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Determinants of influenza and pertussis vaccine uptake in pregnant women in Ireland: A cross-sectional survey in 2017/18 influenza season

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ABSTRACT

In Ireland seasonal influenza and pertussis vaccination during pregnancy is recommended and every year national campaigns are organised to raise awareness and improve uptake. We estimated influenza and pertussis vaccine uptake and identified factors associated with vaccination status in pregnant women in 2017/18.

We conducted a face-to-face omnibus survey, with quota sampling, among women aged 18–55 years and collected socio-demographic characteristics, self-reported vaccination status, awareness of vaccine campaigns, and attitudes towards vaccination. Sample was weighted to ensure representativeness with the target population. We performed univariate and multivariable logistic regression analyses on survey data.

Overall, 241 pregnant women were enrolled. Influenza and pertussis vaccine uptake was 61.7% and 49.9%, respectively. Awareness of vaccine campaign and socio-economic status (SES) were associated with both influenza and pertussis vaccine uptake. The association between SES and uptake of vaccines differed by awareness. Women aware of the influenza vaccine campaign and with mid and low SES were less likely to be vaccinated, compared to those with high SES (aOR = 0.46; 95%CI: 0.22–0.97; aOR = 0.27; 95%CI: 0.12–0.60, respectively); women not aware of the pertussis vaccine campaign and with mid and low SES were less likely to be vaccinated, compared to those aware and with high SES (aOR = 0.15; 95%CI: 0.04–0.48; aOR = 0.05; 95%CI: 0.01–0.24, respectively).

General practitioner (GP) recommendation was the main reason for receiving influenza vaccine (39.2%), and 71.8% of women were recommended pertussis vaccination from their GPs.

The survey reports moderate uptake of vaccines among pregnant women, inequalities in uptake by SES and identifies GPs as primary source for vaccine recommendation. We recommend multifaceted campaigns, by engaging GPs, to target all socio-economic groups.

1. Introduction

1.1. Influenza vaccination

In 2012, the World Health Organization recommended prioritisation of influenza vaccination for pregnant women as they are particularly at risk of severe complications, resulting in higher risk of hospitalisation and admission to intensive care [1–6]. Influenza during pregnancy may also lead to preterm birth, lower birth weight, neonatal death and stillbirth [7,8]. High rates of influenza-related hospitalisations [9] and mortality [10] are also reported among infants less than six months of age, for whom no vaccines are available [3]. In Ireland, during the 2016/17 influenza season, 5.2% of hospitalised cases occurred among children younger than one year of age, reporting the highest age-specific hospitalisation rate (118.9/100,000 population) [11].

Maternal immunisation during pregnancy provides both direct and indirect protection to pregnant women and their infants, through transplacental antibody transfer [12–14].

Although influenza vaccination during pregnancy has been shown to be safe and effective in preventing both mother and infant influenza virus infection and hospitalisation [15–17], influenza vaccine recommendation for pregnant women has not uniformly been incorporated into routine immunisation programs across Europe and vaccination uptake remains low [18].

In Ireland, influenza vaccination during pregnancy has been recommended since 2011 [19].

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1.2. Pertussis vaccination

Pertussis, is a major health problem among children and remains a significant cause of infant morbidity and mortality, even in resource-rich nations [20]. New-borns are at greatest risk of developing pertussis infection with serious complications such as pneumonia, seizures or brain damage [21], and the case fatality rate for babies younger than one year of age is up to 1% [22].

Currently, the highest incidence, morbidity and mortality occurs in infants, particularly in those aged less than two months [23]. Maternal immunisation is considered the most cost-effective strategy for protecting infants against pertussis infection, before they are eligible for vaccination [24]. Worldwide, many industrialised countries have recently experienced a growing number of cases of pertussis, despite high vaccination coverage in infants [25,26].

In 2017 in Ireland, the incidence of pertussis almost doubled compared with 2015 (5.5/100,000 population and 2.5/100,000 population, respectively), and more than a quarter of cases were reported in infants aged less than six months [27].

Increasing evidence is available to support the recommendation that pertussis vaccine during pregnancy is effective [28,29] and safe [30] in both the pregnant women and their babies.

Pertussis vaccine recommendation for pregnant women was introduced in Ireland in 2012, and it is currently recommended between 16 and 36 weeks gestation in each pregnancy [23].

1.3. Rationale for the study

In Ireland, since the recommendation for seasonal influenza and pertussis vaccine during pregnancy was introduced, the National Immunisation Office promotes national vaccine campaigns to raise awareness and improve vaccine uptake in pregnant women. Communication letters and training materials are sent to healthcare providers, updated guidelines and resources are published online [31], and posters and leaflets are widely distributed in health care settings (e.g. hospital, general practice, pharmacy and health centres). Media coverage through press/media conferences, radio and TV interviews are also organised.

However, there is no national information system available for estimating seasonal influenza and pertussis vaccine coverage in pregnant women, in Ireland. Telephone and face-to-face surveys conducted in previous years were the only sources of information on vaccine coverage in this target group. These studies reported 22% (in 2012/13) [32] and 31% (in 2016/17) (unpublished data) influenza vaccine uptake, and 2.3% (in 2012/13) pertussis vaccine uptake (unpublished data).

The aim of this study was to estimate uptake of seasonal influenza and pertussis vaccines during pregnancy, and to identify factors associated with uptake of these vaccines during the 2017/18 influenza season in Ireland.

2. Methodology

2.1. Study design and sampling technique

We undertook a cross-sectional household omnibus face-to-face survey. Omnibus are surveys, conducted by market research companies, in which various organisations pay for their questions to be included. Demographic and socio-economic information of the respondents including age, social class, community type (urban and rural), and province of residence are routinely collected by the market research company as part of the omnibus survey.

The study population consisted of women aged 18–55 years, residing in Ireland and living in a household, who were either pregnant at the time of the interview (March 2018) or at any time since September 2017 and who had delivered prior to interview. All women meeting these criteria will be herein referred to as pregnant women.

A market research company conducted the sampling and carried out the field interviews. The sampling frame consisted of primary sampling units (PSUs), based on aggregates of District Electoral Divisions (DEDs) within the four provinces of Ireland: Leinster, which includes Dublin (the capital), Munster, Connacht and Ulster (Republic of Ireland only). Within provinces, PSUs were sorted by geographic division into: (a) county boroughs, which represent large urban areas; (b) urban (i.e. cities, towns and villages with a population of over 1,500); and (c) rural (i.e. towns and villages with under 1500 in population), resulting in 17 geographical strata. For each stratum the cumulative population was computed. Strata were further sorted by county and then by area within county. Finally, sampling points were selected according to probability proportional to size of the strata, using a random start and a sampling interval. Based on previous surveys on the target population, the market research company selected 34 sampling points (Personal communication, Kantar Millward Brown).

From the latest national estimates on vaccines uptake (31% for influenza vaccine uptake and 2% for pertussis vaccine uptake) (unpublished data), we calculated that 220 pregnant women were required for a desired precision of ±6% for influenza vaccine and ±2% for pertussis vaccine, with a confidence level of 95%,using OpenEpi version 3.01.

We developed a questionnaire to self-report vaccination status, month of vaccination against influenza, week of gestation for vaccination against pertussis, awareness of vaccines campaigns, sources of information and reasons for and against getting influenza vaccine.

Within each sampling point the survey was conducted door-to-door to find the target population, and individuals were selected through quota sampling. Quotas were set based on the most recent national population estimates, obtained from the Central Statistics Office (CSO), for provinces [33], and on the last available data from the Association of Irish Market Research Organisations (AIMRO) for social class categories (Personal communication, Kantar Millward Brown).

After obtaining oral informed consent from respondents, interviewers used digital handheld devices to show images of the vaccines campaigns and to record participants' responses. As standard practice, the company conducted a quality control through telephone back-checks on 10% of interviewed to validate quota criteria.

We used a social class definition from the AIMRO standards which is based on the occupation of the chief income earner (Personal communication, Kantar Millward Brown).

Ethical approval to conduct the survey was obtained from the Royal College of Physicians of Ireland Research Ethics Committee.

2.2. Statistical analysis

Data were weighted to match the quota sample to the target population parameters. Weighting parameters included province and social class derived from national estimates [33] (for social class categories; personal communication, Kantar Millward Brown).

The outcome measures were having received influenza or pertussis vaccine. We estimated influenza vaccine uptake by excluding women who were not able to indicate the month of vaccination, and pertussis vaccine uptake by excluding those who did not know their vaccination status or those who were not eligible for vaccination (<16 weeks gestation at time of survey).

We categorised women in three age groups (18–24 years, 25–34 years and ≥ 35 years), grouped social class categories into high, medium and low socio-economic status (SES), and combined Connacht and Ulster (Republic of Ireland, only) regions allowing for larger strata. We calculated frequencies and proportions of variables included in the analysis.

Analyses were conducted using Stata® v.15 (StataCorp., USA) and specific commands for survey analysis and weights were used to account for the sampling nature of the survey. Results showed in text and tables refer to the weighted sample, unless otherwise specified.

We performed univariate logistic regression analysis to identify factors associated with the uptake of influenza and pertussis vaccines among pregnant women. We estimated crude odds ratios (ORs) and 95% confidence intervals (CI). A p-value <0.05 (two-tailed) was considered statistically significant. To assess the presence of effect modification and confounding, we conducted stratified analysis by the main factors associated with the outcomes. We also tested for the presence of collinearity between independent variables by regression analysis; if the value of the variance inflation factor was<10, collinearity was excluded.

All variables with a p-value <0.25 (two-tailed) on univariate logistic regression analysis were included in the multivariable logistic regression analyses. For each outcome, we built models with interaction term, accounting for effect modification, adjusting for age. The Wald test was used to assess the effect of each variable on the model; if the test gave a p-value <0.05 the variable was kept. Results were reported as adjusted ORs (aOR) with the respective 95% CIs.

3. Results

3.1. Participant's characteristics

In total, 241 pregnant women were enrolled. The characteristics of the participants are reported in Table 1. The median age of participants was 31 years (range: 18–50 years). The majority lived in urban areas (84.6%) and 46.1% reported high SES (Table 1).

3.2. Influenza vaccine uptake

The overall influenza vaccine uptake in pregnant women was 61.7% (95%CI: 55.3-67.8) (Table 2).

Influenza vaccine uptake did not significantly differ by age group, community type and province of residence.

However, uptake significantly increased from the lowest SES (45.6%) to the highest (72.1%); women with the lowest SES were less likely to be vaccinated compared with women with higher SES (OR: 0.32; 95%CI: 0.16-0.64).

Awareness of the influenza vaccine campaign was reported by 80.6% of women (Table 1) and those not aware were less likely to be vaccinated compared with women aware of the campaign (OR: 0.25; 95%CI: 0.13-0.52) (Table 2). Women from all SES reported high level of awareness of the influenza vaccine campaign (83.3% in high SES, 81.5% in mid SES and 74.2% in low SES).

Health care setting was the most cited source of information (87.5%) followed by TV (18.4%) (Supplementary Fig. S1).

The most common reasons for receiving influenza vaccine were: general practitioner (GP) recommendation (39.2%), and being pregnant (23.8%) (Fig. 1); while the most common reasons for not receiving the vaccine were no particular reason (21.4%), and a general dislike in getting vaccinations (19.4%) (Fig. 2).

Stratified analysis by awareness of the influenza vaccine campaign reported differences between stratum-specific and crude estimates on the relationship between vaccine uptake and SES: low and mid SES was significantly associated with lower vaccine uptake only in the subgroup of women aware of the campaign (Supplementary Table S2).

In multivariable analysis, among women aware of the influenza vaccine campaign, those with mid and low SES were less likely to be vaccinated compared to those with high SES (aOR = 0.46; 95%CI: 0.22-0.97; aOR = 0.27; 95%CI: 0.12-0.60, respectively), whereas among women not aware the likelihood of being vaccinated was the same across SES (Table 3).

3.3. Pertussis vaccine uptake

Overall, 49.9% (95%CI: 43.3–56.6) of women reported uptake of the pertussis vaccine during pregnancy (Table 2). Vaccine uptake did not differ by age group or community type, but increased across SES (from 35.8% for low to 57.6% for high SES), with women in the lowest SES less likely to be vaccinated compared to those with high SES (OR: 0.41; 95%CI: 0.21-0.82). Significant differences in uptake was shown by province of residence: women living in Connacht/Ulster were less likely to get the pertussis vaccine compared with those living in Leinster (OR: 0.26; 95%CI: 0.12-0.54) (Table 2).

Table 1
Characteristics of study participants in the Omnibus survey on influenza and pertussis vaccine uptake among pregnant women, Ireland, 2017/18 influenza season.

Variable		Study participants		
		No. crude	No. weighted[a]	%[b]
All respondents		241	241	100.0
Age group (years)	18–24	35	33	13.7
	25–34	143	145	60.2
	35+	63	63	26.1
Socio-economic status	High	94	111	46.1
	Mid	85	74	30.5
	Low	62	56	23.4
Community type	Rural	38	37	15.4
	Urban	203	204	84.6
Province	Leinster	131	139	57.6
	Munster	56	63	26.3
	Connacht/Ulster	54	39	16.2
Awareness of vaccine campaign	Influenza	196	194	80.6
	Pertussis	169	168	69.9

[a] Weighted data rounded to nearest integer.
[b] Percentage of weighted sample.

Table 2
Factors associated with influenza and pertussis vaccine uptake in pregnant women (univariate analysis), Ireland, 2017/18 influenza season.[a]

		Influenza vaccine[b]					Pertussis vaccine[c]				
		Total[d]	No. vaccinated[d]	%	OR (95%CI)	p	Total[d]	No. vaccinated[d]	%	OR (95%CI)	p
Overall uptake		238	147	61.7			231	116	49.9		
Age group (years)	18–24	32	18	56.0	Ref		33	16	49.2	Ref	
	25–34	143	88	61.2	1.24 (0.57–2.68)	0.586	141	71	50.2	1.04 (0.49–2.24)	0.911
	35+	63	42	65.9	1.52 (0.64–3.61)	0.345	57	29	49.6	1.02 (0.43–2.41)	0.967
Socio-economic status	High	110	79	72.1	Ref		107	62	57.6	Ref	
	Medium	72	42	58.5	0.55 (0.29–1.03)	0.062	70	35	49.1	0.71 (0.39–1.31)	0.272
	Low	56	26	45.6	**0.32 (0.16–0.64)**	**0.001**	54	19	35.8	**0.41 (0.21–0.82)**	**0.012**
Community type	Rural	37	25	67.9	Ref		36	15	40.1	Ref	
	Urban	201	122	60.6	0.73 (0.34–1.54)	0.406	195	101	51.8	1.60 (0.76–3.37)	0.215
Province	Leinster	136	80	58.7	Ref		130	73	56.5	Ref	
	Munster	63	47	73.5	1.95 (0.98–3.87)	0.057	63	33	51.5	0.82 (0.43–1.55)	0.712
	Connacht/Ulster	39	21	53.1	0.80 (0.42–1.52)	0.490	38	10	25.1	**0.26 (0.12–0.54)**	**<0.001**
Awareness of the campaign	Yes	191	130	68.2	Ref		116	96	58.6	Ref	
	No	47	17	35.3	**0.25 (0.13–0.52)**	**<0.001**	115	20	23.3	**0.29 (0.15–0.58)**	**<0.001**

[a] Statistically significant results are indicated in bold font.
[b] Three women excluded (unknown month of vaccination).
[c] Nine women excluded (unknown vaccination status or vaccinated before week 16 of pregnancy).
[d] Weighted data rounded to nearest integer.

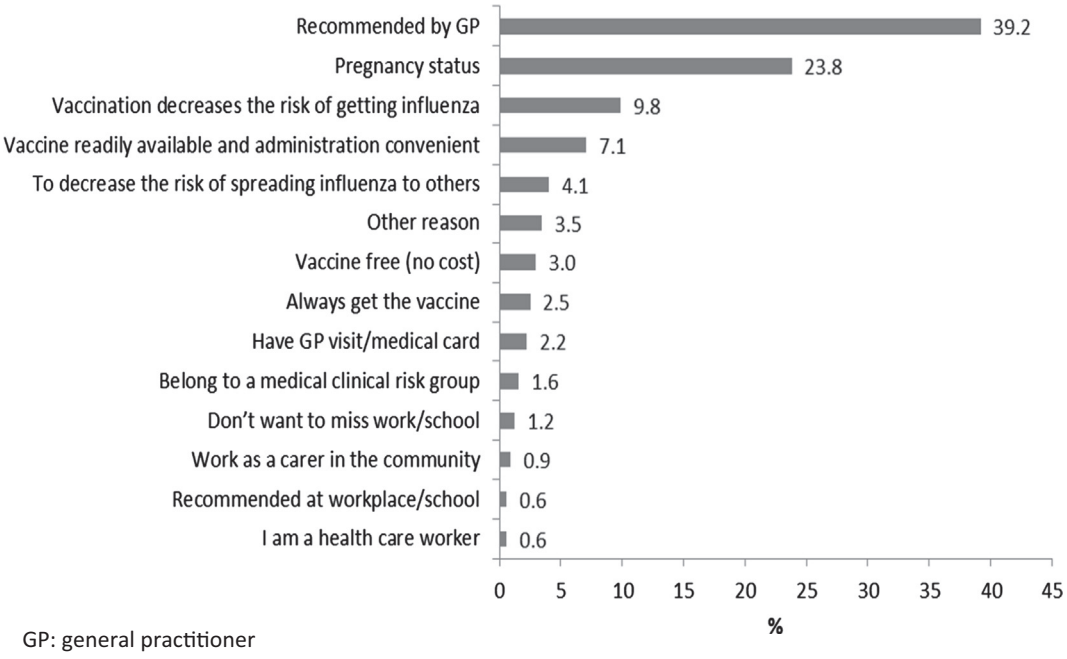

Fig. 1. Reasons for receiving seasonal influenza vaccine in pregnant women, Ireland, 2017/18 influenza season.

The majority of women (69.9%) reported being aware of the current campaign promoting pertussis vaccine during pregnancy (Table 1), and the main cited sources of information were health care setting (76.5%) and poster/leaflets (41.2%) (Supplementary Fig. S1).

Pregnant women not aware of the current pertussis vaccine campaign were less likely to be vaccinated compared with women aware of the campaign (OR: 0.29; 95%CI: 0.15-0.58) (Table 2).

In addition, women who reported being vaccinated for seasonal influenza were nine times more likely to be vaccinated against pertussis compared to those not vaccinated for influenza (OR: 9.4; 95% CI: 4.8-18.2).

Pertussis vaccine was mainly recommended by GPs (71.8%), followed by obstetricians or midwives (14.6%), practice nurses (13.7%), or other healthcare workers (10.0%). GPs and practice nurses administered the vaccine to 95.8% of the vaccinated women.

Stratified analysis by awareness of the pertussis vaccine campaign showed that low SES was significantly associated with lower vaccine uptake only in the subgroup of women not aware of the campaign (Supplementary Table S2).

Multivariable analysis showed that women not aware of the pertussis vaccine campaign and with mid and low SES were less likely to be vaccinated compared to those aware and with high SES (aOR = 0.15; 95%CI: 0.04-0.48; aOR = 0.05; 95%CI: 0.01-0.24, respectively); however, among those aware of the vaccine campaign the likelihood of being vaccinated did not significantly differ by SES (Table 3). Province of residence was also independently associated with vaccine uptake: those in Connacht/Ulster province

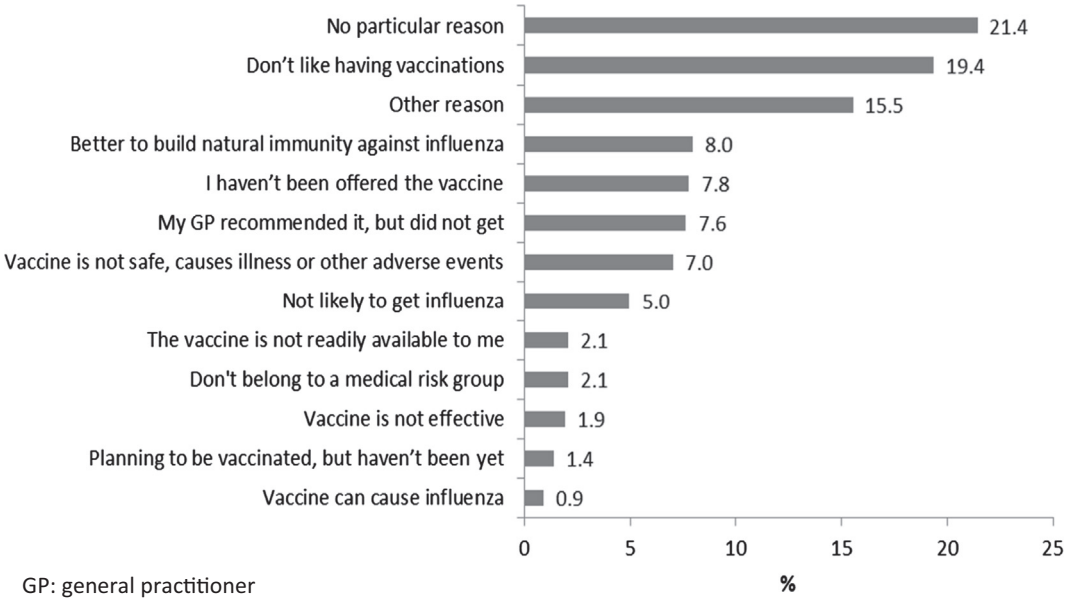

Fig. 2. Reasons for not receiving seasonal influenza vaccine in pregnant women, Ireland, 2017/18 influenza season.

Table 3
Multivariable analysis for factors associated with influenza and pertussis vaccine uptake in pregnant women, Ireland, 2017/18 influenza season.[a,b]

Variables		Influenza vaccine uptake		Pertussis vaccine uptake	
		aOR (95%CI)	p	aOR (95%CI)	p
Socio-economic status and Awareness of the campaign	High - Yes	Ref		Ref	
	Mid - Yes	**0.46 (0.22–0.97)**	**0.042**	0.92 (0.43–1.99)	0.838
	Low - Yes	**0.27 (0.12–0.60)**	**0.002**	0.52 (0.21–1.26)	0.150
	High - No	**0.13 (0.04–0.45)**	**0.001**	0.44 (0.15–1.32)	0.144
	Mid - No	**0.13 (0.04–0.43)**	**0.001**	**0.15 (0.04–0.48)**	**0.002**
	Low - No	**0.15 (0.04–0.52)**	**0.002**	**0.05 (0.01–0.24)**	**<0.001**
Province	Leinster	NI		Ref	
	Munster			0.62 (0.31–1.23)	0.170
	Connacht/Ulster			**0.17 (0.08–0.40)**	**<0.001**

NI: Not included.
[a] Statistically significant results are indicated in bold font.
[b] Adjusted for age (continuous).

were less likely to be vaccinated compared to those living in Leinster province (aOR: 0.17; 95%CI: 0.08-0.40) (Table 3).

4. Discussion

This study showed substantial improvements in uptake of vaccines during pregnancy, identified predictors of vaccination, including vaccine campaign awareness and SES, and consequently potential areas for improvement.

In this study influenza vaccine uptake (61.7%) considerably increased compared to those reported in our previous surveys conducted in 2012/13 (22%) [32] and 2016/17 (31.3%) (unpublished data) and in other cross-sectional studies, conducted during 2016 in individual hospitals in Ireland, reporting uptakes between 39.1% and 55.1% [34–36]. Our estimate is also higher than those reported in other countries for the same season (2017/18). England reported an uptake of 47.2% from routine surveillance conducted at GP practice level [37] and an internet panel survey among pregnant women in the USA showed an uptake of 49.1% [38]. The higher influenza vaccine uptake observed in our study may be associated with two factors. Firstly, we conducted the survey at the end of the 2017/18 season (March 2018). This season was notable for its prolonged influenza circulation, with high activity up to February 2018 [39] and substantial media attention. Therefore we captured influenza vaccine uptake for the entire season, while other studies presented previous seasons or early 2017/2018 season data. Secondly, the sampling methodology adopted for the present survey differed from our previous study, the former recruiting a smaller sample size.

The uptake of the pertussis vaccine also increased (49.9%) compared with data from a telephone survey conducted in 2012/13 influenza season (2.3%) (unpublished data). Notably, the latter was based on a smaller sample size, conducted soon after the recommendation for pertussis vaccine during pregnancy was made. In the current survey, pertussis vaccine uptake was also higher than that reported in a survey conducted in 2016 in an Irish hospital, showing 31% uptake [34]. However, the uptake estimated in our survey was lower compared with UK and US estimates (70% and 54.4%, respectively) for the same time period [38,40].

In our study, the main determinant for both vaccines uptake was being aware of vaccine campaigns. Healthcare settings were regarded as the main source of information. In addition, GP recommendation was the most commonly cited reason for being vaccinated against influenza, and GP was identified as the primary source for pertussis vaccine recommendation. Our findings are

consistent with other studies reporting that women who are offered vaccination by a healthcare worker show more positive attitudes towards vaccination and higher vaccine uptake compared to women who are not offered the vaccine [35,38,41–46], highlighting the key role of GPs and other antenatal care providers supporting informed decision-making among pregnant women.

Amongst the reasons for not being vaccinated against influenza, women reported no particular reason, or vague reasons. Wilson et al. [42] in a review on vaccine hesitancy reported that concerns about the safety of vaccination during pregnancy, poor knowledge about vaccine effectiveness and influenza-related complications, and a healthcare worker not recommending the vaccination are the main factors contributing to vaccine hesitancy.

In Ireland, although both vaccines were provided free of charge at the time of the study, GPs were entitled to request payment for influenza vaccine administration from women without medical cards (obtainable according to income eligibility criteria) and for pertussis vaccine administration from all pregnant women. Thus, the association reported in our study between high SES and high vaccines uptake suggests that women in the highest SES may have been more able to pay than lower income women without medical cards. Notably, during the pandemic influenza season (2009/10) in Ireland, studies reported that having a medical card was associated with higher vaccine uptake in the older population [47] and among pregnant women, those with high SES were also more likely to get vaccinated [48].

Multivariable analysis showed that awareness of the vaccine campaigns were the main predictors of uptake, although with a SES gradient.

For influenza vaccine, among women aware of the vaccine campaign the likelihood of being vaccinated was low in the mid and low SES, compared to those with high SES. For pertussis vaccine uptake, a SES gradient was reported only in the subgroup of women not aware of the vaccine campaign.

The explanation of SES disparities in uptake of vaccines by awareness of the campaigns might be due to access to different sources of information and understanding of complex messages, highlighting the importance to consider women's sociodemographic determinates in planning future community health education and information campaigns, targeting the different population strata also by using a variety of media strategies [49]. These results also support the importance of provision of free vaccine administration to increase vaccine uptake during pregnancy.

Province of residence was independently associated with pertussis vaccine uptake, with those living in Connacht/Ulster less likely to be vaccinated compared to those living in Leinster. This finding may reflect increased awareness in the province linked to control measures established following an infant death due to pertussis in the preceding 12 months, and an outbreak of pertussis that occurred in August 2017 in one county of Leinster. During the outbreak, letters were sent to GPs, obstetricians and public health nurses, advising them to recommend the vaccine for all pregnant women in each pregnancy, according to the national recommendation. Vaccine administration was also made free of charge for all pregnant women in that county. An audit conducted in 2018 identified a 77% uptake of the pertussis vaccine in pregnant women in that county (personal communication).

This study has some limitations. The sample size was calculated to estimate overall vaccine uptake, thus findings from the subgroup analysis should be interpreted with caution as the small numbers in each stratum may not have sufficient power to detect significant differences.

The presence of an information bias cannot be out ruled as results are based on self- reported information not validated with medical records.

Furthermore, selection bias can be present if a woman's decision to participate in this survey was related to having received the vaccine. We did not obtain overall response rate data as it is not standard practice of the market research company to collect number of refusals in quota-based omnibus surveys therefore, we could not compare the characteristics of those contacted with those who participated.

Recall errors due to the retrospective study design may have also occurred. However, we consider it likely that pregnant women tend to remember pregnancy related decisions, such as vaccination, thus recall bias in pregnant women should be minor.

Last, other socio-demographics and behavioural characteristics were not investigated in the study, as the cost of omnibus surveys is proportional to the number of questions included. However, with limited resources and within a short time frame, the survey provided valuable information not otherwise available.

To our knowledge this is the first study evaluating both influenza and pertussis vaccine uptake and their determinants in pregnant women at national level, through an omnibus household survey. Especially when immunisation registries are not available these surveys represent flexible, cost saving and timely methods to assess vaccine coverage without adding additional workload to the health system. In addition, weighting adjustment allow a representative sample of the target population, minimising sampling bias.

5. Conclusion and recommendations

The study allowed us to estimate influenza and pertussis vaccine uptake in pregnant women and to identify determinants of vaccines uptake which are helpful to guide future policy decisions. In order to support informed decision making and increase vaccine uptake, we recommend that multi-component strategies are implemented by: (i) targeting GPs and women through community health education and information campaigns, and (ii) providing vaccines (and their administration) free of charge to all pregnant women.

Finally, we recommend the inclusion of antenatal immunisation records in the national immunisation registry currently being developed in order to monitor vaccine uptake during pregnancy on an ongoing basis.

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.

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Author's contribution

SC coordinated the study; JM and SC conceived the study; AQ, JM, SC designed the study protocol; AQ performed the data analysis and drafted the initial manuscript, AQ, JM, MF and SC contributed to the interpretation of the results, multiple reviews and critical feedback on the manuscript and gave final approval before submission.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.vaccine.2019.09.008.

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