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**Reference:**

Maertens Kirsten, Braeckman Tessa, Top Geert, van Damme Pierre, Leuridan Elke.- Maternal pertussis and influenza immunization coverage and attitude of health care workers towards these recommendations in Flanders, Belgium  
Vaccine / International Society for Vaccines - ISSN 0264-410X - 34:47(2016), p. 5785-5791

Full text (Publisher's DOI): <http://dx.doi.org/doi:10.1016/J.VACCINE.2016.09.055>

To cite this reference: <http://hdl.handle.net/10067/1372650151162165141>

# **Maternal pertussis and influenza immunization coverage and attitude of health care workers towards these recommendations in Flanders.**

Maertens K., Braeckman T., Top G., Van Damme P., Leuridan E

## **Abstract**

In Belgium, pertussis vaccination is recommended for all pregnant women in every pregnancy. Adults in close contact with young infants are equally advised to receive a pertussis containing booster dose. Maternal influenza vaccination is likewise recommended in Belgium in the second or third trimester of pregnancy, within the influenza season.

A quantitative multicenter survey study has been performed between October 2014 and May 2015 in both postpartum women (N=823, response rate= 89.2%) and health care workers (HCWs) (N=261) to assess the coverage of both vaccines during pregnancy along with the coverage of the pertussis cocoon strategy, and to evaluate the knowledge and recommending attitude of HCWs towards maternal vaccination strategies and the cocoon strategy among surveyed women and HCWs.

Overall coverage of pertussis vaccination during pregnancy was 64.0%. Most women were vaccinated by their general practitioner (GP) (82.4%), and most often in the third trimester (74.0%) of pregnancy. Overall coverage of influenza vaccination during pregnancy was 45.0%. Again the GP administered most vaccines (67.6%); vaccines were equally administered in the second or third trimester of pregnancy. Educational level had a significant influence on both the pertussis and influenza vaccination coverage during pregnancy while working situation and parity had only an influence on the maternal pertussis vaccination coverage and country of birth only on the maternal influenza vaccination coverage.

Overall, 78.4% of gynecologists and GPs recommends both maternal pertussis and influenza vaccination and 67.0% recommends both maternal vaccination strategies and the cocoon strategy. Within the group of the midwives, only 23.7% recommends both maternal pertussis and influenza vaccination and 10.5% recommends both maternal vaccination strategies and the cocoon strategy.

High coverage is reached among pregnant women for pertussis and influenza vaccination. Several underserved populations of pregnant women regarding maternal immunization, are identified.

## Introduction

Pregnant women and neonates are at increased risk for vaccine-preventable disease-related morbidity and mortality [175]. Pertussis is a global cause of morbidity and mortality in infants too young to be protected by the currently available vaccines and vaccination schedules. In 2013, whooping cough caused an estimated 63,000 deaths in children below 4 years of age worldwide [40]. In Belgium, the number of confirmed pertussis cases also increased during the last decade with the highest incidence in the youngest infants. Some of these cases ended fatal, with 1-5 cases yearly before 2012. After 2012, no infant fatalities due to pertussis have been notified (Oral communication Scientific Institute of Public Health Belgium). Globally, yearly influenza epidemics are estimated to result in 3-5 million influenza cases and 250,000-500,000 deaths [176]. Pregnant women as well as children under 6 months of age who are too young to be vaccinated with the currently available vaccines, are vulnerable to severe disease resulting in a high rate of influenza related hospitalizations and deaths [177].

Maternal pertussis and influenza vaccination programs have already proven to be effective in preventing illness and hospitalization in both pregnant women and newborn infants [15, 178]. According to the recommendations of the World Health Organization (WHO), vaccination of pregnant women with a tetanus, diphtheria, acellular pertussis (Tdap) vaccines in the second or third trimester of pregnancy (at least one week prior to delivery) should be introduced as a routine complementary strategy in countries with increasing infant morbidity and mortality from pertussis [40]. For influenza, WHO recommends vaccination with inactivated influenza vaccines at any stage of pregnancy. However, the Strategic Advisory Group of Experts (SAGE) of WHO emphasized in April 2015, that maternal influenza vaccination is not a universal recommendation but a recommendation to maximize beneficial effects of influenza vaccines in countries with existing, or initiating new, influenza vaccination programs [179, 180].

In Belgium, national recommendations are made by the National Immunization Technical Advisory Group (NITAG). Implementation of the vaccination policy is managed at the subnational level of the 3 regions: the Flemish, Brussels Capital and Walloon region. Pertussis vaccination during pregnancy has been recommended since August 2013 for pregnant women during every pregnancy between 24 and 32 weeks of gestation. If the vaccine is not given during pregnancy, it should be administered in the immediate postpartum within the cocoon strategy. Additionally, all adults in close contact with young infants have been advised to receive a pertussis booster dose once during adult life as part of the cocoon strategy since 2009 [10]. Maternal influenza vaccination has been recommended in Belgium for pregnant women in the second or third trimester of pregnancy coinciding with the influenza season, for more than 10 years [181]. In Flanders, adult pertussis

booster has been free of charge since July 2014 and the influenza vaccine is available for pregnant women at a reduced fee.

Health care workers (HCWs) are frequently involved in nosocomial outbreaks of pertussis and influenza infection [182, 183]. Therefore, all HCWs, especially those in contact with risk groups such as pregnant women and newborn infants, should be immunized with an acellular pertussis (aP) containing vaccine and influenza vaccine to minimize potential exposure to patients [10, 181].

Achieving vaccine acceptance among both pregnant women and their health care providers is an important healthcare challenge. To identify potential barriers that could be addressed in order to improve the maternal vaccination coverage, a quantitative cross-sectional survey study has been performed. The main aim of the study was to determine the coverage of pertussis and influenza vaccination during pregnancy, along with the assessment of the pertussis cocoon strategy in Flanders. In addition, we aimed to assess the women's awareness and attitude towards the existing maternal immunization recommendations. In a second part of the study, HCWs were interviewed to evaluate their attitude towards the existing maternal vaccination strategies and the cocoon strategy and to determine the pertussis vaccination coverage among this occupational group.

## Methods

### Study design

A quantitative cross-sectional multicenter study was performed in all five provinces in Flanders, Belgium, between October 2014 and May 2015. Within a group of postpartum women, questions regarding awareness, coverage and attitude towards the existing maternal vaccination recommendations and the cocoon strategy were asked (Annex A). Within a group of HCWs, questions regarding awareness, informing and recommending attitude on maternal vaccination and cocoon vaccination were asked (Annex B). The study was approved by the ethical committee of the University hospital of Antwerp, Belgium (leading ethical committee) and by the regional ethical committees of all collaborating hospitals.

## Study population

### Postpartum women

In Flanders, 35 hospitals with more than 800 deliveries per year were identified. From these hospitals, 10 hospitals were selected for participation in the study through random sampling; all selected hospitals agreed to participate. The number of participating hospitals per province was proportional to the number of hospitals per province. Surveys were taken by trained investigators from hospitalized postpartum women. All potential participants were informed on the background, objectives and privacy rules related to the survey. Written informed consent was obtained from all participating women. Exclusion criteria were: aged below 18 years; languages other the Dutch, English, French and Arabic or absence of signed informed consent. The participants did not receive any payment.

### Health care workers

Gynecologists and midwives in each participating hospital (in-hospital HCWs) and general practitioners (GPs) in Flanders were invited to complete an encoded questionnaire. In-hospital HCWs received a cover letter together with the questionnaire to explain the purpose of the survey. Several reminder e-mails were sent and the study was also promoted during scheduled staff meetings. GPs were surveyed during symposia or training courses. HCWs did not receive any incentive for participation.

## Data collected

Both questionnaires used a combination of check boxes and free text answers. A pilot survey in both target groups was performed to ensure comprehensiveness.

From postpartum women, data were collected on socio-demographic background and obstetrical conditions including gestational age at delivery and complications during pregnancy. Knowledge, attitudes and behavior towards recommendations for vaccination during pregnancy and the cocoon strategy were addressed as well as their vaccination status.

From in-hospital HCWs and GPs, data were collected on demographical background, knowledge and attitude towards current recommendations for maternal pertussis and influenza vaccination and the cocoon strategy and their current pertussis vaccination status (Questionnaires in annex, can be provided upon request).

## Statistical analysis

Questionnaires from both postpartum women and HCWs were collected and encoded data were entered into two separate Microsoft Access 2013 databases.

Statistical analysis was performed using SPSS version 23.0. Statistical tests included parametric tests: t-tests and chi-square tests and their non-parametric alternatives: (paired) Wilcoxon tests and Fisher exact tests whenever the underlying assumptions of the parametric tests were violated i.e. normality and sparseness, respectively [56, 57]. Multiple logistic regression models were used to identify determinants that could potentially influence maternal pertussis and influenza vaccination coverage. Only significant influences of variables on the vaccination coverage were reported. A p-value <0.05 was considered as statistically significant.

## Results

### Demographics

Questionnaires from postpartum women were collected between October 20<sup>th</sup> 2014 and May 6<sup>th</sup> 2015. Of the 923 women approached, 823 agreed to participate (overall response rate: 89.2%). Main reasons for non-participation were: failure to obtain informed consent, minor aged participant, language, etc. All participants were pregnant during the period in time whereas the recommendations were in place and influenza vaccines were available. Therefore, the opportunity to receive the influenza vaccine during pregnancy was completely dependent on the recommending behavior of the HCWs. Surveys were collected on average 2.4 days postpartum. Demographic details of the participating women are summarized in Table 1. The surveyed women were demographically representative for the total population of young mothers in Flanders [184].

Questionnaires of HCWs were collected between October 11<sup>th</sup> 2014 and May 20<sup>th</sup> 2015. In total, 261 HCWs were surveyed: 103 in-hospital HCWs and 158 GPs. Demographic details of the participating HCWs can be found in Table 1. Mean age of the in-hospital HCWs was significantly lower ( $p < 0.001$ ) compared to the mean age of the GPs.

<b><u>WOMEN</u></b>		
Mean age in years (SD)		29.8 (4.8)
Number of days postpartum at moment survey (SD)		2.4 (1.7)
Mean gestational age at birth in weeks (SD)		39.3 (1.6)
Gestational age at birth, No. (%)	< 37 weeks	39 (4.7)
	≥ 37 weeks	784 (95.3)
Country of birth, No. (%)	Belgium	618 (75.1)
	EU-country	59 (7.2)
	Non EU-country	146 (17.7)
Country of birth of parents, No. (%)	Belgium	523 (63.5)
	EU-country	77 (9.4)
	Non EU-country	223 (27.1)
Highest level of education, No. (%)	No education	13 (1.6)
	Primary school	65 (7.9)
	Secondary school	334 (40.6)
	Bachelor degree	256 (31.1)
	Master degree	150 (18.2)
	Doctoral degree	4 (0.5)
Employment situation, No. (%)	Unknown	1 (0.1)
	Full-time	410 (49.8)
	Part-time	141 (17.1)
	Independent	47 (5.7)
	Unemployed with alimony	87 (10.6)
	Unemployed without alimony	118 (14.3)
	Student	18 (2.2)
Parity, No. (%)	Other	2 (0.2)
	Primiparous	372 (45.2)
	Multiparous	451 (54.8)
<b><u>IN-HOSPITAL HEALTH CARE WORKERS</u></b>		
Mean age in years (SD)		35.6 (11.1)
Gender, No. (%)	Male	10 (9.7)
	Female	93 (90.3)
Occupation, No. (%)	Gynecologist	27 (26.2)
	Midwife	76 (73.8)
<b><u>GENERAL PRACTITIONERS</u></b>		
Mean age in years (SD)		46.9 (12.2)
Gender, No. (%)	Male	78 (49.4)
	Female	80 (50.6)

**Table 1:** Demographic characteristics of the study participants

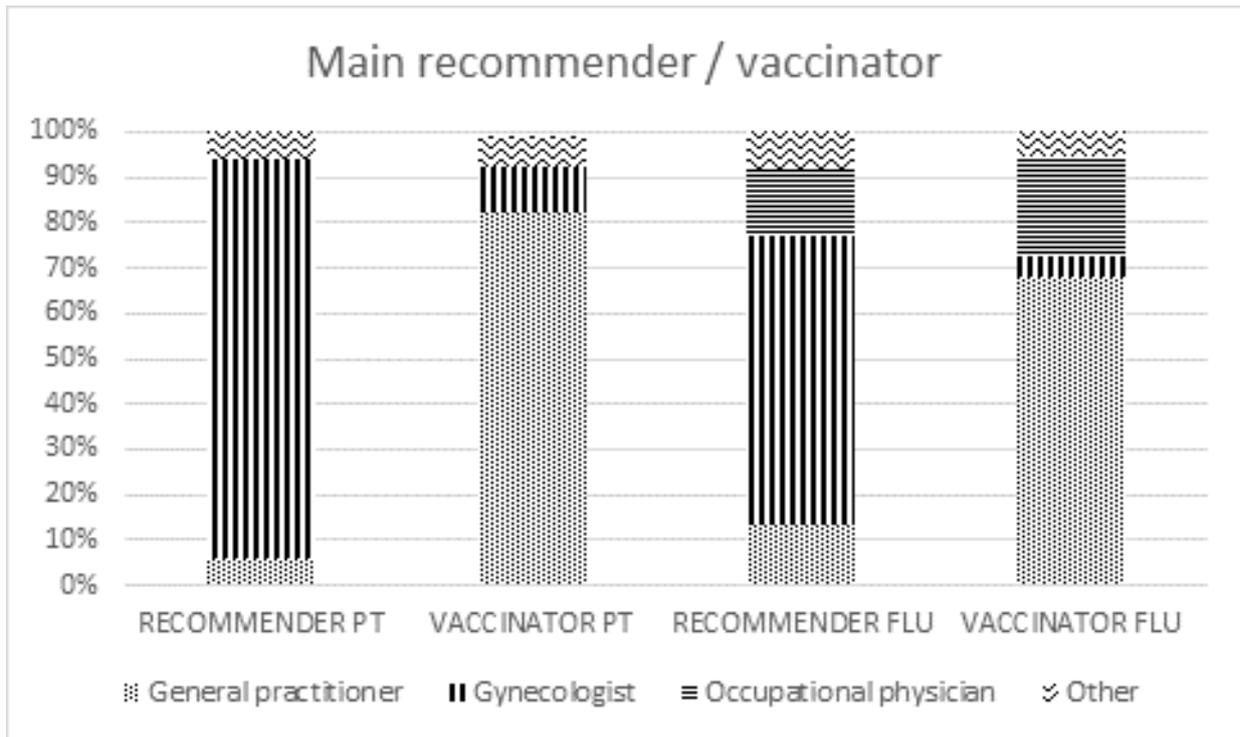
## Uptake of pertussis and influenza vaccine during pregnancy

Of the 823 respondents, 527 women (64.0%) were vaccinated with an aP containing vaccine during their current pregnancy. Most women were vaccinated in the second (24.3%) or third (74.0%) trimester of pregnancy. For women who recalled their vaccination date (N=225), the moment of vaccination was on average at 30.8 weeks of pregnancy (SD 3.8). No seasonality in pertussis vaccination coverage was seen (Fig. 2A). Maternal pertussis vaccination was in most cases recommended by the gynecologist (87.9%). In contrast, vaccination was mostly performed by the GP (82.0%) (Fig. 1). Main reasons for not being vaccinated with Tdap during pregnancy were: vaccine not offered during pregnancy by HCW (49.7%), Tdap vaccination during previous pregnancy (19.9%), vaccination discouraged by HCW (7.8%), forgetfulness (6.4%), safety concerns (4.7%) and others (8.1%).

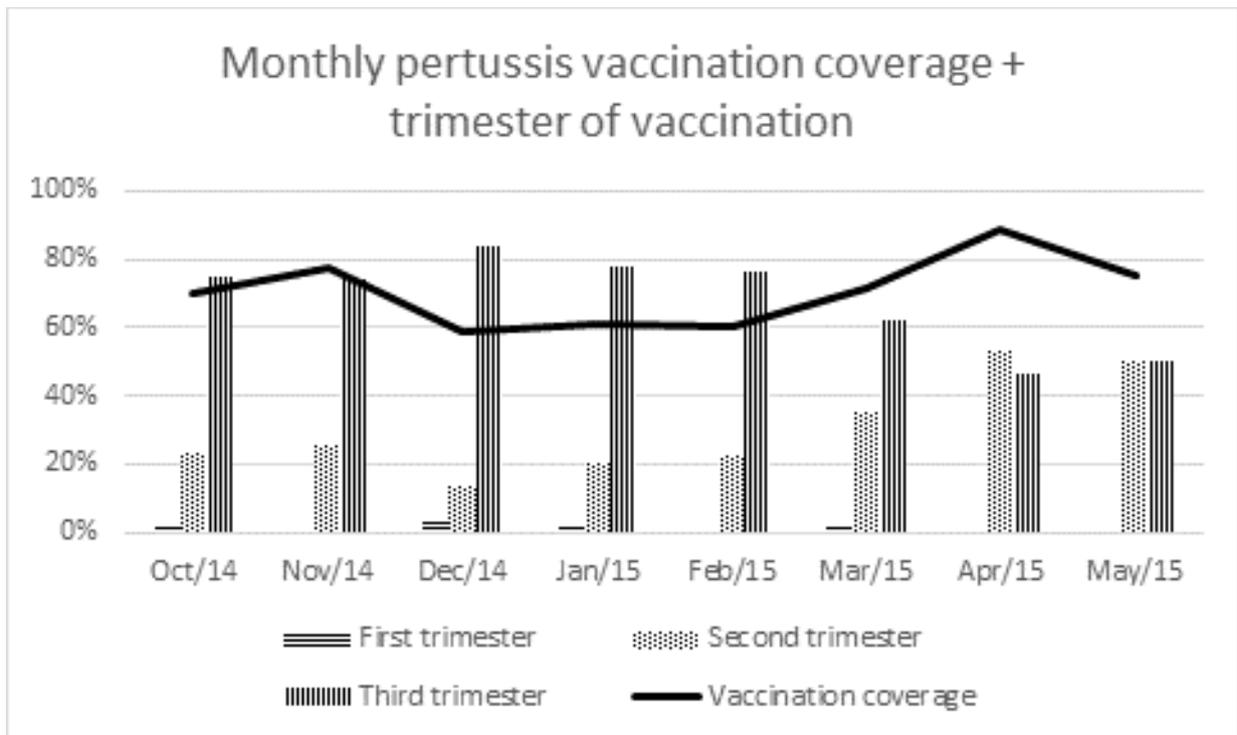
From the 296 women who did not receive the pertussis vaccine, only ten women (3.4%) were vaccinated postpartum at the moment of the survey. Main reasons for not yet receiving the cocoon vaccination were: vaccine not yet offered by HCW (50.3%), vaccinated during previous pregnancy (21.3%), recently delivered and no opportunity yet to get vaccinated (17.5%) and others (10.6%). Among the 286 women who did not yet receive the cocoon vaccination at the moment of the survey, 117 women (40.9%) were planning to get vaccinated in the upcoming days/weeks.

370 women (45.0%) were vaccinated against influenza during this pregnancy. Again, most women were vaccinated during the second (47.3%) or third (50.3%) trimester of pregnancy. A variation in vaccination coverage and trimester of vaccination was clear throughout the study period due to programmatic reasons as the vaccine is available in October during a limited period in time, and women receive in the fall the vaccine, regardless of second or third trimester (Fig. 2B). Main recommenders for maternal influenza vaccination were the gynecologist (64.1%) and the occupational physician (14.7%). Main vaccinators were the GP (68.1%) and the occupational physician (21.9%) (Fig. 1). Main reasons for not being vaccinated with an influenza vaccine during pregnancy were: vaccine not offered during pregnancy by HCW (40.2%), not convinced of the necessity to be vaccinated against influenza (19.9%), vaccination discouraged by HCW (6.8%), reasons of belief (6.4%), safety concerns (5.7%), forgetfulness (5.1%), vaccine not available (6.2%) and others (9.7%).

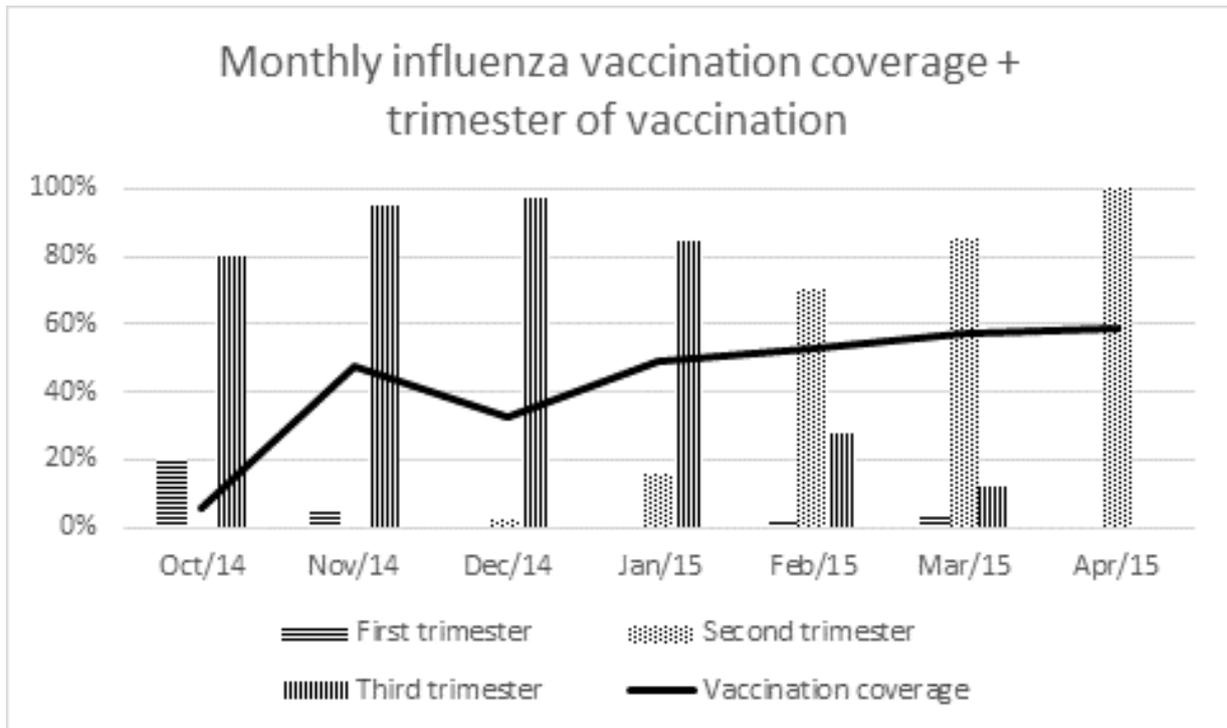
To summarize, 213 women (25.9%) were vaccinated with a Tdap vaccine only and 56 women (6.8%) were vaccinated with an influenza vaccine only; 314 women (38.2%) received both vaccines and 240 women (29.2%) received not vaccine at all (Fig. 3).



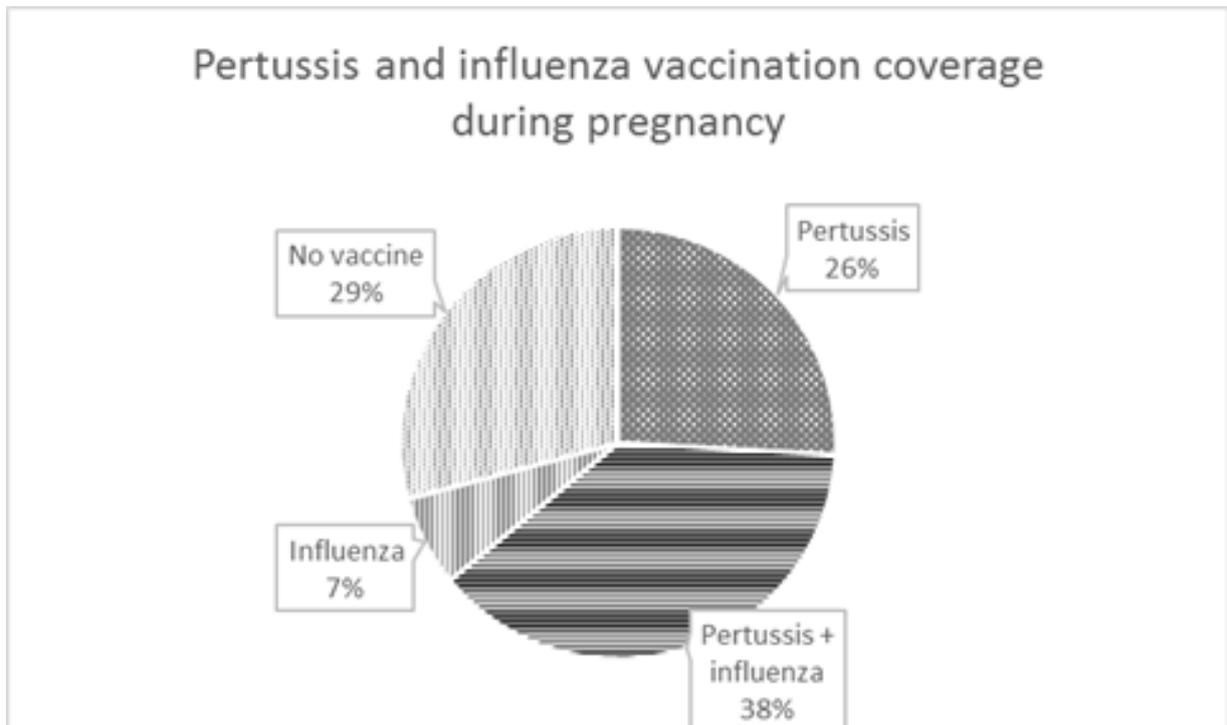
**Figure 1:** Main recommenders and vaccinators of the maternal vaccination strategies



**Figure 2A:** Pertussis vaccination coverage and trimester of vaccination by month of delivery



**Figure 2B:** Influenza vaccination coverage and trimester of vaccination by month of delivery



**Figure 3:** Coverage pertussis and influenza vaccination during pregnancy

### **Influencing factors on uptake of maternal pertussis and influenza vaccination**

The multiple logistic regression model indicated a significant influence of maternal level of education ( $p<0.001$ ), maternal work situation ( $p<0.001$ ) and parity ( $p=0.005$ ) on the maternal pertussis vaccination status. A higher level of education and full time employment was associated with a higher pertussis vaccination coverage. Primiparous women were significantly better vaccinated than multiparous women.

In this multiple logistic regression model for influenza vaccination during pregnancy, a significant influence of country of birth of the grandparent of the newborn ( $p=0.003$ ) and maternal level of education ( $p<0.001$ ) was found. A significantly higher influenza vaccination coverage was obtained if the grandparent of the newborn were born in Belgium or an EU-country. Again a higher maternal level of education was associated with a higher influenza vaccination coverage.

### **Uptake of the cocoon strategy in partners**

815 women reported to have a partner and 510 partners (62.6%) were vaccinated with a pertussis containing vaccine during the last 10 years. From these 510 vaccinated partners, 372 partners (72.9%) were vaccinated during the current pregnancy.

### **Awareness and recommending attitude of HCWs towards the maternal vaccination strategies and the cocoon strategy**

In total, 86.2% of all surveyed HCWs were aware of the current NITAG recommendation on pertussis vaccination during pregnancy. 70.1% of all HCWs inform pregnant women on pertussis vaccination during pregnancy; 75.1% recommends maternal pertussis vaccination, whereas 72.0% recommends maternal influenza vaccination. The cocoon strategy is recommended by 64.4% of the HCWs.

In general, gynecologists and GPs are better aware of the current recommendation for pertussis vaccination compared to midwives. Both groups of HCWs are more likely to inform and recommend the maternal vaccination strategies and the cocoon strategy compared to midwives (Table 2).

		<u>In-hospital HCWs</u>		<u>GPs</u>	<u>Total</u>
		<u>(N=103)</u>		<u>(N=158)</u>	<u>(N=261)</u>
		<u>Gynecologists</u>	<u>Midwives</u>		
		<u>(N=27)</u>	<u>(N=76)</u>		
Aware of recommendation pertussis vaccination during pregnancy, No. (%)	Yes	27 (100)	53 (69.7)	145 (91.8)	225 (86.2)
	No	0 (0)	23 (30.3)	13 (8.2)	36 (13.8)
Inform pregnant women on pertussis vaccination during pregnancy, No. (%)	Yes	27 (100)	30 (39.5)	126 (79.7)	183 (70.1)
	Sometimes	0 (0)	17 (22.4)	13 (8.2)	30 (11.5)
	No	0 (0)	29 (38.2)	19 (12.0)	48 (18.4)
Recommend pertussis vaccination during pregnancy, No. (%)	Yes	27 (100)	32 (42.1)	137 (86.7)	196 (75.1)
	Sometimes	0 (0)	9 (11.8)	7 (4.4)	16 (6.1)
	No	0 (0)	35 (46.1)	14 (8.9)	49 (18.8)
Recommend cocoon strategy, No. (%)	Yes	24 (88.9)	21 (27.6)	123 (77.8)	168 (64.4)
	Sometimes	1 (3.7)	4 (5.3)	8 (5.1)	13 (5.0)
	No	2 (7.4)	51 (67.1)	27 (17.1)	80 (30.7)
Recommend influenza vaccination during pregnancy, No. (%)	Yes	20 (74.1)	35 (46.1)	133 (84.2)	188 (72.0)
	Sometimes	6 (22.2)	10 (13.2)	13 (8.2)	29 (11.1)
	No	1 (3.7)	31 (40.8)	12 (7.6)	44 (16.9)

**Table 2:** Attitude of HCWs towards maternal vaccination and cocoon vaccination

## Influencing factors on the attitude of HCWs towards maternal immunization and cocoon vaccination

Older age of in-hospital HCWs relates positively to recommending pertussis ( $p < 0.001$ ) and influenza ( $p = 0.034$ ) vaccination during pregnancy, yet this is not true for the cocoon strategy ( $p = 0.089$ ). For the GPs on the other hand, younger age relates to increased likelihood of recommending influenza vaccination ( $p = 0.024$ ). In general, HCWs who recommend pertussis vaccination during pregnancy are more likely to also recommend influenza vaccination during pregnancy and vice versa.

## Pertussis vaccination status of HCWs

Overall, 70.1% of all HCWs were vaccinated with a pertussis containing vaccine during the previous 10 years. For the in-hospital HCWs, 63.0% of the gynecologists and 80.3% of the midwives were vaccinated with a Tdap vaccine during the last 10 years. 65.8% of the GPs were up to date with their pertussis vaccination status. No association between the pertussis vaccination status of HCWs and their recommending attitude was found.

## Discussion

The present study reveals a relatively high coverage of pertussis (64.0%) and influenza (45.0%) vaccination during pregnancy and of the cocoon strategy (62.6% of partners of pregnant women) in Flanders, Belgium. The main recommenders and administrators of maternal vaccination as well as the main reasons for women not to get vaccinated, were identified. Underserved populations of pregnant women for these recommendations are women with a migration background (non EU-country), lower maternal educational level and employment status. The attitude of gynecologists and GPs towards maternal pertussis and influenza vaccination and the cocoon strategy, is overall positive; 78.4% of gynecologists and GPs recommends both maternal pertussis and influenza vaccination and 67.0% recommends both maternal vaccination strategies and the cocoon strategy. In contrast, only 23.7% of midwives recommends both maternal pertussis and influenza vaccination and 10.5% recommends both maternal vaccination strategies and the cocoon strategy. This in line with lower trust towards vaccination in the particular group of HCWs, as has been described before [185]. The overall measured pertussis immunization status of HCWs during the last 10 years in Flanders is 70.1%

Compared to the coverage described in a recently conducted monocentric Belgian study by Laenen et al. [186], we report higher coverage for both vaccines. However, in contrast to our study results, higher coverage rates for influenza (42.8%) were described compared to pertussis (39.2%). Most plausible explanations for the discrepancy are that pregnant women were surveyed before delivery and thus, vaccines administered after 32 weeks of pregnancy were not considered in this assessment of the coverage. Moreover, the study was performed before the free availability of Tdap in the Flemish health care facilities. As for influenza vaccines, several countries have observed that

co-payment could be a barrier for the uptake, although this has been assessed in populations at risk other than pregnant women [187, 188]. This observation might also be relevant in Flanders; offering influenza vaccines free of charge might enhance the uptake. However, no literature data are available on comparison of both strategies in pregnant women, and we observe comparable coverage in the UK, where the vaccine is offered free of charge for pregnant women, and Belgium, despite the difference in payment system.

During the last decade, maternal vaccination strategies are becoming more important with an increasing number of countries issuing recommendations on maternal influenza and pertussis vaccination. A study in the United States [189] reported a maternal influenza vaccination coverage of 35.0% during the 2014-2015 influenza season, in the same period as the here presented study. In the United Kingdom, an influenza vaccination uptake during pregnancy of 30.0% was found in the 2014-2015 influenza season [190], which is lower compared to the coverage measured here in Flanders.

Since the recommendation for maternal pertussis vaccination is more recently adopted in a number of countries, only limited studies on the coverage of this strategy are available. In a study in the United States [191], conducted between April 2012 and March 2014, a coverage of 35.0% was found, with increasing coverages from 13.8% in January 2013 to 51.0% in March 2014. A possible explanation for the higher coverage we report, could be the free availability of Tdap in Flemish health care facilities and the support of professional organizations to stimulate maternal immunization. In the United Kingdom, where maternal pertussis vaccination is also free of charge and highly stimulated through information campaigns, a lower maternal pertussis vaccination coverage of 56.4% was reported between April 2014 and March 2015 [192].

The majority of women in our study were vaccinated for pertussis and influenza during the second or third trimester of gestation (according to the recommendations), a time point that is considered to be biologically optimal to maximize the placental transport of maternal antibodies from mother to infant [193]. In Flanders, main recommenders for maternal vaccination were the gynecologist whereas the GPs were the main vaccinators. Antenatal care is mainly performed by gynecologists in Belgium, although shared care with GPs is gaining more interest. In contrast to prenatal care, vaccination is historically not one of the tasks for gynecologists, but fits neatly within the GP consultation, explaining the interaction between both groups of HCWs in informing on vaccination and performing the vaccination.

One of the main reasons not to get vaccinated, was that vaccination was not offered or was even discouraged by a HCW. This finding highlights the concept that provider attitude is the key to achieve high maternal vaccination coverages, as previously demonstrated [194, 195]. In contradiction to the article by Wilson et al. where safety is identified as one of the main concerns (41.0%), not many safety issues were reported in the present study for both vaccines (4.78% for pertussis and 5.7% for influenza) [196].

Several underserved populations have been identified. Ethnicity, level of education, work situation and parity have a significant influence on either the pertussis or influenza vaccination coverage. The influence of ethnicity on vaccination coverage in general [197] and among pregnant women [186, 198, 199], has already been shown in previous studies with lower vaccination coverage among ethnic minorities. Identification of reasons for lower coverage, whether to deal with an underserved population or an under informed population and additional campaigns and education of both HCWs and the target group, could enhance the coverage of the vaccination [200]. Other influencing factors as described by Wilson et al. as the social context factors, are confirmed in the present analysis: the maternal educational level and being a second generation immigrant [196]. Also, lower maternal education has been previously associated in Belgium with a lower maternal influenza vaccination coverage [186]. Our present multicenter retrieved results, confirm the findings in the single center evaluation in Belgium, yet Wiley et al. did not identify maternal education as an influencing factor for pertussis vaccine uptake in Australia [201].

For women who were not immunized during pregnancy, low vaccination coverages for maternal cocoon vaccination were counted. This could be a consequence of collecting surveys very soon after delivery (average 2.4 days postpartum), resulting in women not yet having the opportunity to receive the vaccine. Most of these women showed the intention to comply with the cocoon strategy at a later time point.

We report a higher coverage rate (62.2% vaccinated during the last decade) of the partners compared to a Swiss study, whereas only 17.0% of the partners were accurately protected against pertussis [202]. At the moment of conduct, cocooning was the only strategy in place in Switzerland to protect young infants from pertussis. In Australia, however, as a public health response to an ongoing pertussis epidemic, high coverage rates of cocoon strategy were reached: up to 70.0% of the fathers reported vaccination in relation to the birth of their most recent child. Another 10% of the fathers received a pertussis containing vaccine during the last 10 years [203]. HCWs, especially gynecologists, seem to be the most important stakeholders in the recommendations of the maternal vaccination programs and the cocoon strategy. On the other hand, GPs are the main vaccinators within these strategies in Flanders. According to the survey results from HCW, most rather gynecologists and GPs recommend maternal pertussis and influenza vaccination during pregnancy, confirming the high

recommendation percentage found in the survey of the target group. Nonetheless, special attention needs to go to the group of midwives, whose awareness on the current recommendations could be improved. In Flanders, among this occupational group, there is a tendency of vaccine hesitancy when vaccines are administered during pregnancy, mainly due to safety reasons. In the future, further research on this hesitancy is absolutely needed. This survey highlights the need for proper education for all vaccine providers, regardless of their role, because consistent messages from all HCWs are necessary to further improve immunization rates.

This study has several potential limitations. First of all, we only included hospitals with a relatively high number of deliveries. Therefore, the results of this study may not be completely generalizable to the entire population in Flanders. Consequently, the Flemish maternal pertussis and influenza vaccination coverage in women delivering at home (only 0.8% of total number of deliveries in Flanders in 2013) or in smaller maternity wards remains unknown. A planned vaccination coverage study among a sample of infants in Flanders in 2016, will include a survey of the parents and could shed light on this gap in the data. Secondly, the maternal pertussis and influenza vaccination status is self-reported and can therefore be subject to erroneous recall resulting in an over- or underestimation of the vaccination coverage in pregnant women. However, since recall is limited to the last 9 months and no other vaccines (e.g. tetanus) are administered during pregnancy in Belgium, the bias is less presumable. A third potential limitation is that most surveys of GPs were collected at congresses or training sessions. It could be that the public attending these sessions is not representable for the general population of GPs in Flanders, resulting in a possible selection bias because of over-representation of vaccinators. However, the high percentage of GPs vaccinating pregnant women, as was reported by the target group itself is an argument that GPs in general are aware of the recommendation and do vaccinate during pregnancy.

Surveys were collected in many different languages (Dutch, French, English, Arabic) to maximize the response rate. Nevertheless, we were still not able to survey all women, mainly due to language problems. The migration background might be a relevant influencing factor on vaccine uptake.

A few strengths of this study include the study design, which is a randomized, multicenter study, in comparison with the Laenen et al. study [186]. Also the surveys from HCWs were collected anonymously thereby allowing HCWs to freely express their opinions.

## Conclusion

The overall positive attitude of HCW towards maternal immunization is reflected by a relatively high vaccination coverage. However, there is still room of improvement by targeting underserved populations of pregnant women and improve both the awareness and attitude of midwives on the current recommendations.

## Acknowledgments

The authors would like to thank all participating women and health care workers. We would also like to thank all participating hospitals for the fruitful collaboration within this study. The assistance of Dr. Tinne Lernout (Scientific Institute of Public Health, Brussels, Belgium) in the start-up of the study and Ms. Lieve Van Dyck (University of Antwerp, Antwerp, Belgium) and Ms. Channouf Asmae (University of Antwerp, Antwerp Belgium) in conducting the surveys, is gratefully acknowledged.

This work was supported by a grant from the “Agency for Care and Health”. EL is beneficiary of a postdoctoral mandate fellowship from the Fund for Scientific Research-Flanders (FWO 12D6114N).

Authors do not have a commercial or other association that might pose a conflict of interest (e.g. pharmaceutical stock ownership, consultancy, pharmaceutical board membership, relevant patents, or research funding).

## Annex A

### Survey of post-partum women: Pertussis vaccination during pregnancy

Code: .....

Date of testing: ...../...../.....

Not completed due to language problem

<p>1. Age: .....</p> <p>2. Country of birth:</p> <p><input type="checkbox"/> Belgium</p> <p><input type="checkbox"/> EU country</p> <p><input type="checkbox"/> non-EU country</p> <p>3. Parents' country of birth:</p> <p><input type="checkbox"/> Belgium</p> <p><input type="checkbox"/> EU country</p> <p><input type="checkbox"/> non-EU country</p> <p>4. Highest degree completed:</p> <p><input type="checkbox"/> Primary school</p> <p><input type="checkbox"/> Secondary school</p> <p><input type="checkbox"/> Bachelor/University college</p> <p><input type="checkbox"/> Master/University</p> <p><input type="checkbox"/> Other: .....</p>	<p>7. Did your pregnancy proceed normally?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No: .....</p> <p>.....</p> <p>.....</p> <p>8. Weight of child at birth:.....g</p> <p>9. Length of child at birth:.....cm</p> <p>10. Length of pregnancy at birth:.....weeks</p> <p>11. Delivery date: ...../...../.....</p> <p>12. Location of delivery:.....</p> <p>.....</p>
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<p>5. What is your current employment situation?</p> <p><input type="checkbox"/> Full-time</p> <p><input type="checkbox"/> Part-time</p> <p><input type="checkbox"/> Self-employed</p> <p><input type="checkbox"/> Unemployed, with social welfare benefits</p> <p><input type="checkbox"/> Unemployed, with no social welfare benefits</p> <p><input type="checkbox"/> Other: .....</p> <p>.....</p> <p>6. Postal code + place of residence: .....</p>	
<p>13. Were you aware of the recommendation for pertussis vaccination during your pregnancy?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>	<p>13a. <b>If yes</b>, from whom had you received this information?</p> <p><input type="checkbox"/> Gynaecologist</p> <p><input type="checkbox"/> General Practitioner</p> <p><input type="checkbox"/> Midwife</p> <p><input type="checkbox"/> Occupational Physician</p> <p><input type="checkbox"/> Family/friends</p> <p><input type="checkbox"/> Pharmacist</p> <p><input type="checkbox"/> Other:.....</p> <p>.....</p>
<p>14. Were you vaccinated for pertussis during your pregnancy?</p>	<p>14a. <b>If yes</b>, who recommended this vaccination?</p>

Yes

No

Gynaecologist

General Practitioner

Midwife

Occupational Physician

Other:.....

14b. **If yes**, who administered this vaccination?

Gynaecologist

General Practitioner

Midwife

Occupational Physician

Other:.....

14c. **If no**, why were you not vaccinated?

Afraid of the injection

Practitioner advised against it

Family/friends advised against it

Afraid of side-effects

Vaccination was not offered to me

Forgot

Spiritual convictions

Other: .....

15. If you were vaccinated for pertussis during your pregnancy: **when** during your pregnancy were you vaccinated for pertussis?

During the first three months of the pregnancy

Between the third and sixth months of the pregnancy

During the last three months of the pregnancy

Date: ...../...../.....

16. Were you vaccinated during a previous pregnancy?

Yes

No

Not applicable

16a. **If yes**, for what were you vaccinated?

Pertussis

Flu

Both

Other:.....

.....

17. If you were not vaccinated during the pregnancy, were you vaccinated for pertussis after delivery?

Yes

No

17a. **If yes**, who recommended this vaccination?

Gynaecologist

General Practitioner

Midwife

Occupational Physician

Other:.....

.....

17b. **If yes**, who administered this vaccination?

Gynaecologist

General Practitioner

	<input type="checkbox"/> Midwife <input type="checkbox"/> Occupational Physician <input type="checkbox"/> Other:..... ..... <b>17c. If no, why were you not vaccinated?</b> <input type="checkbox"/> Afraid of the injection <input type="checkbox"/> Practitioner advised against it <input type="checkbox"/> Family/friends advised against it <input type="checkbox"/> Afraid of side-effects <input type="checkbox"/> Vaccination was not offered to me <input type="checkbox"/> Forgot <input type="checkbox"/> Spiritual convictions <input type="checkbox"/> Other: ..... ..... .....
<p><b>18. If you were not vaccinated for pertussis after delivery, are you planning to be vaccinated?</b></p> <input type="checkbox"/> Yes <input type="checkbox"/> No	<p><b>18a. If yes, when are you planning to be vaccinated?</b></p> <input type="checkbox"/> This week <input type="checkbox"/> This month <input type="checkbox"/> Don't know <p><b>18b. If no, why not?</b></p> <input type="checkbox"/> Afraid of the injection <input type="checkbox"/> Practitioner advised against it <input type="checkbox"/> Family/friends advised against it

	<input type="checkbox"/> Afraid of side-effects <input type="checkbox"/> Vaccination was not offered to me <input type="checkbox"/> Forgot <input type="checkbox"/> Spiritual convictions <input type="checkbox"/> Other: ..... ..... .....
<p>19. Was your partner vaccinated for pertussis during the pregnancy or after the delivery?</p> <input type="checkbox"/> Yes <input type="checkbox"/> No	<p>19a. Who recommended this?</p> <input type="checkbox"/> Gynaecologist <input type="checkbox"/> General Practitioner <input type="checkbox"/> Midwife <input type="checkbox"/> Occupational Physician <input type="checkbox"/> Other:..... ..... <p>19b. <b>If yes</b>, who administered this vaccination?</p> <input type="checkbox"/> Gynaecologist <input type="checkbox"/> General Practitioner <input type="checkbox"/> Midwife <input type="checkbox"/> Occupational Physician <input type="checkbox"/> Other:..... ..... <p>19c. <b>If no</b>, is your partner planning to be vaccinated?</p> <input type="checkbox"/> Yes <input type="checkbox"/> No <p>19d. <b>If no</b>, why was he not vaccinated?</p> <input type="checkbox"/> Afraid of the injection

	<input type="checkbox"/> Practitioner advised against it <input type="checkbox"/> Family/friends advised against it <input type="checkbox"/> Afraid of side-effects <input type="checkbox"/> Vaccination was not offered to him <input type="checkbox"/> Forgot <input type="checkbox"/> Spiritual convictions <input type="checkbox"/> Other: ..... ..... .....
<p>20. Were you vaccinated for flu during this pregnancy?</p> <input type="checkbox"/> Yes <input type="checkbox"/> No	<p>20a. <b>If yes</b>, who recommended this vaccination?</p> <input type="checkbox"/> Gynaecologist <input type="checkbox"/> General Practitioner <input type="checkbox"/> Midwife <input type="checkbox"/> Occupational Physician <input type="checkbox"/> Other:..... ..... <p>20b. <b>If yes</b>, who administered this vaccination?</p> <input type="checkbox"/> Gynaecologist <input type="checkbox"/> General Practitioner <input type="checkbox"/> Midwife <input type="checkbox"/> Occupational Physician

	<input type="checkbox"/> Other:..... ..... 20c. <b>If no</b> , why were you not vaccinated? <input type="checkbox"/> Afraid of the injection <input type="checkbox"/> Practitioner advised against it <input type="checkbox"/> Family/friends advised against it <input type="checkbox"/> Afraid of side-effects <input type="checkbox"/> Vaccination was not offered to me <input type="checkbox"/> Forgot <input type="checkbox"/> Spiritual convictions <input type="checkbox"/> Other: ..... ..... .....
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16. If you were vaccinated for influenza during your pregnancy: when during the pregnancy were you vaccinated for influenza?

During the first three months of the pregnancy

Between the third and sixth months of the pregnancy

During the last three months of the pregnancy

Date: ...../...../.....

Do you have any comments about vaccination during pregnancy?

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Contact: Kirsten Maertens , [kirsten.maertens@uantwerpen.be](mailto:kirsten.maertens@uantwerpen.be) +3232652885  
Dr Elke Leuridan, [elke.leuridan@uantwerpen.be](mailto:elke.leuridan@uantwerpen.be)

## Annex B

### Survey of health-care providers: Pertussis vaccination during pregnancy

Code: .....

Date of testing: ...../...../.....

Not completed due to language problem

Dear participant,

The Superior Health Council of Belgium has issued a new recommendation regarding pertussis vaccination during pregnancy. We at the Centre for the Evaluation of Vaccinations at the University of Antwerp are conducting a survey of health-care providers in order to study the follow-up to this recommendation.

We would like to ask you to take a moment of your time to answer the following brief questions.

<p>1. Sex:</p> <p><input type="checkbox"/> Male</p> <p><input type="checkbox"/> Female</p> <p>2. How old are you? .....</p> <p>3. In which province do you work primarily? .....</p>	<p>4. What is your training?</p> <p><input type="checkbox"/> Gynaecologist</p> <p><input type="checkbox"/> General Practitioner</p> <p><input type="checkbox"/> Midwife</p> <p><input type="checkbox"/> Other: .....</p>
<p>5. Are you aware of the new recommendation of the Superior Health Council of Belgium regarding pertussis vaccination during pregnancy?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>	<p>5a. <b>If yes</b>, from whom/in what way did you receive information about it? .....</p>
<p>6. Are you aware of the new recommendation of the Flemish Association for Obstetrics and Gynaecology (VVOG) regarding pertussis</p>	<p>6a. <b>If yes</b>, from whom/in what way did you receive information about it?</p>

<p>vaccination during pregnancy?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p>	<p>.....</p>
<p>7. Do you systematically inform pregnant women about the existence of the recommendation for pertussis vaccination during pregnancy?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p><input type="checkbox"/> Sometimes</p>	<p>7a. <b>If no</b>, why not?</p> <p><input type="checkbox"/> Not informed</p> <p><input type="checkbox"/> No time during the consultation</p> <p><input type="checkbox"/> Disagree with recommendation: why?.....</p> <p><input type="checkbox"/> Other: .....</p> <p>7b. <b>If sometimes</b>, why sometimes?</p> <p><input type="checkbox"/> No time during the consultation</p> <p><input type="checkbox"/> Disagree with recommendation: why?.....</p> <p><input type="checkbox"/> Other: .....</p>
<p>8. Do you systematically advise pregnant women to be vaccinated for pertussis during pregnancy?</p> <p><input type="checkbox"/> Yes</p> <p><input type="checkbox"/> No</p> <p><input type="checkbox"/> Sometimes</p>	<p>8a. <b>If no</b>, why not?</p> <p><input type="checkbox"/> Not informed</p> <p><input type="checkbox"/> No time during the consultation</p> <p><input type="checkbox"/> Disagree with recommendation: why?.....</p> <p><input type="checkbox"/> Other: .....</p> <p>8b. <b>If sometimes</b>, why sometimes?</p> <p><input type="checkbox"/> No time during the consultation</p> <p><input type="checkbox"/> Disagree with recommendation: why?.....</p> <p><input type="checkbox"/> Other: .....</p>
<p>9. Do you systematically recommend the cocoon strategy?</p> <p><input type="checkbox"/> Yes</p>	<p>9a. <b>If no</b>, why not?</p> <p><input type="checkbox"/> Not informed</p>

<input type="checkbox"/> No  <input type="checkbox"/> Sometimes	<input type="checkbox"/> No time during the consultation  <input type="checkbox"/> Disagree with recommendation: why?.....  <input type="checkbox"/> I systematically vaccinate women during pregnancy.  <input type="checkbox"/> Other: .....  <b>9b. If sometimes, why sometimes?</b>  <input type="checkbox"/> No time during the consultation  <input type="checkbox"/> Disagree with recommendation: why?.....  <input type="checkbox"/> Other: .....
<p>10. Do you systematically advise pregnant women to be vaccinated for influenza during pregnancy?</p> <input type="checkbox"/> Yes  <input type="checkbox"/> No  <input type="checkbox"/> Sometimes	<p>10a. <b>If no</b>, why not?</p> <input type="checkbox"/> Not informed  <input type="checkbox"/> No time during the consultation  <input type="checkbox"/> Disagree with recommendation: why?.....  <input type="checkbox"/> Other: .....  <p>10b. <b>If sometimes</b>, why sometimes?</p> <input type="checkbox"/> No time during the consultation  <input type="checkbox"/> I vaccinate only high-risk groups  <input type="checkbox"/> Disagree with recommendation: why?.....  <input type="checkbox"/> Other: .....
<p>11. Have you been vaccinated for pertussis in the last 10 years?</p> <input type="checkbox"/> Yes  <input type="checkbox"/> No	<p>11b. <b>If yes</b>, date of last pertussis vaccination:.....</p>

Do you have any comments about vaccination during pregnancy?

.....  
.....  
.....  
.....  
.....

Thank you for you cooperation. The results of this survey will be available in an anonymised form on the CEV website: [www.uantwerpen.be/cev](http://www.uantwerpen.be/cev) .

Contact: Kirsten Maertens , [kirsten.maertens@uantwerpen.be](mailto:kirsten.maertens@uantwerpen.be) +32 3 2652885  
Dr Elke Leuridan, [elke.leuridan@uantwerpen.be](mailto:elke.leuridan@uantwerpen.be)

