests strong engagement from the target population, it is important to consider potential biases. Secondly, due to the study's design, it was not possible to investigate the correlation of reported changes with the specific type of vaccine administered. Participants did not declare the type of vaccine taken in terms of dose order, preventing a detailed analysis of vaccine-specific effects. Thirdly, participants did not provide information about the phase of their menstrual cycle at the time of vaccination or during the reporting of changes. Additionally, the period of time between vaccine administration and the completion of the questionnaire was not specified, which may introduce variability in the reported changes and their temporal relationship to vaccination. Moreover, the study lacks a control group of unvaccinated women, which is important for establishing a causal relationship between vaccination and menstrual changes. Finally, it is important to note that no further follow-up was conducted for the participants in this study. Therefore, the long-term outcomes or resolution of the reported changes could not be assessed.

5. Conclusion

The majority of women in our study reported having a normal menstrual cycle in terms of frequency, length, and quantity after receiving various types of COVID-19 vaccines. However, a lower portion of women did report experiencing altered menstrual cycles, albeit in different patterns. These findings emphasize the importance of healthcare providers being aware of the potential for menstrual cycle changes after COVID-19 vaccination.

Author contribution

Mhd Homam Safiah and Maysoun Kudsi were responsible for the design of this study. Mhd Homam Safiah and Khaled Kalalib Al Ashabi were responsible for the literature search and write-up and wrote the final draft. Naram Khalayli and Yara Hodaifa participated in the data collection. Maysoun Kudsi reviewed the final draft. All authors read and approved the final draft.

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CRediT authorship contribution statement

Mhd Homam Safiah: Writing – review & editing, Writing – original draft, Software, Investigation, Formal analysis, Conceptualization. **Khaled Kalalib Al Ashabi:** Writing – review & editing, Writing – original draft. **Naram Khalayli:** Investigation, Data curation, Conceptualization. **Yara Hodaifa:** Data curation. **Maysoun Kudsi:** Supervision.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB) at SPU (Syrian Private University Institutional Review Board), under the date (24/6/2022) and under registration number (348). Informed consent was obtained from every participant before participation. All procedures performed in studies involving human participants were following the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2024.102804>.

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