Received: 16 July 2022 | Revised: 3 April 2023 | Accepted: 5 April 2023

DOI: 10.1002/ijgo.14797

CLINICAL ARTICLE

Obstetrics

Pregnancy vaccination predictive factors and uptake profiles among Italian women: A cross-sectional survey study on a large population

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Funding information
Regione Toscana (Tuscany Region); Sant'Anna School

Abstract

Objectives: To assess influenza and Tdap (tetanus, diphtheria, pertussis) vaccine coverage during pregnancy, explore key socioeconomic and maternity pathway-related predictors of vaccination, and detect specific patterns of vaccination uptake.

Methods: The authors cross-sectionally analyzed self-reported data obtained from the systematic survey on the maternity pathways of Tuscany. They selected all pregnant women that completed from March 2019 to June 2022 the third-trimester questionnaire ($n = 25\,160$), which included two dichotomous items on influenza and Tdap vaccination, as well as socioeconomic and pathway-related questions. Multilevel logistic models were performed to assess vaccination predictors and cluster analysis to identify vaccination patterns.

Results: Vaccination coverage was higher for pertussis (56.5%) than for influenza (18.9%). The main predictors of vaccination were high socioeconomic status, attending private gynecologists, and receiving vaccine information. Three clusters were identified: cluster 1 included women receiving both Tdap and influenza vaccines; cluster 2 included women receiving no vaccinations; and cluster 3 included women receiving only the pertussis vaccine. Although women from cluster 3 were of middle to low education status, vaccine information was the main adherence determinant also in this group.

Conclusions: Health workers and policymakers should focus on groups of pregnant women less prone to vaccination to promote vaccination information and encourage wider uptake and coverage.

KEYWORDS
influenza, Italy, patient-reported data, pertussis, pregnancy, vaccine/vaccination

1 | INTRODUCTION

Immunization during pregnancy has been shown to be an important tool for providing protection for both mother and fetus against certain pathogens.[1] The Italian National Vaccine Prevention Plan 2017–2019 recommended that pregnant women receive the combined Tdap (tetanus, diphtheria, pertussis) vaccine ideally between the 27th and 36th gestational weeks and be vaccinated against influenza before or during the flu season.

Indeed, while pertussis infection may be mild or asymptomatic in adults and older children, it can cause severe morbidity and mortality in infants too young to be vaccinated. Maternal immunization from pertussis allows the transfer of maternal antibodies to the fetus, thus ensuring protection of the infant in the first few months of life.[2] On the other hand, influenza in pregnancy can cause serious complications for both mother and infant, such as cardiopulmonary hospitalizations and an increased risk of stillbirth, neonatal death, preterm delivery, and congenital heart disease.[3]

Despite the availability of free vaccines in Italy for pregnant women and numerous studies proving their safety and efficacy,[4,5] Italy has very low pregnancy vaccination rates mainly against influenza but also against pertussis, as previously demonstrated.[6,7] One of the main causes is a general unawareness about maternal immunization and its benefits for pregnant women, along with poor information, lack of recommendations by health professionals, or other factors related to the maternity pathway in general.[8] In addition, vaccine adherence often depends on the socioeconomic background of pregnant women.[9]

A multicenter study from Italy[10] showed that vaccine coverage rates in the 2018 to 2019 season for pertussis and influenza were 61% and 15%, respectively. Particularly, influenza vaccine coverage was still far behind coverage rates in neighboring countries and the average European rates (25%).

Several studies exploring socioeconomic and pathway determinants of vaccine adherence through surveys have been published,[11–13] also in the Italian context.[14] However, these studies have used medium-sized populations and only limited numbers of socioeconomic and pathway-related variables. In contrast, this study used a very large study population and a wide number of covariates, obtaining data from the systematic and longitudinal survey on the maternity pathways of Tuscany, Italy.[15–17] We aimed to: (1) compute the influenza and Tdap vaccine uptake rate, (2) explore key socioeconomic and pathway-related predictors of influenza and Tdap vaccine uptake, and (3) identify subgroups of respondents with specific patterns of vaccination coverage.

2 | METHODS

This is a cross-sectional survey study exploring patient-reported vaccine coverage during pregnancy and the barriers and facilitators to access to vaccination. As an observational study, it follows the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology)/RECORD (Reporting of Studies Conducted Using Observational Routinely Collected Data) guidelines. The study setting was the Italian Region of Tuscany, responsible for the health care services delivered to 3.7 million inhabitants. Tuscany is divided into three Local Health Authorities and 26 health districts and receives approximately 6% of the national health care fund (7 billion euros in 2019).

We used the same data source that we used in a previous paper.[16] This source was the systematic survey on the maternity pathways of Tuscany, launched by Sant'Anna School of Advanced Studies and Tuscany Region Health Authority and embedded into the app *hAPPyMamma* (which includes the digital Pregnancy Booklet in Tuscany).[15] The eligible population for the survey consisted of the general population of pregnant women receiving the Pregnancy Booklet in Tuscany. The booklet collects the list and due dates for all pregnancy examinations that are provided free of charge by the Regional Health Service of Tuscany. Pregnant women are invited to participate and, if they accept, are recruited via online invitation. Questionnaires are administered at eight different timepoints from the beginning of pregnancy up to 1 year post partum. As previously explained,[16] informed consent and ethics approval were not necessary for using such data for research purposes.

This study comprised all women who completed the third-trimester questionnaire (T3g) from March 2019 to June 2022 ($n = 25\,160$). For comparison, approximately 70 000 women gave birth in Tuscany from January 2019 to December 2022. The T3g questionnaire included dichotomous questions about vaccination during pregnancy, specifically on the influenza and pertussis vaccines, which in Italy are licensed only in combination with tetanus and diphtheria as the Tdap vaccine. It also included several questions about the maternity care pathway utilization and the vaccine information each woman received during pregnancy. Conversely, sociodemographic and childbirth data were obtained from the T0g (beginning of pregnancy) and T0p (hospitalization for childbirth) questionnaires, respectively, by merging the data sets through anonymized encrypted identifiers.

2.1 | First aim

We used the dichotomous variables for Tdap and influenza vaccination to compute vaccine uptake rates as reported by respondents. For this aim, we used a two-step approach as a robustness check. Particularly, we obtained the general population of pregnant women during the 2-year period 2020 to 2021 from the Birth Assistance Certificate ($n = 43\,264$), an administrative database including all women giving birth each year in Tuscany. Then, we selected from the entire survey population ($n = 25\,160$) the subgroup of women who were beyond 40 weeks of gestation in 2020 to 2021 ($n = 18\,363$). We stratified both the general population of pregnant women and the study subgroup by age (three-level variable), nationality (two-level variable), and education (three-level variable), resulting in 18

TABLE 1 Sociodemographic features of our respondents.

Full study population ($n = 25\,160$)	Percentage (n)
Age	
16–29 years	20.03 (5040)
30–39 years	69.38 (17453)
≥40 years	10.59 (2663)
Missing	4
Nationality	
Italian	92.03 (23154)
Non-Italian	7.97 (2006)
Education level	
Middle school or less	9.79 (2463)
High school	39.80 (10014)
University	50.41 (12683)
Parity	
Primigravidae	61.00 (15348)
Multiparous	39.00 (9812)
Weight class	
Normal	69.45 (17473)
Underweight	6.97 (1754)
Overweight	16.46 (4142)
Obesity	7.12 (1791)
Twin pregnancy	
No	98.46 (24771)
Yes	1.54 (387)
Missing	2
High-risk pregnancy	
No	80.97 (20371)
Yes	19.03 (4787)
Missing	2
Smoking during pregnancy	
No	93.82 (23603)
Yes	6.18 (1554)
Missing	3
Folate intake during pregnancy	
Yes	95.33 (23984)
No	4.24 (1066)
Never heard	0.44 (110)
Income level	
High	70.53 (17743)
Medium	25.19 (6338)
Low	4.28 (1076)
Missing	3
Job	
Employed	83.59 (21032)
Unemployed	5.95 (1496)
Student	1.67 (421)
Housewife	8.79 (2211)
Planned pregnancy	
Yes	56.02 (14094)
Not excluded	33.66 (8470)
No	10.32 (2596)

strata. We then calculated the number of women per stratum for each health district, both among the general population and in the study subgroup. After dividing the two values to obtain the "weight" variable, we computed vaccination uptake rates weighted on the general population.

2.2 | Second aim

We used the dichotomous variables for vaccination uptake as outcomes. We ran multivariate multilevel logistic regression models (*melogit* command in Stata Software [StataCorp LLC, College Station, TX, USA]) to explore which women's characteristics and maternity pathway attributes were associated with higher odds of having pertussis and influenza vaccination. The variable "health district of residence" was used as the top-level grouping variable. The covariates were classified as follows: (1) respondents' sociodemographic features; (2) maternity care pathway variables; and (3) vaccine information during pregnancy. Also, for this objective, we adopted a two-step approach, running the same models described above, with the same approach, but weighted on the general population of pregnant women.

2.3 | Third aim

Cluster analysis[18] was performed in SAS software (SAS Institute, Cary, NC, USA) to identify subgroups of patients with distinct self-reported vaccination coverage patterns. The variables used to detect clusters were the dichotomous variables for pertussis and influenza vaccines. After running cluster analysis, we transformed the cluster variables into dichotomous variables, one for each cluster. Then, we used multilevel logistic regressions to investigate which characteristics were significantly associated with each cluster profile, using the dichotomous "cluster" variables as outcomes. The models were built as already described for the second aim.

3 | RESULTS

Our study population consisted of 25 160 respondents. Their sociodemographic features are shown in Table 1. Most women were aged between 30 and 39 years (69.4%), highly educated (50.4%), and Italian (92.0%). Compared with the general population (Table S2), our

TABLE 2 Multilevel models for pertussis vaccine uptake.

	Full population		Weighted subgroup	
Pertussis vaccine uptake	**OR**	**SE**	**OR**	**SE**
Sociodemographic				
Age 30–39 vs. <30 years	**1.33*****	0.10	**1.36*****	0.13
Age > 39 vs. <30 years	1.00	0.11	1.01	0.16
Non-Italian vs. Italian	**0.65****	0.09	**0.68***	0.11
Medium vs. high education	0.93	0.06	0.99	0.07
Low vs. high education	0.91	0.12	**0.75***	0.08
Multiparous vs. primigravida	**0.60*****	0.04	**0.61*****	0.06
Underweight vs. normal weight	0.85	0.09	0.93	0.10
Overweight vs. normal weight	1.01	0.08	1.01	0.09
Obese vs. normal weight	1.13	0.14	1.20	0.18
Twin vs. single pregnancy	0.98	0.27	0.85	0.23
High-risk vs. low-risk pregnancy	1.12	0.09	1.22	0.17
Smoking during pregnancy vs. not	**0.78***	0.10	0.75	0.16
Folate not taken vs. taken	0.84	0.13	0.80	0.18
Never heard of folate vs. taken	0.71	0.37	1.01	0.56
Medium vs. good income level	**0.87***	0.06	**0.78***	0.08
Poor vs. good income level	0.77	0.13	0.65	0.19
Unemployed vs. employed	0.87	0.11	0.99	0.16
Student vs. employed	**0.62***	0.14	**0.38****	0.14
Housewife vs. employed	0.95	0.14	0.94	0.21
Pregnancy not excluded vs. planned	**0.82*****	0.05	**0.85****	0.06
Pregnancy not planned vs. planned	**0.64*****	0.07	**0.64*****	0.09
Maternity pathway attributes				
Discomfort during pregnancy vs. not	1.00	0.06	1.08	0.11
Medium vs. not difficult access to services	1.14	0.10	0.90	0.08
Difficult vs. not difficult access to services	0.90	0.13	0.69	0.13
Some delays in examinations vs. not	1.07	0.07	1.08	0.08
Frequent delays in examinations vs. not	1.16	0.23	1.09	0.25
Medium involvement in choices vs. low	1.05	0.08	0.99	0.10
High involvement in choices vs. low	1.01	0.08	0.96	0.10
Hospital visits vs. counseling centers	1.05	0.10	1.01	0.13
Private visits vs. counseling centers	**1.22***	0.11	1.20	0.16
Gynecologist vs. midwife	**1.52*****	0.16	**1.61****	0.28
Gynecologist and midwife vs. midwife	1.21	0.13	1.21	0.20
Another specialist vs. midwife	1.38	0.89	1.04	0.64
Sessions of BAC	1.00	0.00	1.00	0.00
Examination booking explained vs. made by health workers	**0.80***	0.08	**0.76***	0.09
Examination booking never heard vs. made by workers	1.37	0.41	1.70	0.61
Two to 5 vs. >5 close people during pregnancy	0.98	0.08	1.05	0.10
One vs. >5 close people during pregnancy	0.85	0.09	0.88	0.09
Zero vs. >5 close people during pregnancy	0.94	0.23	0.85	0.24
Enough vaccine information during BAC vs. a lot	1.10	0.08	1.13	0.11
Poor vaccine information during BAC vs. a lot	1.11	0.09	1.16	0.12

TABLE 2 (Continued)

Pertussis vaccine uptake	Full population OR	SE	Weighted subgroup OR	SE
Vaccine information				
Vaccine info from counseling centers vs. not	**3.12*****	0.21	**3.20*****	0.29
Vaccine info from the GP vs. not	**2.45*****	0.20	**2.83*****	0.34
Vaccine info from other physicians vs. not	**3.44*****	0.28	**3.83*****	0.44
Vaccine info from the Pregnancy Booklet vs. not	**2.03*****	0.22	**1.91****	0.36
Vaccine info from *hAPPyMamma* vs. not	1.35	0.26	1.48	0.30
Constant	**0.55****	0.11	**0.47****	0.13
Health district variance	0.50	0.15	0.59	0.13

Note: Bold values indicate significance.

Abbreviations: BAC, birth-accompanying course; GP, general practitioner; OR, odds ratio; SE, standard error.

*$P<0.05$; **$P<0.01$; ***$P<0.001$.

study population included higher proportions of women with such characteristics. Moreover, 61.0% of participants were primiparous, while 98.5% of women had only one child. A total of 69.5% of women were of normal weight. Women who reported planning pregnancy were 56.0%, and 19.0% of the population had a high-risk pregnancy. During pregnancy, most women did not smoke (93.8%) and took folic acid (95.3%). Finally, 83.6% of women were employed, with 70.5% of the study cohort reporting a good income. See Table S1 for details on the maternity pathway-related variables.

3.1 | First aim

The vaccination uptake rate for pertussis was 56.5% ($n=14\,222$) and for influenza was 18.9% ($n=4751$). Only 15.6% ($n=3919$) of respondents received both the influenza and pertussis vaccines. Furthermore, the weighted vaccine coverage was 49.7% for pertussis and 16.6% for influenza.

3.2 | Second aim

As shown in Table 2, women who received the pertussis vaccine were most often aged 30 to 39 years, Italian, primigravidae, with good income status, and employed. They also reported that they did not smoke during pregnancy. They had planned pregnancy and visited gynecologists privately. Their examinations were booked directly by health workers. Moreover, they obtained more often vaccine information from counseling centers, the general practitioner (GP), other doctors, or the Pregnancy Booklet. Weighted models showed that the effect of smoking in pregnancy and visit setting lost significance, while educational level acquired significance, with high education as a predisposing factor.

As for the influenza vaccine (Table 3), women who reported receiving this vaccine were more often aged 30 to 39 years and highly educated. They reported a high-risk pregnancy, discomfort during pregnancy, and difficulty in accessing health services. They were followed privately by a gynecologist and significantly more often received vaccine information from all sources analyzed. Interestingly, in the weighted models, age, level of risk of pregnancy, discomfort during pregnancy, and difficulty in booking examinations lost statistical significance, while being employed became a significant predictor of vaccination.

3.3 | Third aim

We identified three clusters (Table S3). Cluster 1 included 18.9% of women from the study population, who all reported receiving the pertussis vaccination, and—mostly (82.5%)—also the influenza vaccine. Women from cluster 2 (40.2%) received no vaccinations. Finally, all women from cluster 3 (40.9%) received the pertussis vaccine but not the influenza vaccine.

As shown in Table 4, women from cluster 1 (*all vaccinated*) were significantly more often aged 30 to 39 years and with a high education level. They were more likely to report high-risk pregnancy and discomfort during pregnancy. They mainly attended gynecologists, regardless of the visit setting, and obtained a lot of information on vaccination during birth-accompanying courses (BACs). They received vaccination information significantly more often from counseling centers, the GP, other physicians, or the Pregnancy Booklet.

Women in cluster 2 (*nonvaccinated*) were more often younger than 30, non-Italian, and multiparous. They more frequently stated that they smoked during pregnancy. They had an average but not good income level. They were students more than employed women and they had less frequently planned pregnancy. They made their visits during pregnancy less often to private specialists than to free counseling centers and they referred more often only to a midwife. Women in this cluster reported receiving vaccine information from all sources analyzed significantly less than the other women.

Finally, women in cluster 3 (*Tdap-vaccinated*) had a low/middle education and were more often primigravidae. They had planned pregnancy and had more than five close people assisting them during pregnancy. Despite saying that they obtained enough but not

TABLE 3 Multilevel models for influenza vaccine uptake.

	Full population		Weighted subgroup	
Influenza vaccine uptake	**OR**	**SE**	**OR**	**SE**
Sociodemographic				
Age 30–39 vs. <30 years	**1.21***	0.10	1.26	0.20
Age > 39 vs. <30 years	1.04	0.13	1.08	0.19
Non-Italian vs. Italian	0.86	0.14	0.82	0.15
Medium vs. high education	**0.74*****	0.05	**0.72*****	0.06
Low vs. high education	**0.66****	0.10	0.81	0.12
Multiparous vs. primigravida	1.02	0.08	1.21	0.13
Underweight vs. normal weight	1.09	0.12	1.38	0.25
Overweight vs. normal weight	1.11	0.09	0.91	0.09
Obese vs. normal weight	0.91	0.12	1.10	0.21
Twin vs. single pregnancy	1.15	0.29	1.07	0.30
High-risk vs. low-risk pregnancy	**1.21***	0.09	1.13	0.12
Smoking during pregnancy vs. not	0.84	0.12	0.77	0.15
Folate not taken vs. taken	1.07	0.18	1.53	0.41
Never heard of folate vs. taken	1.24	0.74	1.20	0.82
Medium vs. good income level	0.96	0.07	1.06	0.12
Poor vs. good income level	0.83	0.17	0.76	0.17
Unemployed vs. employed	1.05	0.14	1.13	0.20
Student vs. employed	0.76	0.21	**0.38****	0.14
Housewife vs. employed	0.98	0.17	1.29	0.27
Pregnancy not excluded vs. planned	1.00	0.06	0.93	0.07
Pregnancy not planned vs. planned	0.79	0.10	0.93	0.17
Maternity pathway attributes				
Discomfort during pregnancy vs. not	**1.14***	0.07	0.99	0.09
Medium vs. not difficult access to services	0.92	0.08	0.88	0.10
Difficult vs. not difficult access to services	**0.70***	0.12	1.08	0.40
Some delays in examinations vs. not	0.92	0.06	0.85	0.08
Frequent delays in examinations vs. not	1.10	0.23	0.72	0.23
Medium involvement in choices vs. low	0.97	0.07	1.02	0.08
High involvement in choices vs. low	0.91	0.07	0.95	0.10
Hospital visits vs. counseling centers	1.08	0.11	1.13	0.15
Private visits vs. counseling centers	1.15	0.11	1.17	0.15
Gynecologist vs. midwife	**1.34****	0.16	**1.47****	0.21
Gynecologist and midwife vs. midwife	**1.32***	0.16	**1.32***	0.18
Another specialist vs. midwife	1.00	0.61	0.80	0.66
Sessions of BAC	1.00	0.00	1.00	0.00
Examination booking explained vs. made by health workers	0.94	0.11	1.08	0.17
Examination booking never heard vs. made by workers	1.01	0.32	1.10	0.32
Two to 5 vs. >5 close people during pregnancy	1.12	0.09	1.12	0.12
One vs. >5 close people during pregnancy	1.09	0.12	1.09	0.18
Zero vs. >5 close people during pregnancy	1.02	0.26	1.22	0.42
Enough vaccine information during BAC vs. a lot	**0.82****	0.06	0.86	0.09
Poor vaccine information during BAC vs. a lot	1.02	0.08	1.00	0.12

TABLE 3 (Continued)

Influenza vaccine uptake	Full population OR	Full population SE	Weighted subgroup OR	Weighted subgroup SE
Vaccine information				
Vaccine info from counseling centers vs. not	**1.22****	0.08	**1.54*****	0.12
Vaccine info from the GP vs. not	**1.76*****	0.12	**2.01*****	0.20
Vaccine info from other physicians vs. not	**1.49*****	0.10	**1.44*****	0.14
Vaccine info from the Pregnancy Booklet vs. not	**1.45*****	0.13	**1.42****	0.19
Vaccine info from *hAPPyMamma* vs. not	**1.51****	0.24	**1.47***	0.29
Constant	0.12	0.02	0.10	0.03
Health district variance	0.20	0.07	0.25	0.06

Note: Bold values indicate significance.

Abbreviations: BAC, birth-accompanying course; GP, general practitioner; OR, odds ratio; SE, standard error.

*$P<0.05$; **$P<0.01$; ***$P<0.001$.

a lot of vaccine information during BACs, they reported receiving vaccine information more frequently from family counseling centers, the GP, or other physicians.

4 | DISCUSSION

In this study, we used data reported by a large population of pregnant women to analyze predisposing factors to pregnancy vaccination and identify vaccination patterns. We found that the self-reported vaccination coverage for pertussis (56.5%, weighted 49.7%) was higher than for influenza (18.9%, weighted 16.6%), in line with the literature.[19] Indeed, the maternal influenza vaccine uptake rates have been reported to range between 6% and 15% in previous studies from Italy,[3,7,10,14] which are below the European average (25%) and similar to those found in Spain (7%–12%),[20] while data from France are more variable (1%–35%).[21,22] On the other hand, pertussis vaccine uptake has been reported to be 61% in Italy,[14] 50% to 79% in Spain,[20] 54% in the United States,[23] and 64% in the United Kingdom.[24]

The slightly higher influenza vaccine uptake observed in our study population may also depend on the higher proportion of Italian, highly educated, and 30- to 39-year-old women than in the general population of pregnant women (Table S2). Such characteristics are known to be predictors of vaccination uptake[25] and our findings supported this evidence. In any case, our study confirmed that influenza vaccination coverage during pregnancy remains too low in Italy, despite being recommended for more than a decade.

The low vaccination adherence found in our study population could also be due to the effect of the coronavirus disease 2019 (COVID-19) pandemic, which hit Italy right in the middle of the study period. Indeed, many studies have shown increased vaccination hesitancy during the pandemic,[26] especially among pregnant women who constitute a population particularly susceptible to potential adverse effects. This undesired influence seems more pronounced for the influenza than for the pertussis vaccine.[27] Moreover, such a trend has been detected for pertussis and influenza vaccines, but it has also been shown that pregnant women who have greater hesitation to influenza and pertussis vaccination also have a greater propensity to refuse anti–COVID-19 vaccination.[28] This evidence reinforces the need to promote vaccination by providing comprehensive information and recommendations to pregnant women.[29]

Our study also shows other predictive factors of vaccination in pregnancy. Multiparity was associated with lower odds of receiving the Tdap vaccine—in line with the literature[30]—but not the influenza vaccine. Pregnant women who smoked received the pertussis vaccine less often, probably due to less awareness of preventive behaviors to take during pregnancy. Similarly, the odds of receiving the Tdap vaccine were lower in women with a poor income level and who had not planned to become pregnant. All of these effects were not observed for the influenza vaccine, for which the only predisposing characteristic was high-risk pregnancy.

Visiting a gynecologist privately and having all examinations directly booked by health care workers increased Tdap vaccine uptake, while for influenza the effect of visit setting was absent. This may be related to the fact that gynecologists are the main source of information about pregnancy vaccination.[30] Not surprising, we found that receiving vaccine information from counseling centers, the GP, other physicians, or by reading the Pregnancy Booklet instructions increased the odds of taking the Tdap and influenza vaccines, with a specifically pronounced effect on pertussis, as shown by the higher odds ratio values.

Clusters 1 and 2 seem to support these results. Indeed, the characteristics of women from cluster 1 (*all vaccinated*) almost reflected the predisposing factors to vaccination described above. Indeed, most women from cluster 1 received both the influenza and pertussis vaccine, probably because they were more aware of preventive behaviors to adopt during pregnancy, participated more in the maternity pathway utilization, and had high-risk conditions.

In contrast, women from cluster 2 (*nonvaccinated*) possessed all factors associated with lower odds of being vaccinated, and thus had no vaccination at all. These women might have given less attention to prevention, probably because, being non-Italian, they understood less information on the importance of vaccination due to linguistic

TABLE 4 Multilevel models for cluster profiles.

	Cluster 1		Cluster 2		Cluster 3	
Clusters	OR	SE	OR	SE	OR	SE
Sociodemographic						
Age 30–39 vs. <30 years	**1.21***	0.10	**0.73*****	0.06	1.13	0.07
Age > 39 vs. <30 years	1.05	0.13	0.98	0.11	1.02	0.10
Non-Italian vs. Italian	0.87	0.14	**1.49****	0.21	0.80	0.11
Medium vs. high education	**0.74*****	0.05	1.10	0.07	**1.15****	0.06
Low vs. high education	**0.65****	0.10	1.09	0.14	**1.25***	0.15
Multiparous vs. primigravida	1.02	0.08	**1.60*****	0.12	**0.69*****	0.05
Underweight vs. normal weight	1.10	0.12	1.16	0.13	0.84	0.08
Overweight vs. normal weight	1.10	0.09	0.97	0.08	0.95	0.06
Obese vs. normal weight	0.90	0.12	0.97	0.12	1.10	0.11
Twin vs. single pregnancy	1.19	0.30	1.13	0.31	0.82	0.19
High-risk vs. low-risk pregnancy	**1.20***	0.09	0.92	0.07	0.93	0.06
Smoking during pregnancy vs. not	0.84	0.12	**1.35***	0.18	0.89	0.10
Folate not taken vs. taken	1.06	0.18	1.16	0.18	0.83	0.12
Never heard of folate vs. taken	1.24	0.73	1.19	0.63	0.70	0.34
Medium vs. good income level	0.96	0.07	**1.17***	0.08	0.91	0.06
Poor vs. good income level	0.88	0.17	1.25	0.22	0.93	0.15
Unemployed vs. employed	1.05	0.14	1.12	0.14	0.88	0.10
Student vs. employed	0.76	0.21	**1.62***	0.36	0.77	0.16
Housewife vs. employed	0.99	0.17	1.00	0.15	0.98	0.13
Pregnancy not excluded vs. planned	1.00	0.06	**1.19****	0.07	**0.89***	0.05
Pregnancy not planned vs. planned	0.79	0.10	**1.54*****	0.17	0.84	0.09
Maternity pathway attributes						
Discomfort during pregnancy vs. not	**1.14***	0.07	0.98	0.06	0.93	0.05
Medium vs. not difficult access to services	0.93	0.08	0.88	0.08	1.14	0.09
Difficult vs. not difficult access to services	**0.70***	0.12	1.12	0.17	1.14	0.15
Some delays in examinations vs. not	0.92	0.06	0.98	0.07	1.07	0.06
Frequent delays in examinations vs. not	1.10	0.22	0.87	0.18	1.00	0.18
Medium involvement in choices vs. low	0.97	0.07	0.96	0.07	1.06	0.07
High involvement in choices vs. low	0.90	0.07	1.06	0.09	1.02	0.07
Hospital visits vs. counseling centers	1.08	0.11	0.90	0.09	1.01	0.09
Private visits vs. counseling centers	1.15	0.11	**0.82***	0.07	1.04	0.08
Gynecologist vs. midwife	**1.34***	0.16	**0.63*****	0.07	1.18	0.12
Gynecologist and midwife vs. midwife	**1.33***	0.16	**0.78***	0.08	1.01	0.10
Another specialist vs. midwife	0.99	0.60	0.58	0.41	1.57	0.83
Sessions of BAC	1.00	0.00	1.00	0.00	1.00	0.00
Examination booking explained vs. made by health workers	0.93	0.11	1.17	0.12	0.92	0.08
Examination booking never heard vs. made by workers	1.00	0.31	0.89	0.26	1.09	0.28
Two to 5 vs. >5 close people during pregnancy	1.11	0.09	1.00	0.08	0.92	0.06
One vs. >5 close people during pregnancy	1.08	0.12	1.19	0.12	**0.83***	0.08
Zero vs. >5 close people during pregnancy	1.00	0.26	1.24	0.31	0.83	0.18
Enough vaccine information during BAC vs. a lot	**0.83***	0.06	0.96	0.07	**1.19****	0.08
Poor vaccine information during BAC vs. a lot	1.04	0.08	0.88	0.07	1.07	0.07

TABLE 4 (Continued)

Clusters	Cluster 1		Cluster 2		Cluster 3	
	OR	SE	OR	SE	OR	SE
Vaccine information						
Vaccine info from counseling centers vs. not	**1.23****	0.08	**0.32*****	0.02	**1.89*****	0.11
Vaccine info from the GP vs. not	**1.76*****	0.12	**0.34*****	0.03	**1.24****	0.08
Vaccine info from other physicians vs. not	**1.49*****	0.10	**0.29*****	0.02	**1.61*****	0.10
Vaccine info from the Pregnancy Booklet vs. not	**1.45*****	0.13	**0.44*****	0.05	1.17	0.10
Vaccine info from *hAPPyMamma* vs. not	**1.50***	0.24	0.69	0.14	0.79	0.12
Constant	**0.12*****	0.02	**1.66***	0.35	**0.53*****	0.09
Health district variance	0.19	0.07	0.52	0.16	0.19	0.07

Note: Bold values indicate significance.

Abbreviations: BAC, birth-accompanying course; GP, general practitioner; OR, odds ratio; SE, standard error.

*$P<0.05$; **$P<0.01$; ***$P<0.001$.

barriers. Also, women from cluster 2 visited more public counseling centers than private gynecologists during pregnancy. This evidence raises the need for wider and proactive vaccine information and recommendation from health providers working in the public sector.

Finally, women from cluster 3 (*Tdap-vaccinated*) were low/medium educated but primigravidae, and they had planned pregnancy and more than five close people helping them throughout. Although they had enough but not completely satisfying information during BACs, they more often received vaccination information from all sources analyzed. Presumably, these women were advised to specifically take the pertussis vaccine but avoid the influenza vaccine, and they trusted the advice.

It is known that pregnant women are more predisposed to pertussis than to influenza vaccination, since they more often believe that influenza vaccination is unnecessary, are less aware of the benefits to the newborn, and wrongly think that this vaccine may result in risks to the newborn.[14,19] However, it is also known that recommendation by health workers is the main determinant of vaccination uptake.[14] In this study, although we had no specific questions about vaccine recommendation, we demonstrated that women who were privately followed by gynecologists and had received vaccination information were more likely to be vaccinated. Even women with medium/low education level who had received vaccination information were specifically vaccinated against influenza and pertussis.

A limitation of this study is that our population was not fully representative of the general population of pregnant women due to selection bias. To mitigate this limitation, we weighted our models, confirming our results. Another limitation is that the data are self-reported and may contain unverifiable information. Also, we could not verify the actual vaccine coverage from administrative data since the databases recording vaccines are organized by drugs dispensed, not by individuals, and could not be cross-referenced with the birth database. In addition, we had no information on COVID-19 vaccination as we lacked specific questions. Finally, we did not consider seasonality, which may affect influenza vaccine uptake.

Nevertheless, the strength of this study is the simultaneous assessment of numerous factors potentially influencing vaccination uptake through a large study population obtained from a validated data source. This study can also provide guidance to health workers and policymakers to promote broader recommendation of vaccination in pregnancy especially in less predisposed subgroups and based on the different population's needs, provide more information about vaccination and the benefits for newborns, implement policies that stimulate vaccine uptake among the most fragile segments of the population, and generally increase pregnancy vaccine coverage.

In conclusion, we found that vaccination coverage in Tuscany against pertussis was higher than against influenza. Furthermore, this study confirmed the results of previous studies on predisposing factors to vaccination. Women with lower socioeconomic status had lower vaccination adherence, but, when they received information about vaccination and its benefits, they were more likely to vaccinate against pertussis and influenza. Therefore, health care providers and policymakers should promote vaccination information and recommendation through different strategies that meet the different needs of the population, focusing mainly on groups less prone to vaccination to improve vaccine uptake in pregnancy.

AUTHOR CONTRIBUTIONS

Amerigo Ferrari and Giaele Moretti participated in the design, methodology, implementation, conduct, monitoring, analysis, and writing of the study. Ilaria Corazza participated in the interpretation of the study and writing of the Discussion section. Professors Tommaso Simoncini and Paolo Mannella coordinated the collaboration between Pisa University and Sant'Anna School, reviewed the article drafts, and approved the final version. Manila Bonciani coordinated the design and development of the systematic survey on the maternity pathways of Tuscany and the web app *hAPPyMamma*, and participated in designing the study design, interpreting the results, and writing, reviewing, and editing the manuscript.

ACKNOWLEDGMENTS

The first author thanks both the MeS Laboratory of Sant'Anna School and the Obstetrics and Gynecology Division of Pisa University for the successful collaboration and support given for the study. He also thanks the Regional Health Authority of Tuscany and all health professionals of the Tuscan health care system, who actively promoted participation in the systematic survey. Without their work, the collection of data used for this study would not have been possible. Open Access Funding provided by Scuola Superiore Sant'Anna within the CRUI-CARE Agreement.

FUNDING INFORMATION

The data source and the publication charges were funded as part of the research activities of the MeS Lab of Sant'Anna School of Advanced Studies. Such activities were funded by the Tuscany Region Health Authority under the collaboration agreement with Sant'Anna School. Tuscany Region had no role in the study design, data collection and analysis, or writing and submitting of the article for publication.

CONFLICT OF INTEREST STATEMENT

No conflicts of interest declared by the authors.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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REFERENCES

1. Mackin DW, Walker SP. The historical aspects of vaccination in pregnancy. *Best Pract Res Clin Obstet Gynaecol*. 2021;76:13-22. doi:10.1016/j.bpobgyn.2020.09.005
2. Griffin JB, Yu L, Watson D, et al. Pertussis immunisation in pregnancy safety (PIPS) study: a retrospective cohort study of safety outcomes in pregnant women vaccinated with Tdap vaccine. *Vaccine*. 2018;36:5173-5179. doi:10.1016/j.vaccine.2018.07.011
3. Scatigna M, Appetiti A, Pasanisi M, D'Eugenio S, Fabiani L, Giuliani AR. Experience and attitudes on vaccinations recommended during pregnancy: survey on an Italian sample of women and consultant gynecologists. *Hum Vaccines Immunother*. 2022;18:1-8. doi:10.1080/21645515.2021.1894061
4. Munoz FM, Bond NH, Maccato M, et al. Safety and immunogenicity of tetanus diphtheria and acellular pertussis (Tdap) immunization during pregnancy in mothers and infants: a randomized clinical trial. *J Am Med Assoc*. 2014;311:1760-1769. doi:10.1001/jama.2014.3633
5. Sukumaran L, McCarthy NL, Kharbanda EO, et al. Safety of tetanus toxoid, reduced diphtheria toxoid, and acellular pertussis and influenza vaccinations in pregnancy. *Obstet Gynecol*. 2015;126:1069-1074. doi:10.1097/AOG.0000000000001066
6. Agricola E, Gesualdo F, Alimenti L, et al. Knowledge attitude and practice toward pertussis vaccination during pregnancy among pregnant and postpartum Italian women. *Hum Vaccines Immunother*. 2016;12:1982-1988. doi:10.1080/21645515.2016.1188242
7. Napolitano F, Napolitano P, Angelillo IF. Seasonal influenza vaccination in pregnant women: knowledge, attitudes, and behaviors in Italy. *BMC Infect Dis*. 2017;17:1-7. doi:10.1186/s12879-016-2138-2
8. Li Y, Brousseau N, Guay M, et al. Coverage for pertussis vaccination during pregnancy with 4 models of vaccine delivery: a quasiexperimental, multicentre observational study. *CMAJ Open*. 2022;10:E56-E63. doi:10.9778/cmajo.20210011
9. Lucyk K, Simmonds KA, Lorenzetti DL, Drews SJ, Svenson LW, Russell ML. The association between influenza vaccination and socioeconomic status in high income countries varies by the measure used: a systematic review. *BMC Med Res Methodol*. 2019;19:153. doi:10.1186/s12874-019-0801-1
10. Vilca LM, Cesari E, Tura AM, et al. Barriers and facilitators regarding influenza and pertussis maternal vaccination uptake: a multi-center survey of pregnant women in Italy. *Eur J Obstet Gynecol Reprod Biol*. 2020;247:10-15. doi:10.1016/j.ejogrb.2020.02.007
11. Andre K, Gavrilov V, Graham S, et al. Influential factors in patient uptake of influenza vaccination during pregnancy; a survey-based audit in a tertiary hospital setting. *N Z Med J*. 2019;132:42-51.
12. Chan HJ, Chang JY, Erickson SR, Wang CC. Influenza vaccination among pregnant women in the United States: findings from the 2012-2016 National Health Interview Survey. *J Women's Heal*. 2019;28:965-975. doi:10.1089/jwh.2018.7139
13. Mak DB, Regan AK, Vo DT, Effler PV. Antenatal influenza and pertussis vaccination in Western Australia: a cross-sectional survey of vaccine uptake and influencing factors. *BMC Pregnancy Childbirth*. 2018;18:1-10. doi:10.1186/s12884-018-2051-3
14. Vilca LM, Sarno L, Cesari E, et al. Differences between influenza and pertussis vaccination uptake in pregnancy: a multi-center survey study in Italy. *Eur J Public Health*. 2021;31:1150-1157. doi:10.1093/eurpub/ckab095
15. Bonciani M, De Rosis S, Vainieri M. Mobile health intervention in the maternal care pathway: protocol for the impact evaluation of hAPPyMamma. *JMIR Res Protoc*. 2021;10(1):e19073. doi:10.2196/19073
16. Ferrari A, Bonciani M, Russo E, Mannella P, Simoncini T, Vainieri M. Reported outcome measures for pregnancy-related urinary and fecal incontinence: a prospective cohort study in a large Italian population. *Int J Gynecol Obstet*. 2022;159:1-9. doi:10.1002/ijgo.14132
17. Ferrari A, Corazza I, Mannella P, Simoncini T, Bonciani M. Influence of COVID-19 pandemic on self-reported urinary incontinence during pregnancy and postpartum: a prospective study. *Int J Gynecol Obstet*. 2022;1-8. doi:10.1002/ijgo.14522
18. Recchia A. Contiguity-constrained hierarchical agglomerative clustering using SAS. *J Stat Softw*. 2010;33:1-12. doi:10.18637/jss.v033.c02
19. Leary STO, Riley LE, Lindley MC, et al. Obstetrician – gynecologists' strategies to address vaccine refusal among pregnant women. *Obstet Gynecol*. 2019;133:40-47. doi:10.1097/AOG.0000000000003005
20. Fernández-Cano MI, Arreciado Marañón A, Reyes-Lacalle A, et al. Influenza and pertussis maternal vaccination coverage and influencing factors in Spain: a study based on primary care records registry. *Int J Environ Res Public Health*. 2022;19:1-13. doi:10.3390/ijerph19074391
21. Corbeau M, Mulliez A, Chenaf C, Eschalier B, Lesens O, Vorilhon P. Trends of influenza vaccination coverage in pregnant women: a ten-year analysis from a French healthcare database. *Sci Rep*. 2022;12:1-9. doi:10.1038/s41598-022-11308-3
22. Bartolo S, Deliege E, Mancel O, et al. Determinants of influenza vaccination uptake in pregnancy: a large single-centre cohort study. *BMC Pregnancy Childbirth*. 2019;19:1-9. doi:10.1186/s12884-019-2628-5
23. Razzaghi H, Kahn KE, Black CL, et al. Influenza and Tdap vaccination coverage among pregnant women — United States, April 2020. *MMWR Morb Mortal Wkly Rep*. 2020;69:1391-1397. doi:10.15585/mmwr.mm6939a2

24. UK Health Security Agency. Prenatal pertussis vaccination coverage for pregnant women in England: October to December 2021. *Health Protection Report*. 2022;16:4.
25. Truong J, Bakshi S, Wasim A, Majid U. What factors promote vaccine hesitancy or acceptance during pandemics? A systematic review and thematic analysis. *Health Promot Int*. 2022;37:37. doi:10.1093/heapro/daab105
26. Ackerson BK, Sy LS, Glenn SC, et al. Pediatric vaccination during the COVID-19 pandemic. *Pediatrics*. 2021;148:1-11. doi:10.1542/peds.2020-047092
27. Lumbreras Areta M, Valiton A, Diana A, et al. Flu and pertussis vaccination during pregnancy in Geneva during the COVID-19 pandemic: a multicentric, prospective, survey-based study. *Vaccine*. 2022;40:3455-3460. doi:10.1016/j.vaccine.2022.04.076
28. De Brabandere L, Hendrickx G, Poels K, Daelemans W, Van Damme P, Maertens K. Influence of the COVID-19 pandemic and social media on the behaviour of pregnant and lactating women towards vaccination: a scoping review. *BMJ Open*. 2023;13:1-11. doi:10.1136/bmjopen-2022-066367
29. Olusanya OA, Bednarczyk RA, Davis RL, Shaban-Nejad A. Addressing parental vaccine hesitancy and other barriers to childhood/adolescent vaccination uptake during the coronavirus (COVID-19) pandemic. *Front Immunol*. 2021;12:1-7. doi:10.3389/fimmu.2021.663074
30. Cappozzo F, Dal A, Scollo M, et al. dTap vaccination uptake during pregnancy: pregnant women-focused and health professionals-focused predictors in the Veneto region (Italy). *Vaccine*. 2021;39:6913-6919. doi:10.1016/j.vaccine.2021.10.012

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Ferrari A, Moretti G, Corazza I, Mannella P, Simoncini T, Bonciani M. Pregnancy vaccination predictive factors and uptake profiles among Italian women: A cross-sectional survey study on a large population. *Int J Gynecol Obstet*. 2023;00:1-11. doi:10.1002/ijgo.14797