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Knowledge, attitudes, and practices towards COVID-19 and COVID-19 vaccines among Obstetrician-Gynaecologists

Nicola Luigi Bragazzi[1,C,E-F], Michele Buchinger[2,A-F], Lukasz Szarpak[3,4,D-F] ✉, Jaroslaw Chmielewski[5,E-F], Małgorzata Goździewska[6,E-F], Joanna Gotlib[7,E-F], Rola Elias Farah[2,A-F]

[1] *University of Parma, Parma, Italy*
[2] *Azrieli Faculty of Medicine, Bar-Ilan University, Tel Aviv, Israel*
[3] *Baylor College of Medicine, Houston, United States*
[4] *LUXMED Group, Poland*
[5] *International European University, Kyiv, Ukraine*
[6] *Institute of Rural Health, Lublin, Poland*
[7] *Medical University of Warsaw, Warsaw, Poland*
A – Research concept and design, B – Collection and/or assembly of data, C – Data analysis and interpretation, D – Writing the article, E – Critical revision of the article, F – Final approval of the article

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Abstract

Introduction and Objective.The article assesses the knowledge, attitudes, and practices of Obstetrician-Gynaecologists (OB/GYNs) in Israel regarding COVID-19, its impact on fertility, pregnancy and childbirth, and their positions on COVID-19 vaccines.

Materials and method. A cross-sectional anonymous survey was employed, and the data analyzed using logistic regression models.

Results. A total of 172 OB/GYN participants aged 44.9 years, primarily female (59.7%), mostly attending physicians (60.4%), had a mean knowledge score of 75.62%, with 81.1% having sufficient knowledge about general COVID-19 information, 11.9% having specific knowledge about pregnancy, birth, and breastfeeding, and 40.3% having knowledge about COVID-19 vaccination. Notably, only 27% of participants correctly identified the increased risk of preeclampsia in pregnant women with COVID-19. Nevertheless, all OB/GYN participants recommended the COVID-19 vaccination during pregnancy. The majority (65.1%) recommended vaccination across all trimesters, while a smaller percentage recommended it only in the second (25%) or third (6%) trimesters, and very few in the first trimester (4%). The study found that attitudes towards vaccination were influenced by workplace, role, religion, religious observance, and marital status.

Conclusions The study showed a good level of knowledge regarding COVID-19 vaccines which contributed to OB/GYNs' recommendations to their patients. These findings can be valuable for designing future COVID-19 vaccination campaigns.

Key words

knowledge, vaccination, questionnaire, gynaecologist, COVID-19

INTRODUCTION

In December 2019, a new coronavirus SARS-CoV-2 was identified in Wuhan, China. This virus spread rapidly and led to a global pandemic [1–4]. On 11 February 2020, the World Health Organization (WHO) named the disease 'Coronavirus Disease 2019' (COVID-19) [5–7].

Pregnant women with COVID-19 are at higher risk of adverse outcomes. Indeed, SARS-CoV-2 infection and contraction of COVID-19 in pregnancy is associated with an increased risk of serious maternal morbidity and mortality, intensive care unit (ICU) admissions, need for mechanical ventilation [8, 9], preterm birth, preeclampsia, and events of hypercoagulability [10, 11, 12], among others. Therefore, several organizations have issued specific guidelines that indicate vaccination for everyone, including pregnant women, breastfeeding mothers, and women planning pregnancy in the future [13].

In Israel, at the time of our study, three different vaccines for COVID-19 were approved for use [14], two mRNA-based vaccines, Pfizer and Moderna, and one viral vector-based vaccine, AstraZeneca. Pfizer and Moderna vaccines have 95% efficacy in preventing symptomatic COVID-19 one week or more after completing a two-dose series [15, 16]. The AstraZeneca vaccine is 70% effective in preventing symptomatic COVID-19 two weeks or more after completing a two-dose series [17].

In a study that collected information in the V-safe database on 35,691 pregnant women between the ages of 16–54 who received an mRNA vaccine against COVID-19 [18], it appears that there are no safety issues in administering the vaccine to this specific population. The proportion of adverse events in pregnancy and around childbirth, such as preterm birth, small size for gestational age, congenital malformations,

✉ Address for correspondence: Lukasz Szarpak, Baylor College of Medicine, United States
E-mail: lukasz.szarpak@gmail.com

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and neonatal death, is the same as that of pregnant women studied before the pandemic. Vaccination was associated with a clinically insignificant change in menstruation cycle duration [19], and the pro-thrombotic syndrome was observed in a small number of individuals who received the adenoviral vector-based vaccine AstraZeneca and Johnson & Johnson [20].

According to the American College of Obstetricians and Gynaecologists (ACOG) recommendations, COVID-19 vaccines can be given in parallel with other vaccines, including those routinely given during pregnancy, such as the influenza vaccine and immunization against diphtheria, tetanus, and pertussis [21]. Vaccines and booster doses can be given at any stage of pregnancy [21, 22], and the COVID-19 vaccine is also additionally recommended for breastfeeding women. Maternal antibodies pass through breast milk and may have a protective effect on the infant [23]. The vaccines currently available do not affect fertility [24] and there is no need to delay pregnancy after receiving them [21].

Despite all the data that supports COVID-19 vaccine efficacy and safety, many women have questions whether to take the vaccine when offered [13]. 'Vaccine hesitancy' is defined as a delay in acceptance or refusal of vaccination despite the availability of vaccination services. It is influenced by many factors, among them vaccination confidence plays a major role. It includes trust in the safety and effectiveness of vaccines, trust in health care workers and health services, and trust in policymakers making the decisions to approve or not approve a vaccine for a population [25, 26].

Strategies for addressing COVID-19 vaccine hesitancy include interpersonal-level interventions, such as clinician recommendations. Doctors are the most trusted source of information [27] n concerning COVID-19 [28], and their recommendations can influence the vaccination rate. In a study examining the willingness of patients in Austria to get vaccinated against COVID-19, 66% of respondents indicated that a doctor's recommendation was a necessary factor in their decision-making process [29].

To offer strong recommendations to their patients, clinicians need to be updated regarding information about COVID-19, vaccine efficacy, safety, and reactogenicity [30]. Despite the importance of this topic, only a few studies have assessed the knowledge, attitudes, and practices of health workers, including Obstetrician-Gynecologists, regarding COVID-19 and COVID-19 vaccines [31–35]. Physicians' perceptions of the vaccination of pregnant women and those wishing to become pregnant have also been reported [36, 37]. However, to the best of our knowledge, no study has been conducted to investigate the link between Obstetrician-Gynecologists' knowledge, attitudes, and practices towards COVID-19 and the vaccine and their recommendations to their patients about the COVID-19 vaccine.

OBJECTIVE

The aim of the study is to fill in the gap in knowledge, evaluate the knowledge, as well as the attitudes and practices of Obstetrician-Gynecologists in Israel towards COVID-19, specifically regarding the effect of COVID-19 disease on fertility, the course of pregnancy, and childbirth, and their positions regarding COVID-19 vaccines. It is hypothesized that there is a direct link between clinicians' level of knowledge about COVID-19 and the vaccine, and their recommendations to patients regarding COVID-19 vaccines.

MATERIALS AND METHOD

A cross-sectional anonymous survey was constructed based on a literature review of previously published relevant questionnaires [34–37] and WHO recommendations. The survey was conducted between 27 April 2022 31 July 2022. At that point in time, the Pfizer, AstraZeneca, and Moderna vaccines had been approved and were in use in Israel.

Approval for performing this study by the local Ethics Committee of the medical faculty of Bar-Ilan University in Tel Aviv, Israel, was waived because of the survey-based nature of the study. The participants, Obstetrician-Gynecologists (either residents or attending physicians), agreed to participate in the study.

Google Forms were used to design the questionnaire which was prepared in a Hebrew version and submitted to the participants. All questions in Google Forms were marked as 'required' to avoidthe possibility of missing data. The questionnaire was extensively advertised and distributed; more specifically, the link was shared in a private Facebook group moderated by physicians. It was also sent individually to Obstetrician-Gynecologists working at the Northern District of Clalit Health Services and at the Emek Medical Centre. The questionnaire was hand-delivered to the Ziv and Baruch Padeh Medical Centres during their morning meetings, in Galilee, Bnai Zion, and Kaplan Medical Centres, and at the Scottish Hospital of Nazareth during working hours and at the annual conference of the Israel Society of Obstetrics and Gynecology on 21 June 2022 in Haifa.

A pilot study group of 12 doctors (5 males; mean age 40; range 27 m- 53) from the Galilee Medical Centre in Nahariya, was performed in order to validate the questionnaire.

The questionnaire consisted of 5 sections: socio-demographic data, general knowledge regarding COVID-19, specific knowledge regarding pregnancy, birth, breastfeeding, and COVID-19, knowledge regarding COVID-19 vaccination, and attitudes and practices towards COVID-19 vaccines.

The socio-demographic section asked the participants for their gender, age, marital status, number of children, religion and religious observance, role (resident or attending physician), area of specialization and professional experience, workplace, whether they have been infected with COVID-19, whether they were vaccinated against COVID-19, and the number of doses they received.

The general knowledge section also had 5 questions that assessed the participants' knowledge of COVID-19 prevention, transmission, and management. The total score for the section ranged from 0–5.

The specific knowledge section regarding COVID-19 pregnancy, birth, and breastfeeding had 14 questions with a total score ranging from 0–14. Each question had the answer options of 'true', 'false', or 'I don't know'. Only the correct answer was given a score of 1, and all other answers scored 0. The knowledge section regarding the COVID-19 vaccination section had 14 questions: 11 yes/no/I don't know questions, and 3 multiple-choice questions. The maximum score for this section was 14.

Finally, the attitudes and practices towards the COVID-19 section consisted of 7 questions. In this part, a 5-point

Likert-type scale was used for 6 items ('strongly disagree' = 1, 'disagree' = 2, 'uncertain' = 3, 'agree' = 4, and 'strongly agree' = 5). The last item was a multiple-choice question regarding the vaccination of pregnant women.

Bloom's cut-off of ≥80% was used to determine sufficient knowledge, as this knowledge-scoring system has been adopted in numerous publications concerning the same topic.

A dedicated statistician carried out all statistical analyses. Participants' characteristics were summarized descriptively using means, standard deviations (SD), or percentages, as appropriate. The relationship between the level of knowledge and the degree of consent to recommend the vaccine was examined by the Pearson test. The MANOVA test was used: the dependent variable was the degree of consent to recommend the vaccine, and the independent variable was the level of knowledge (areas of knowledge: general knowledge, specific knowledge regarding pregnancy, childbirth, and breastfeeding, and knowledge about the vaccine). A forward stepwise logistic regression was used to identify possible predictors of clinicians' recommendations. T-tests and *post-hoc* tests with ANOVA were applied to measure the differences between socio-demographic groups.

RESULTS

There were 172 Obstetrician-Gynaecologist participants; 13 questionnaires (all hand-delivered) were excluded from the analysis because they were not fully completed. Participants were of an average age of 44.9 years (27–74 years), and were mainly female (59.7%, and attending physicians (60.4%) (Tab. 1).

Knowledge. The mean score for the knowledge section was 75.62% (SD = 10.62). Based on a cut-off score of 80% in each section, 81.1% of participants had sufficient knowledge in general knowledge regarding COVID-19 section, 11.9% in the specific knowledge regarding pregnancy, birth, breastfeeding, and COVID-19 section, and 40.3% in knowledge regarding the COVID-19 vaccination section.

The least correctly answered question was regarding the risk of developing preeclampsia in pregnant women with COVID-19 (the risk is higher than in pregnant women who do not have COVID-19). Only 27% selected the correct answer. The set of items and percentage of scores are presented in Table 2.

Attitudes and practices. All the Obstetrician-Gynaecologist participants recommended COVID-19 during pregnancy. 65.1% of pregnant women were recommended vaccination at all trimesters, 25% only in the second trimester of pregnancy, 6% in the third trimester of pregnancy, and only 4% recommended vaccination in the first trimester of pregnancy (Tab. 3)

T-tests and *post hoc* tests with ANOVA showed that the attitudes scores had a statistically significant association with workplace (private medical facilities Obstetrician-Gynaecologists scored higher than hospital Obstetrician-Gynaecologists), role (attending physicians scored higher than residents), religion (Jewish and Druze/Unitarian scored higher than Muslim and Christian), religious observance (secular participants scored higher than those who were religious), and marital status (married participants had the highest scores).

Table 1. Sample characteristics (n= 159 OB/GYN)

		n	%
Gender	Male	64	40.3
	Female	95	59.7
Marital status	Married	129	81.1
	Divorced	7	4.4
	Single	21	13.2
	Other	2	1.3
Workplace	Hospital	122	76.7
	Private medical facilities	37	23.3
Religion	Jewish	93	58.5
	Muslim	21	13.2
	Christian	36	22.6
	Druze/Unitarian	7	4.4
	Other	2	1.3
Religious observance	Secular	106	66.7
	Traditional	40	25.2
	Religious	13	8.2
Role	Attending physician	96	60.4
	Resident	63	39.6
Previous infection with COVID-19	No	72	45.3
	Yes	87	54.7
COVID-19 vaccination	No	1	0.6
	Yes	158	99.4

	Range	Mean	SD
Age	27.0-74.0	44.9	12.48
No. of children	0.0-6.0	2.2	1.4
No. of years in residency for residents	0.0-6.0	3.22	1.83
No. of years in practice for attending physicians	1.0-45.0	18.2	11.79

Knowledge, attitudes, and practices about COVID-19 and the vaccine. There was a statistically significant correlation between the total knowledge score and the degree of consent to recommend the vaccine. Moreover, the knowledge scores of Obstetrician-Gynaecologists who recommended the vaccine during the third trimester of pregnancy, and those who recommended the vaccine at all trimesters were nearly identical (78.79% and 77.73%, respectively).

The correlation between knowledge in different fields and clinicians' recommendations (attitudes section) is summarized in Table 4. Participants with higher scores in the 'Specific knowledge regarding pregnancy, birth, breastfeeding, and COVID-19' and 'Knowledge regarding COVID-19 vaccination' sections were more likely to score higher in the attitudes section. There was no statistically significant correlation between the 'General knowledge regarding COVID-19' section and the 'attitudes' section. When comparing knowledge in different fields, the 'Knowledge regarding COVID-19 vaccination' section was the strongest predictor of vaccine recommendations by Obstetrician-Gynaecologists.

Stepwise logistic regression demonstrated that the number of children and the 'Knowledge regarding COVID-19 vaccination' score were good predictors of vaccine

Table 2. Knowledge of OB/GYN regarding COVID-19 (n= 159 OB/GYN).

Knowledge	Question	Percentage (%)
General knowledge regarding COVID-19	Covid-19 is transmitted through respiratory droplets	94%
	Hand washing protects against Covid-19	92%
	Face masks protect against Covid-19	98%
	Incubation period for Covid-19 is 2-14 days	97%
	To reduce the risk of infection, people with Covid-19 should be isolated and treated	95%
Specific knowledge regarding pregnancy, birth, breastfeeding and COVID-19	Pregnant women are at a higher risk of developing Covid-19 than non-pregnant women	50%
	Pregnant women with Covid-19 have more complications compared to non-pregnant women of the same age	91%
	Pregnant women with Covid-19 should take additional precautions to protect themselves from Covid-19, more than non-pregnant women of the same age,	58%
	Pregnant and postpartum women with Covid-19 can take NSAIDs and acetaminophen	55%
	Covid-19 positive pregnant patients are more likely to have preterm labour, compared to pregnant women who do not have Covid-19	77%
	Compared with pregnant women of similar age, pregnant women with Covid-19 are more prone to hospitalizations, intensive care hospitalizations and artificial respiration	89%
	Pregnant women with Covid-19 have a higher risk of developing preeclampsia compared to pregnant women who do not have Covid-19	27%
	Pregnant women with Covid-19 have an increased risk of miscarriage	43%
	Pregnant women with Covid-19 have an increased risk of thromboembolic events, compared to non-pregnant women and Covid-19 patients	73%
	Vertical transmission appears to be uncommon	69%
	Pregnant women with Covid-19 can pass the virus onto the foetus or baby intrauterine or during delivery	56%
	Caesarean section is indicated for the delivery of all pregnant Covid-19 patients	97%
	A Covid-19 infected mother can transmit the virus to the baby through contact or respiratory droplets during breastfeeding	90%
	Covid-19 can be transmitted through breast milk	69%
Knowledge regarding COVID-19 vaccination	How many types of Covid-19 vaccines have been approved for use by the FDA?	42%
	The Pfizer and Moderna Covid-19 vaccines are messenger RNA vaccines	92%
	The AstraZeneca vaccine is a viral vector vaccine	48%
	Based on results of clinical trials, Pfizer and Moderna vaccines are effective in preventing symptomatic Covid-19 disease in individuals who received two doses, with no evidence of previous infection at	42%
	Thrombosis with thrombocytopenia syndrome (TTS) was identified in patients who received	71%
	Clinical trials have confirmed that Covid-19 vaccines adversely affect fertility and foetal development	92%
	To date, the v-safe registry data on the reactogenicity profile and side-effects in pregnant women have not indicated any safety concerns	69%
	The rate and range of side-effects from the vaccines are similar in pregnant and non-pregnant women	82%
	The effectiveness of the vaccines can vary depending on the length of time that has elapsed since the vaccine and the viral strain	86%
	Based on the information accumulated so far, a booster dose increases the effectiveness of the vaccine	91%
	It is permissible to give Covid-19 vaccine simultaneously with vaccines recommended to pregnant women, such as vaccine against pertussis or influenza, or at any time before or after these vaccines	75%
	It is best not to give the vaccine to woman who are planning pregnancy because the vaccine affects fertility	94%
	A woman who received the first dose of the vaccine and became pregnant - it is recommended that she complete the second and third doses of the vaccine according to the accepted schedule	95%
	Coronavirus vaccine should not be given to women who are breastfeeding	95%

Table 3. Attitudes scores (n= 159 OB/GYN)

Vaccine recommendation	Strongly disagree	2	3	4	Strongly agree	Mean	SD
I recommend COVID-19 vaccine to all pregnant women (without contraindication)	0%	1%	6%	20%	73%	4.65	0.63
I recommend the vaccine only to pregnant women who are at high risk of contracting the virus	45%	33%	4%	9%	9%	2.03	1.28
I recommend COVID-19 vaccine to all women (without contraindication) of reproductive age who are not pregnant	1%	5%	4%	13%	77%	4.62	0.83
I recommend vaccination of all women (without contraindication) planning to undergo assisted reproduction	1%	4%	2%	19%	74%	4.61	0.81
I recommend an interval between vaccination and pregnancy	44%	30%	9%	7%	9%	2.08	1.29
I recommend an interval between vaccination and ART (Assisted Reproductive Technology)	38%	31%	11%	9%	11%	2.23	1.33

Table 4. Knowledge in different fields and clinicians' recommendation (n= 159 OB/GYN)

		Knowledge score	Clinicians' recommendations	General knowledge regarding COVID-19	Specific knowledge regarding pregnancy, birth, breastfeeding and COVID-19	Knowledge regarding COVID-19 vaccination
Knowledge score	Pearson Correlation	1	.435**	.255**	.825**	.856**
	Sig. (2-tailed)		<.001	.001	<.001	<.001
Clinicians' recommendations	Pearson Correlation	.435**	1	.032	.249**	.496**
	Sig. (2-tailed)	<.001		.692	.002	<.001
General knowledge regarding COVID-19	Pearson Correlation	.255**	.032	1	.052	.126
	Sig. (2-tailed)	.001	.692		.516	.114
Specific knowledge regarding pregnancy, birth, breastfeeding and COVID-19	Pearson Correlation	.825**	.249**	.052	1	.446**
	Sig. (2-tailed)	<.001	.002	.516		<.001
Knowledge regarding COVID-19 vaccination	Pearson Correlation	.856**	.496**	.126	.446**	1
	Sig. (2-tailed)	<.001	<.001	.114	<.001	

** Correlation is significant at the 0.01 level (2-tailed).

recommendations by Obstetrician-Gynaecologists (Tab. 4 and 5). Religious observance was close to being statistically significant; more religious physicians were less willing to recommend the COVID-19 vaccine to their patients. The number of years of experience and previous infection with COVID-19 showed little or no predictive power. A heatmap of the correlation between clinician's recommendation, knowledge in different fields, number of children, and number of years of experience is shown in Figure 1. The green colour is associated with a higher positive correlation between measures, while the red colour indicates a higher negative correlation between measures.

	Age	Number of kids	Knowledge score	Clinicians' recommendations	Number of years of experience	General knowledge regarding COVID-19	Specific knowledge regarding pregnancy, birth, breastfeeding and COVID-19	Knowledge regarding COVID-19 vaccination
Age		0.446	0.121	0.106	0.940	0.181	0.059	0.104
Number of kids	0.446		0.297	0.348	0.381	0.108	0.246	0.245
Knowledge score	0.121	0.297		0.435	0.099	0.255	0.825	0.856
Clinicians' recommendations	0.106	0.348	0.435		0.054	0.032	0.249	0.496
Number of years of experience	0.940	0.381	0.099	0.054		0.186	0.050	0.073
General knowledge regarding COVID-19	0.181	0.108	0.255	0.032	0.186		0.052	0.126
Specific knowledge regarding pregnancy, birth, breastfeeding and COVID-19	0.059	0.246	0.825	0.249	0.050	0.052		0.446
Knowledge regarding COVID-19 vaccination	0.104	0.245	0.856	0.496	0.073	0.126	0.446	

Figure 1. Clinician's recommendation, knowledge in different fields, number of children, and number of years of experience

DISCUSSION

The aim of the study was to investigate the link between Obstetrician-Gynaecologists' knowledge, attitudes, and practices towards COVID-19 and COVID-19 vaccines and their recommendations to their patients about the COVID-19 vaccines.

We found that the total knowledge score affected Obstetrician-Gynaecologists' attitudes and practices. Those who were more knowledgeable about COVID-19 and the COVID-19 vaccines presented more positive attitudes towards vaccine uptake, and were more willing to promote it to those eligible. When looking at the different domains of knowledge, it was found that most participants were aware of the way of transmission of the disease (94%), the actions when dealing with COVID-19 cases (95%), and precautionary measures (92% and 98%). However, a lower level of knowledge was found in response to the questions regarding COVID-19 vaccination (40.3%) and pregnancy, birth, breastfeeding, and COVID-19 (11.9%). This lack of knowledge could be due to the rapid evolution of knowledge based on the evolving nature of the disease, which requires continuous learning. Although all participants in the study were favourable towards vaccinating pregnant women, their hesitancy about vaccination during the first and second trimesters of pregnancy remains an issue that deserves further attention.

Logistic regression analysis showed that gender, number of years of experience, and previous infection with COVID-19 had little or no predictive power in vaccine recommendation, while knowledge regarding COVID-19 vaccination (among other domains of knowledge) and the number of children were good predictors of vaccine recommendations by the healthcare workers. As COVID-19 vaccine development was based on novel technologies, thist might explain why the number of years of experience did not confer an advantage to young and senior physicians who needed to study the new subject from scratch.

The finding of a good level of general knowledge among the study participants is in line with a previous study of Youssef et al. (2021) [35], but inconsistent with their results concerning knowledge of COVID-19, breastfeeding (78.9%), and pregnancy (77.1%). Similar to Holzmann-Littig et al. (2021) [32], participants with vaccination hesitancy under-performed in the knowledge test regarding the COVID-19 vaccine.

In contrast to a study evaluating healthcare workers' attitudes towards the COVID-19 vaccination of pregnant women [36], a greater willingness was found to recommend the COVID-19 vaccines in all trimesters of pregnancy (65.1% in the current study, compared to 48%). As the safety of COVID-19 vaccines is continuously evaluated and updated, and information regularly provided, the period of time during which the study was performed could explain the difference between the results.

Future directions. The relevance of the topic of this study to the medical care of pregnant women and maternal and child health in the perinatal period also prompts discussing concerning recent literature on NeuroCOVID-19, which is defined as the neurological, neuropsychological and neuropsychiatric sequelae of COVID-19 [37]. Indeed, such knowledge has the potential to influence the attitudes and practices of healthcare professionals, including Obstetrician-Gynaecologists regarding the recommendation of COVID-19 vaccine use. This highlights the occurrence of multi-dimensional sequelae of SARS-CoV-2 infection and contracting COVID-19, including neurological, neuropsychiatric, and neuropsychological [38, 39, 40, 41].

A cohort study was conducted which included a longitudinal analysis of 1,284,437 patients following SARS-CoV-2 infection and contracting COVID-19, among whom almost a half of this population exhibited mild or severe neurological, neuropsychological or neuropsychiatric disorders [40]. *The Lancet* COVID-19 Commission's Mental Health Task Force [38] concluded that infection and infection-related inflammation (in addition to genetic and environmental factors) may act as the etiopathogenesis of neurological and neuropsychiatric disorders. In addition, the SARS-CoV-2 virus has been detected in brain tissue samples taken at autopsy from individuals who died from COVID-19, suggesting that it may also attack the central nervous system [42]. Case studies of individuals with various neurological and psychiatric disorders due to NeuroCOVID-19 have also been presented, both in adults [41, 43, 44, 45] and in children [46].

Potential mechanisms have been described that may lead to neurological and neuropsychiatric disorders and neuropsychiatric patients after SARS-CoV-2 and COVID-19 COVID-19 infection [46]. These include:

1) systemic dysfunction and multiple organ failure – hypoxaemic patients with severe COVID-19 may develop encephalopathy [47], including uraemic [38, 48];
2) immune system dysfunction – cytokine storm associated with an increase in cytokines (such as IL-6, TNF α) and inflammatory mediators [49]. Cytokines can cross the blood-brain barrier, leading to neuroinflammation and neurotoxic effects associated with confusion and impaired consciousness [38], as well as brain fog [44] and neurological and neuropsychiatric disorders [50];
3) dysfunction of the renin-angiotensin system (RAS), which is caused by reduced levels of ACE2 after SARS-CoV-2 infection [39]. There is also vascular endothelial cell damage [51];
4) direct invasion of the virus into the nervous system – after intranasal infection, SARS-CoV-2 infect olfactory receptor neurons and then travel up the olfactory nerve, where they eventually reach other parts of the brain [40].

During the COVID-19 pandemic, pregnancy has been identified as a risk factor for severity of infection and even mortality [52]. Many of these women may develop NeuroCOVID-19. Hyperventilation causes pregnant women to inhale more air at one time, making them more likely to inhale more virus particles than non-pregnant woman. Due to the hormonal state of the pregnant woman, respiratory failure may occur more frequently, especially in the last months of pregnancy, which promotes hypoxia of the central nervous system [53, 54]. Progesterone-induced changes in the upper respiratory tract mucosa during pregnancy lead to virus attachment to the nasal mucosa and are difficult to remove. Increased expression of ACE2 has also been reported during pregnancy [55]. Studies have shown that ACE2 expression increases during pregnancy, which is also associated with increased susceptibility of pregnant women to SARS-CoV infection [56].

It has also been shown that exposure to COVID-19 *in utero* may be a risk factor for the development of neurological disorders in offspring in the future [39]. A study of 7,772 infants born during the COVID-19 pandemic revealed that maternal

immune activation (MIA) and subsequent inflammation can affect foetal brain development. Inflammatory mediators, cytokines and autoantibodies can cross the placenta and the compromised blood-brain barrier after MIA, leading to neuroinflammation. Results have shown that infants born (at one year of age) to mothers infected with COVID-19 are more likely to be diagnosed with neurological disorders than infants born to uninfected mothers [57].

The above results indicate the urgency of addressing the additional topic of training medical personnel, especially Obstretician-Gynaecologists on NeuroCOVID-19 prophylaxis in pregnant women to prevent both acute and distant neurological and neuropsychiatric sequelae of SARS-CoV-2 infection. These activities will not only raise the level of public awareness, but also increase the effectiveness of interventions, including educational lectures and information leaflets on COVID-19 vaccination, as was carried out at a medical centre in Japan [58], as well as the need for COVID-19 vaccination. It is worth mentioning that in the current study, respondents to the post-intervention questionnaire believed that information leaflets (88.2%) and e-learning opportunities (84.2%) were the most effective strategies. As the current findings show, hesitation to vaccinate may be due to lack of knowledge about COVID-19 vaccination.

Healthcare providers should be vigilant of the increased mental health needs of their pregnant and parenting patients. Clear communication to improve knowledge about the multifaceted implications of COVID-19 and NeuroCOVID-19 among health care professionals, especially Obststrician-Gynaecologists, can increase positive attitudes among pregnant women to receive COVID-19 vaccine, and promote it to those eligible for vaccination. This could also have a major impact on vaccination rates.

Limitations of the study. The presented study has some limitations. First, no validated tool for the assessment of knowledge, attitudes, and practices of Obstetrician-Gynaecologists was available. Hence, tools adapted from previously published relevant questionnaires were used for the assessment of healthcare workers' knowledge, attitudes, and practices [34, 35, 36, 59], and the WHO recommendations. Secondly, on the one hand, the long period of time for conducting the survey contributed to the good response rate; on the other hand, however, it may explain some of the differences between participants' knowledge, as knowledge was not assessed at the same critical phase of the pandemic.

CONCLUSIONS

Thestudy examined knowledge, attitudes, and practices regarding COVID-19 and the COVID-19 vaccines among Obstetrician-Gynaecologists in Israel, which represents a critical group of healthcare workers, as they play a pivotal role in advising pregnant women, a population that might have specific concerns or risks associated with COVID-19 and its vaccines. The results highlight the fact that a good level of knowledge regarding the COVID-19 vaccine could partly explain Obstretician-Gynaecologists vaccine recommendations to their patients. The presented findings should be taken into consideraton when designing new COVID-19 vaccination campaigns, including targeted educational campaigns for healthcare professionals, as this could be a strategic approach to increase vaccine uptake among pregnant women. However, the findings should be contextualized as they may not be generalized to other countries, which warrants further research aimed at covering and addressing gaps in knowledge, such as effective strategies that can be devised to enhance knowledge, attitudes, and practices regarding COVID-19 and its vaccines among Obstretician-Gynaecologists.

Data availability. Data are available from the corresponding author upon reasonable request.

Institutional Review Board Statement. As the research was survey-based study, no permission for its performance was required from the Bioethics Committee of Bar-Ilan University in Tel Aviv, Israel. Written, informed consent was obtained from the study participants prior to the commencing of the study.

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