



Vaccination coverage during pregnancy and factors associated with refusal of recommended vaccinations: An Italian cross sectional study

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ABSTRACT

Background: The vaccines recommended during pregnancy are the Tdap, the influenza vaccine, and, during the SARS-CoV-2 pandemic, the vaccine against COVID-19. This survey aimed at determining vaccination coverage among pregnant women and adverse events, reasons for vaccine refusal, and factors associated with vaccine uptake.

Methods: A single-center cross-sectional study was conducted on women who delivered between March and April 2022 at Careggi University Hospital in Florence, Italy. Information on the vaccinations (Tdap, influenza and COVID-19) received during pregnancy were collected through in-person interviews.

Results: Among 307 enrolled women (response rate 99 % on a study population of 310 eligible women), 74 % of patients were vaccinated with Tdap, 82 % against COVID-19, and only 33 % against influenza. Vaccination coverage for Tdap and COVID-19 was significantly higher among Italian than foreign patients (80 % vs 51 %, $p < 0.001$ and 86 % vs 69 %, $p = 0.002$, respectively), and for Tdap was higher among patients followed in the private vs public care setting. The main reasons behind refusal of vaccinations were low risk perception of influenza (41 %), insufficient information received from the prenatal care provider regarding the Tdap (35 %), and, for the COVID-19, fear of vaccine side effects (64 %), and concerns about effects on the fetus (70 %).

Conclusions: Adherence to the influenza vaccine was low because of reduced perception of the disease risks. The difference in vaccination coverage between Italians and foreigners is an example of healthcare disparity. Better information provided to patients about vaccines' efficacy and safety is advisable to increase acceptance of recommended vaccines.

1. Introduction

Vaccination during pregnancy provides active immunity of the mother, but also passive immunity of the neonate thanks to the transfer of maternal antibodies across the placenta and in the breast milk [1–3]. Therefore, it protects from vaccine-preventable diseases three different populations: the pregnant woman, the developing fetus, and the newborn/infant. The vaccinations internationally recommended in pregnancy are the tetanus-diphtheria-pertussis (Tdap) vaccine, which should be administered during the early part of gestational weeks 27 through 36 of each pregnancy, ideally around the 28th week [4,5], and the influenza vaccine, which is recommended during the flu season, at

any trimester of pregnancy [6]. Following the recommendations of the main international scientific societies, the Italian Ministry of Health included the recommendation for pertussis and influenza vaccinations during pregnancy in the 2017–2019 Italian National Immunization Plan, encouraging obstetric care providers to offer these vaccines to all pregnant women [7]. Despite the current recommendations and the robust data demonstrating the safety and efficacy of these vaccines in pregnancy [8–11], vaccine uptake rates during pregnancy remain low in most countries. Recent data from survey-based studies in the United States [12], England [13], and Italy [14] indicated that the uptake of influenza vaccine was below 50 %. Unsatisfactory rates have also been reported for the Tdap vaccine [12–15]. Common reasons for refusing

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antenatal vaccinations are concerns regarding possible side effects for the baby and doubts regarding the efficacy and necessity of immunization [13].

Pertussis is a serious common childhood disease that can be prevented with immunization. Despite the high vaccination coverage rate among infants, the disease remains a major public health problem with over 35,000 cases reported by 30 European countries in 2018 [16], which poses a high transmission risk to infants who are too young to have started or completed the primary pertussis vaccination series, and who are also the group that may develop the most severe symptoms or may die from the disease [17–19].

Influenza is a leading cause of morbidity and mortality worldwide each year. Pregnant women are at high risk of complications from influenza and they are recognized as a priority group for seasonal influenza vaccination [20]. Children under 6 months of age who are infected have a high rate of complications and hospitalization, and their protection during these months can only be achieved through maternal vaccination in pregnancy, which is safe and effective [21,22].

Due to the COVID-19 pandemic, on September 2021 the Italian National Institute of Health recommended the mRNA COVID-19 vaccine to all pregnant women [23], following the international recommendations, considering the risks of severe complications from COVID-19 infection in pregnancy [24–26], and the numerous and growing evidence regarding the safety of vaccination [27]. Indeed, COVID-19 vaccination confers passive immunity to the newborn [28], and data released by the Center for Disease Control (CDC) in April 2021 did not identify any safety concerns for pregnant women who were vaccinated or for their babies [29]. Despite the recommendation from the main international scientific societies of Obstetrics and Gynecology, the reported COVID-19 vaccination coverage among pregnant women in the United States was suboptimal and lower than in the non-pregnant population [12,30].

While some Italian studies have been conducted about the adherence of the pregnant population to the recommended Tdap and influenza vaccines [14,15,31], there are less data on adherence to the vaccination against COVID19 and on the reasons behind the refusal to get the vaccine [32]. Understanding what are the factors that influence the acceptance of the recommended vaccinations in pregnant women is fundamental to elaborate strategies to increase vaccination coverage in such a population. Direct communication with patients is necessary to understand what are the reasons behind the refusal of a specific vaccination. For this reason, we conducted a cross-sectional study to evaluate vaccination coverage among pregnant women and factors associated with failure to receive the recommended vaccination.

2. Materials and methods

2.1. Study design

This single-center cross-sectional, survey-based study was conducted at the Department of Obstetrics and Gynecology of Careggi University Hospital in Florence, Italy. Women who gave birth at full term between March and April 2022 and who consented to participate in the study were requested to answer a questionnaire on the vaccinations received during pregnancy. This specific recruitment period was chosen to ensure that all included women were pregnant during the winter season, implying that the influenza vaccine was recommended for all of them. The questionnaire was administered by a physician during an in-person interview. Exclusion criteria were preterm delivery and the woman's refusal to participate.

2.2. Data collection

The first part of the questionnaire included the woman's demographic characteristics, obstetric history, and information on prenatal care services received by the pregnant woman. The second part focused on adherence to the recommended vaccinations in pregnancy

and included questions on which vaccinations the woman received, did not receive, or declined, the reason behind refusal, the information and recommendations that the woman received from her prenatal care provider during pregnancy, and any side effect experienced from vaccinations. Given the high incidence of COVID-19 infection in Italy during the study period, women were also asked if they contracted the infection during pregnancy and if they needed hospital admission. The full questionnaire is available as [supporting information in Supplementary materials \(S1\)](#).

2.3. Study objectives

The primary objective of the study was to evaluate the coverage rates for pertussis, influenza, and COVID-19 vaccinations among pregnant women, and, for unvaccinated women, the main reasons why they failed to get vaccinated or refused a vaccination. Secondary aims were: i) to collect information on any adverse event reported by the pregnant women following immunization; ii) to evaluate if there was any difference in rates of vaccination coverage between Italian and foreign women and between the different types of antenatal care services used (private or public care) and iii) to investigate the role of the prenatal care provider in informing the pregnant woman and in recommending vaccinations.

2.4. Ethics

This study was approved by the local ethics committee (ref. number 21389_oss, date of approval January 18, 2022) and written informed consent was obtained from all subjects.

2.5. Statistical analysis

Demographic and obstetric characteristics were summarized descriptively, as number (percentage) for categorical data. Response frequency distribution was tabulated for each question. The chi-square test or Fisher's exact test was used to compare categorical variables between groups. The statistical analyses were conducted using statistical software SPSS version 24.0 and the significance level was set at 5 %.

3. Results

3.1. Study population

Of the 310 women who met the inclusion criteria during the study period, three declined their participation in the study, while the remaining 307 gave their consent and were interviewed by the physician administering the questionnaire (99 % response rate). Women's demographic and obstetric characteristics are reported in [Table 1](#). Most mothers were Italian (79 %) and aged between 30 and 40 years (68 %). Over half of the women were at their first delivery. Almost 60 % of the interviewed women attended public services for antenatal care.

3.2. Vaccination coverage rates and reasons for not getting vaccinated

Overall, 74 % of women were vaccinated with Tdap, 82 % against COVID-19, and only 33 % against influenza ([Fig. 1](#)). 62/307 women (20 %) received only one vaccine, most frequently the COVID-19 vaccine, 215/307 women (70 %) received 2 or 3 vaccines. Among those who received 2 vaccines, the most frequent combination was Tdap and COVID-19 vaccines ([Fig. 2](#)).

The most common reason for getting vaccinated was to protect the baby. The reasons why women failed to receive or refused the vaccinations are listed in [Table 2](#). The main reason for not getting vaccinated against pertussis was the lack of vaccine recommendations or information received by the prenatal care provider during pregnancy (35 %). The main reason for refusal of the influenza vaccine was the reduced

Table 1
Demographic and obstetric characteristics of the 307 women enrolled in the study.

| | n (%) |
|---|------------|
| Age (years) | |
| <25 | 10 (3.3) |
| 25–30 | 47 (15.3) |
| 31–40 | 209 (68.1) |
| >40 | 41 (13.4) |
| Nationality | |
| Italian | 242 (78.8) |
| Foreign | 65 (21.2) |
| Level of education | |
| Lower secondary education | 26 (8.5) |
| Upper secondary education | 104 (33.9) |
| Tertiary education | 177 (57.7) |
| Total number of deliveries | |
| 1 | 170 (55.4) |
| 2 | 118 (38.4) |
| 3 | 14 (4.6) |
| >3 | 5 (1.6) |
| Gestational age at delivery in the present pregnancy | |
| 38 weeks | 79 (25.7) |
| 39 weeks | 98 (31.9) |
| 40 weeks | 94 (30.6) |
| 41 weeks | 36 (11.7) |
| Type of pregnancy | |
| Singleton | 304 (99) |
| Twin | 3 (1) |
| Type of antenatal care | |
| Public care service | 176 (57.3) |
| Private practice | 131 (42.7) |

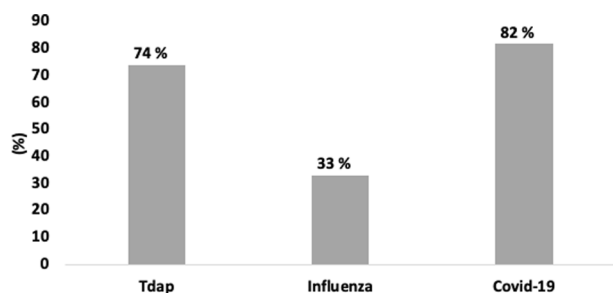


Fig. 1. Vaccination coverage for Tdap, Influenza, and Covid-19 in the study population (%). **Legend:** n = 62 women received only 1 vaccine, n = 215 women received 2 or 3 vaccines.

perception of the risks of the disease (41 %) and for the COVID-19 vaccine was concern about the side effects (64 %) and potential effects on the fetus (69 %).

Only 34.2 % of mothers reported that their partner received the Tdap vaccination during their pregnancy, as part of the “Cocooning strategy” against pertussis.

The main side effect reported by the women for all three vaccines was a local reaction (pain, swelling, or redness at the injection site) (Table 3). No severe adverse reactions were reported.

3.3. Factors associated with vaccination coverage rate

Vaccination coverage for Tdap and COVID-19 was significantly

higher among Italian than foreign women ($p < 0.001$ and $p = 0.002$, respectively) (Table 4). There was a trend toward a higher coverage rate for influenza vaccine among Italians than among foreign women, although it was not statistically significant, and the rate of vaccination coverage remained low in both groups (35 % and 23 % for Italian and foreign mothers, respectively).

Overall, 89 % of mothers said that they received recommendations for vaccines from the prenatal care provider, more frequently among Italians than foreigners (91 % and 80 %, respectively, $p = 0.01$, data not showed). Women who declined one or more of the recommended vaccines were asked if it would have been useful to talk with their prenatal care provider about their doubts and concerns regarding vaccinations during pregnancy. Fifty percent of them answered that they would have accepted the vaccination if better informed about the safety and efficacy of the vaccines, while 43 % said that it would not have changed their attitude regarding the vaccine. The remaining 7 % was uncertain (data not showed).

When interviewed about the prenatal care services received, 57 % of mothers reported that they received antenatal care exclusively in a public care facility (either inside or outside the hospital), while 43 % of the women chose to be assisted by a private gynecologist. As shown in Table 4, the adherence to the Tdap vaccine was significantly higher among women who received private care compared to public care ($p = 0.03$), while no differences were observed for the other two vaccines.

3.4. SARS-CoV-2 infection rate in the study population

Overall, 108/307 women (35.2 %) were infected by SARS-CoV-2 during pregnancy. The incidence of infection was significantly higher among unvaccinated (29/55, 52.7 %) than among vaccinated women (79/252, 31.3 %, $p = 0.003$). Of the 29 unvaccinated women who were infected with SARS-CoV-2, one (3.4 %), a 29-year-old woman, was hospitalized in the intensive care unit because of severe respiratory complications.

4. Discussion

The present study provides insight into vaccination coverage of the recommended vaccines in pregnancy, as well as into the factors influencing vaccine uptake. Adherence to recommended vaccinations among the women interviewed was different for each type of vaccine. It was relatively high for COVID-19 (82 %) and Tdap (74 %) vaccines, but low for the influenza vaccine (33 %). Differences in vaccine coverage between Italian and foreign mothers, and between women followed in private and public antenatal care services, were detected.

4.1. Tdap vaccine

The maternal Tdap vaccine coverage identified in this study was higher than previously reported in the same region (Tuscany) for the years 2019 and 2020 (43 % and 47 %, respectively) [15] and in another multicenter survey study conducted in four Italian hospitals in 2019 (61 %) [14]. It is also higher than the 44 % coverage rate estimated in the USA in 2022 [12], but very similar to that reported in the UK in 2020 (72.2 %) [13].

There are also studies conducted in other regions of Italy that reported a much lower coverage rate for Tdap [33,34]. The observed variability in immunization rates at the national level and over time may be partially due to the differences in the study design, the study period, the methodologies of data collection, the number of cases, and the different characteristics of the populations sampled, making it difficult to compare studies [35]. The increase in pertussis vaccination coverage rate in pregnancy that we observed compared to the data reported by Bonito et al. [15] for the year 2019 and 2020 in the same region likely reflects increased providers’ and pregnant women’s awareness of the government recommendations for the pertussis vaccine in pregnancy,

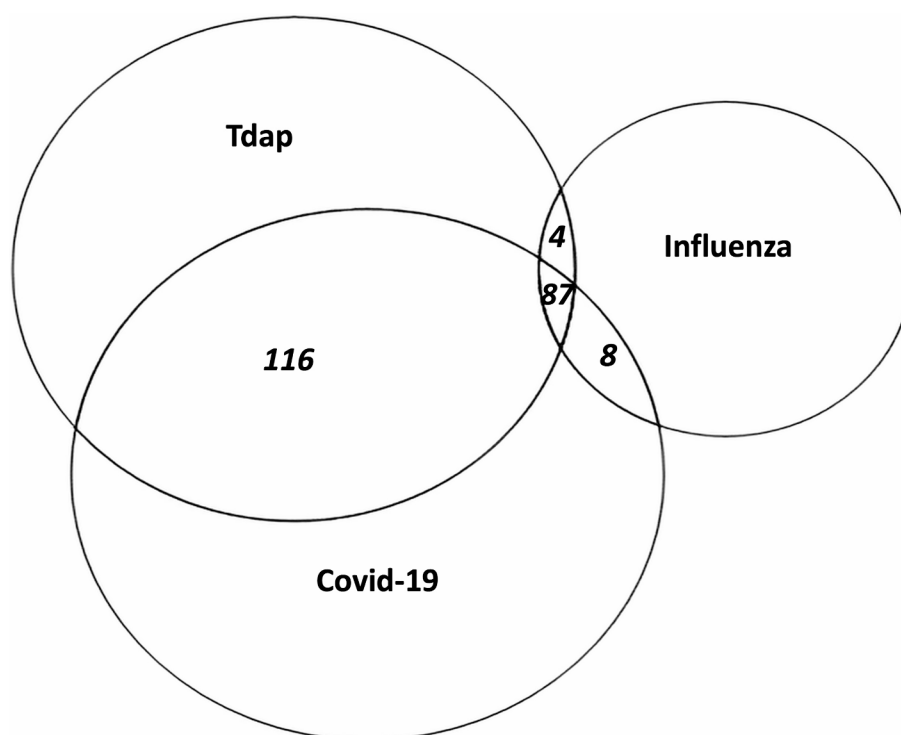


Fig. 2. Venn diagram giving a schematic representation of the proportion of pregnant women who received 2 or 3 vaccines.

Table 2

Reasons given by the unvaccinated women for not getting vaccinated against pertussis, influenza, and COVID-19.

| | Tdap (n = 80) | Influenza (n = 207) | Covid-19 (n = 55) |
|---|------------------|------------------------|----------------------|
| Concerns about side effects, n (%) | 15 (18.8) | 19 (9.2) | 35 (63.6) |
| Lack of confidence in vaccine efficacy, n (%) | 3 (3.8) | 3 (1.5) | 8 (14.5) |
| Concerns about effects on the fetus, n (%) | 18 (22.5) | 22 (10.7) | 38 (69.1) |
| Lack of recommendation or information received by the prenatal care provider, n (%) | 28 (35) | 56 (27.2) | 1 (1.8) |
| General lack of confidence in vaccines, n (%) | 18 (22.5) | 20 (9.7) | 13 (23.6) |
| Forgetfulness, n (%) | 13 (16.3) | 25 (12.1) | 0 |
| Vaccination received before pregnancy, n (%) | 10 (12.5) | 1 (0.5) | 0 |
| Lack of available appointments at the vaccination centers, n (%) | 4 (5) | 1 (0.5) | 0 |
| Not worried about the risks of the disease, n (%) | 3 (3.8) | 85 (41.3) | 0 |
| Prior Covid-19 infection, n (%) | 1 (1.3) | | 12 (21.8) |
| Allergies, n (%) | 1 (1.3) | 1 (0.5) | 1 (1.8) |

and of the need to repeat the administration at each pregnancy, regardless of previous Tdap doses received. Indeed, although the Advisory Committee on Immunization Practices (ACIP) in the United States has recommended pertussis immunization for pregnant women since 2012 [36], in Italy the recommendation was introduced with the 2017–2019 National Plan for Vaccine Prevention [7], and with two Circulars of the Ministry of Health about vaccination in childbearing age and in pregnancy or post-partum in 2018 and 2019 [37,38].

In our study, about one-third of the women who did not receive the

Table 3

Side effects following Tdap, influenza and Covid-19 vaccine reported by the women who received vaccination in pregnancy.

| Side effect | Tdap (227) | Influenza (100) | Covid-19 (252) |
|--|---------------|--------------------|-------------------|
| Fever, n (%) | 0 | 2 (2) | 40 (15.9) |
| Local reactions (pain, swelling, redness at the injection site), n (%) | 53 (23.3) | 28 (28) | 165 (65.5) |
| Headache, n (%) | 3 (1.3) | 2 (2) | 8 (3.2) |
| Asthenia, n (%) | 6 (2.6) | 1 (1) | 24 (9.5) |
| Articular pain, n (%) | 0 | 0 | 17 (6.7) |
| Gastrointestinal effects, n (%) | 1 (0.4) | 1 (1) | 7 (2.8) |
| Muscle pain, n (%) | 1 (0.4) | 1 (1) | 21 (8.3) |
| Lymph node swelling, n (%) | 0 | 0 | 2 (0.8) |
| Dizziness, n (%) | 0 | 0 | 1 (0.4) |

Tdap vaccine said that the reason was the lack of recommendations or information received by the prenatal care provider about the need to receive immunization against pertussis during pregnancy. Although this percentage is substantially reduced compared to the data reported in the multi-center survey conducted by Vilca et al. in Italy in 2019 [31], where the lack of recommendation was the reason given by 60 % of the unvaccinated women, it suggests that still prenatal care providers awareness of their crucial role in recommending the vaccine to pregnant women needs to be increased.

Concerns regarding the potential adverse effects of the vaccine, and fear of side effects on the fetus were also common reasons for vaccine refusal in our study population, reported by one in five women who did not get Tdap vaccine. Our findings confirm that safety concerns regarding pertussis vaccination still exist among pregnant women worldwide [14,39–42]. Indeed, pregnant women appear to have higher hesitancy towards pertussis vaccination than non-pregnant women [43]. Previous studies on the reasons for vaccination refusal have also highlighted the lack of pregnant women’s knowledge about the recommendation to repeat the Tdap vaccine during every pregnancy, and about the

Table 4

Comparison of vaccination coverage rates between Italian and foreigner women, and between different types of antenatal care.

| | Italian (n = 242) | Foreigner (n = 65) | p-value | Public service (176) | Private practice (131) | p-value |
|--------------------------|-------------------|--------------------|---------|----------------------|------------------------|---------|
| Tdap vaccine, n (%) | 194 (80.2) | 33 (50.8) | <0.001 | 122 (69.3) | 105 (80.2) | 0.03 |
| Influenza vaccine, n (%) | 85 (35.1) | 15 (23.1) | 0.06 | 62 (35.2) | 38 (29) | 0.25 |
| COVID-19 vaccine, n (%) | 207 (85.5) | 45 (69.2) | 0.002 | 139 (79) | 113 (86) | 0.10 |

decrease in vaccine effectiveness over time [12,44]. In our study only 12.5 % of unvaccinated pregnant women said that they did not repeat the vaccine because they believed to be protected against pertussis by a previous dose of Tdap received before pregnancy, a percentage that is less than the 35–53 % reported in studies conducted in the USA [12,44]. It is well documented the persistence of antibodies titers one year after vaccination. As a matter of fact, Tdap is immunogenic when given to pregnant women, but antibodies against the different pertussis antigens steadily decline by twelve months post-partum [45]. In particular, Halperin et al. [45] observed that in women immunized during pregnancy antibody levels against all pertussis antigens reached a peak by delivery, or by two months postpartum and even if these levels remained significantly higher than preimmunization ones, they decreased by just over 50 % after one year.

In order to provide the best protection to newborns, the CDC also recommends the Tdap vaccine for the child's close contacts such as father, siblings, and grandparents, a strategy that is also known as "cocooning" [5]. In our study, it is concerning that only one-third of the women reported that their partner received the Tdap vaccination during the woman's pregnancy.

Another worrisome finding of our survey was that 5 % of the unvaccinated women claimed that they failed to get the Tdap vaccine because of the lack of available appointments at the local vaccination centers. This can represent a challenge in promoting vaccination for pregnant women. However, in Tuscany vaccines can be administered at local vaccination centers, at the primary care physician, or at the hospitals that have activated this service. So rather than an access issue, such a response is likely the result of a lack of information of pregnant women about locations where they can be vaccinated.

4.2. Influenza vaccine

Only one-third of women in our study received the influenza vaccine during pregnancy. Since we enrolled women who gave birth in the months of March and April, they all were pregnant during the winter season and therefore they should have received the influenza vaccine. Although the vaccination coverage in our study was considerably higher compared to the 2–15 % coverage rate reported in other studies conducted in different regions of Italy [14,35,46], it is worryingly low compared to data from other countries. Indeed, the influenza vaccine coverage rate was about 50 % in studies conducted in Switzerland [47], Spain [48] and USA [12]. Notably, the main reason for failure to get vaccinated against influenza was the lack of concern about the risks of the disease, although the lack of recommendation or information received by the prenatal care provider had a relevant role, too. Our findings are in accordance with prior studies that showed how the insufficient information received about influenza vaccination, together with maternal perceptions that influenza vaccine was unnecessary, were the most frequently cited causes of vaccine rejection [35,48–50]. Furthermore, women may perceive influenza as a disease affecting only the mother, whereas they consider pertussis relatively riskier as a threat to the infant [51], and that may explain the higher acceptance of the Tdap vaccine compared to the influenza vaccine in pregnancy.

Another factor that may explain the low influenza vaccination coverage in our study is that the survey was carried out during the COVID-19 pandemic, when both pregnant women and healthcare providers were likely more worried by the risks of pregnancy complications due to that emerging respiratory viral disease than by the effects of

influenza. It is possible that prenatal care providers have prioritized the vaccination for COVID-19, underestimating the importance of informing pregnant women about the seasonal flu vaccine. Accordingly, our data showed that the coverage rate of the COVID-19 vaccine was much higher than the rate for the influenza vaccine.

4.3. COVID-19 vaccine

In our survey, womens' fear of COVID-19 as well as an effective communication by the healthcare providers and by the mass media about the severity of the disease in pregnancy and about the efficacy of the vaccine may explain the optimal vaccination coverage rate among our cohort (82 %). While a similar coverage rate for the COVID-19 vaccine has been observed in a study in Japan [52], lower rates have been reported in survey studies conducted in the United States [12], Canada [53], and New Zealand [54], where the coverage rate was 61 %, 48 %, and 44 %, respectively.

Despite the high number of cases and deaths due to the pandemic spread of COVID-19 and the extensive research demonstrating vaccine safety [27,29], in our study 14 % of the women interviewed had hesitancy and unwillingness to accept this vaccination. The main reasons provided by the unvaccinated women were concern about the side effects (64 %) and potential adverse effects on the fetus (69 %). These results are in accordance with the findings of previous similar survey studies examining the reasons for COVID-19 vaccine refusal [32,55].

Fear of potential side effects of COVID-19 vaccine on the fetus seems to be twice more frequent among women trusting mass media, internet sites, and social networks for their information about the vaccination [32], highlighting how the spread of misinformation through the internet and social media had a negative impact on people's attitudes toward this vaccine. This underlines the crucial role of healthcare professionals in providing information and consistent recommendations to pregnant women about the safety and effectiveness of vaccines in pregnancy [27].

Notably, the rate of intensive care unit admission (3.4 %) among the unvaccinated women who had SARS-CoV-2 infection in our cohort was higher than that reported in the general population of women of the same age in the same period, which was 0.008 %, based on national surveillance data published by the Italian National Institute of Health [56], and confirms the vulnerability of the pregnant population to such disease.

4.4. Influence of woman's nationality and place of prenatal care on vaccine uptake

In agreement with our results, differences in vaccination coverage have been observed according to the woman's geographical origin in several studies [15,30,57,58]. In our survey, Tdap and COVID-19 vaccination coverage was significantly higher among Italians compared to foreign pregnant women. The influenza vaccine coverage rate was also higher among Italian women than among foreigners, although the difference was not statistically significant. These results can only partly be explained by the lower percentage of women receiving the recommendation for the vaccines in the group of foreigners than in the group of Italian mothers. In general, foreign women may have more difficulty integrating into society and less access to healthcare facilities. Moreover, it is possible that Italian women are more aware of the national recommendations regarding maternal

immunization, and of the locations where they can receive the vaccine, than women of a different nationality or ethnicity. Our data outline the issue of health inequality, which includes some socio-economic and cultural situations including the condition of immigration. Accordingly, healthcare services should favor equitable access to immunization, by facilitating access for ethnic-minority women, who are more likely to face barriers to vaccination. The adoption of a public health approach to guarantee equity and fights inequalities is also endorsed by the 2017–2019 Italian National Immunization Plan [7].

In our study, the vaccination coverage rate for pertussis also differed by place of antenatal care, being higher among women who were followed at private practices compared to public care. A similar finding was observed in an Irish study on influenza vaccine uptake in pregnancy [59]. The main difference between the two settings in our country is that prenatal private care is usually provided by a gynecologist, while in the public setting, if the pregnancy is considered low-risk, the pregnant woman can be followed by the midwife. It is unclear if such result is related to the lower vaccine uptake that we observed among foreign women, who are also a group that is more likely to be followed in the public than in the private setting, or if it reflects a higher awareness of the recommendations about Tdap in pregnancy or more effective communication skills among prenatal care providers in the private than in the public setting.

4.5. Strategies to increase vaccination uptake by pregnant women

Based on the main reasons for the rejection of each of the recommended vaccines in our survey, we suggest the following specific strategies to increase vaccination acceptance by pregnant women in our setting:

- to increase the uptake of the pertussis vaccine: better information provided by healthcare professionals about the benefits of Tdap to protect the future child, and about the need to repeat it at every pregnancy, irrespective of the previous immunization status;
- to increase the uptake of the influenza vaccine: informing women on the higher risk of morbidity and mortality associated with seasonal influenza for both the mother and the infant compared to the general population;
- for the COVID-19 vaccine: providing reassurance about the safety of the vaccine for the mother and the fetus.

Other strategies to improve vaccine uptake by the pregnant population include: increasing accessibility to vaccines by improving booking systems and opening vaccination centers within hospitals or in close contiguity with the centers where antenatal care is provided, so that the vaccine can be offered at the same time of a prenatal visit; informing pregnant women on vaccine centers' location and on the possibility to receive the vaccination from their family physician; planning the recommended vaccines at the time of the first antenatal visit, as is done for the routine obstetric ultrasounds; distributing informative leaflets on immunization in pregnancy, which should also be available in different languages to overcome language barriers, and involving national scientific societies in the diffusion of information through mass media and social media.

The offer and administration of vaccinations in the prenatal setting could lead to increased vaccination uptake and adherence among pregnant women [31]. The latest available data in USA showed that in the season 2020–2021 the most reported place of Tdap vaccination among women with a live newborn was an obstetrician/gynecologist's or midwife's clinics (67.4 %) followed by hospital (11.0 %), and family or other physician's office (8.7 %) [12].

In addition to women's education on the benefits of maternal immunization, it is important to train prenatal care providers to effectively communicate the importance of vaccination and to spend the appropriate time during antenatal visits not only recommending the vaccines

but also discussing their efficacy and safety for both the mother and the baby. Indeed, our survey showed that half of the women who refused to get a vaccine said that they would have accepted the vaccination if better informed about their safety and efficacy. Notably, the recommendation from a healthcare provider to receive a vaccine during pregnancy remains the key determinant of vaccine uptake [12,46]. Finally, previous studies reported that willingness to get vaccinated during pregnancy increases not only following the recommendation by physicians, but also participating in educational interventions and campaigns to promote maternal immunization [60,61].

In recent years in Italy, and in Tuscany too, some toolkits have been developed and made freely available on the Internet and through the social media (Facebook), with the aim to promote vaccinations and to increase awareness among health providers and all citizens on which vaccinations are recommended for specific risk groups, such as pregnant women (VaccinarsinToscana.org; Vaccinarsi.org; <https://www.trovaimiovaccino.it>) [62,63]. Indeed, the majority of VaccinarsinToscana.org website visitors and Facebook account followers are young females, probably accessing the platforms to search information on vaccinations for themselves and for their children [64].

There are some limitations to the results of the present survey. First, data were obtained only from one hospital in Florence. Therefore, while they likely reflect the vaccination uptake in our region, they may not accurately represent the national coverage rate, which probably varies across the country, because factors such as urban population density, the presence of immigrant population, and differences in the access to healthcare facilities may influence how mothers make vaccination decisions. Secondly, the data were obtained from interviews, and the answers were not verified through the woman's vaccination records, therefore recall bias may have occurred, especially about the adverse event following immunization. Thirdly, the questionnaire was not validated prior to use. Finally, mothers' responses about the reasons for refusal or about the recommendations received can be biased due to forgetfulness or affected by feelings at the time of the interview. Despite these limitations, a key strength of this study is that it is based on in person-interview, which is superior to self-administered questionnaires [65]: the presence of a physician interviewing the woman may increase her understanding of the questions, helping the respondent to answer correctly. Another strength of the present study is the high response rate, as only three eligible women refused to participate in the survey. Thus, we avoided the non-response bias that could lead to an overestimation of vaccine uptake.

5. Conclusion

The present survey revealed that while the coverage rate for Tdap and COVID-19 vaccines in pregnancy is satisfactory, maternal vaccination for influenza remains suboptimal. More efforts should be done to increase the rate of influenza immunization with strategies directed to better educate both pregnant women and healthcare professionals. It is clear that vaccine hesitancy in pregnancy has multiple causes, and women's concerns about vaccines should be addressed during vaccine counseling. Continuous health education on the benefits and the safety of vaccines is highly recommended to increase the level of knowledge and vaccine uptake among pregnant women, with a particular emphasis on women from ethnic minorities.

Ethics approval and consent to participate

This study was approved by the local ethics committee (ref. number 21389_oss, date of approval January 18, 2022) and written informed consent was obtained from all subjects.

Consent for publication

Not applicable.

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CRedit authorship contribution statement

Viola Seravalli: Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Writing – original draft, Writing – review & editing. **Irene Romualdi:** Data curation, Formal analysis, Investigation, Writing – original draft. **Oumaima Ammar:** Formal analysis, Writing – original draft. **Chiara De Blasi:** Data curation, Writing – review & editing. **Sara Boccalini:** Methodology, Validation, Visualization, Writing – review & editing. **Angela Bechini:** Conceptualization, Methodology, Supervision, Writing – review & editing. **Mariarosaria Di Tommaso:** Conceptualization, Methodology, Supervision, Writing – review & editing.

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

The data that support the findings of this 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.jvaxc.2024.100483>.

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