

## CLINICAL STUDY

# Monitoring the vaccination of pregnant women against pertussis – single-centre one-year study in the Czech Republic

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**ABSTRACT**

**OBJECTIVES:** This observational study aimed to analyse data from big maternity hospital, determine the vaccination coverage and provide source information for further activities.

**BACKGROUND:** Although vaccination of pregnant women against pertussis is recommended in the Czech Republic, data on vaccination coverage are not available.

**METHODS:** The self-completed questionnaire was distributed to 5,475 pregnant women in the maternity hospital between 2020 and 2021. Questionnaires collected mother's sociodemographic characteristics, pertussis vaccination status and sources of recommendations for vaccinations during pregnancy.

**RESULTS:** A total of 4,617 completed questionnaires were analysed. Pertussis vaccination coverage during pregnancy was 1.6 % (95% confidence interval, 1.3–2.0 %). Only 12.5 % of women knew about the possibility of being vaccinated against pertussis during pregnancy. Women considered pertussis vaccination in pregnancy as important (12.9 %), useful (49.1 %) and useless (24.0 %). Of 579 pregnant women who had information about pertussis vaccination during pregnancy, only 12.1 % were vaccinated, while among those who did not have this information, 0.1% were vaccinated during pregnancy ( $p < 0.001$ ). The most frequent source of information was Internet, then a general practitioner.

**CONCLUSION:** It is necessary to raise awareness of such recommendations for pregnancy vaccination among public and professionals, to emphasize the benefits of such vaccination in order to increase the vaccination coverage (Tab. 3, Ref. 31). Text in PDF [www.elis.sk](http://www.elis.sk)

**KEY WORDS:** pertussis, whooping cough, pregnancy, vaccination, health knowledge, prevention.

**Introduction**

Pertussis (whooping cough) is an important cause of morbidity and mortality in infants worldwide, and continues to be a public health concern despite high vaccination coverage. The disease, caused by *Bordetella pertussis*, is endemic in all countries. Epidemic cycles have been occurring every 2 to 5 years, even after the introduction of effective vaccination programmes and the

achievement of high vaccination coverage (1, 2). Severe pertussis disease and death in countries with well-established pertussis vaccine programmes are almost entirely limited to the first weeks and months of life (1, 2).

A number of countries have official maternal Tdap (tetanus-reduced-antigen-content-diphtheria-acellular pertussis vaccine) immunization recommendations during pregnancy or Tdap-IPV (Tdap-inactivated poliovirus vaccine) recommendation, which is in place in the United Kingdom (UK) (3, 4).

Recent evidence consistently indicates that maternal immunization with aP-containing vaccine during the third trimester of pregnancy is safe (1, 5). Experience with vaccination of pregnant women in UK indicates high impact on infant pertussis-related mortality (1, 6). A 2014 systematic review in several high income countries showed that vaccination of pregnant women was the most cost-effective strategy for preventing disease in infants too young to be vaccinated and more effective than cocooning (1, 7). Currently, maternal immunization is considered as the most effective and favourable option to supplement infant vaccination to combat pertussis disease in young infants (1, 3).

The main purpose of giving the pertussis vaccine in pregnancy is to protect the smallest children by enhancing the transfer of maternal specific antibodies to the foetus through placenta and breast

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Tab. 1. Patient survey questions regarding pertussis vaccination in pregnancy.

1.	<b>What is the highest level of education you have completed?</b> <input type="checkbox"/> Primary <input type="checkbox"/> Secondary <input type="checkbox"/> University
2.	<b>How many children have you got?</b>
3.	<b>In your opinion, pertussis vaccine in pregnancy (please tick one option):</b> <input type="checkbox"/> should be prohibited <input type="checkbox"/> is useless <input type="checkbox"/> is useful <input type="checkbox"/> is important
4.	<b>Have you received pertussis vaccine in childhood?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> I don't know
5.	<b>Have you received pertussis vaccine in adulthood?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No <input type="checkbox"/> I don't know
➤	<b>5a. If so, please indicate the date (at least approximate)</b>
6.	<b>Have you received pertussis vaccine in pregnancy?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No
➤	<b>6a. If so, please indicate the week of pregnancy and date</b>
7.	<b>Were you aware of the possibility to get vaccinated against pertussis in pregnancy?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No
➤	<b>7a. If so, please indicate who you got the information from.</b> You are allowed to tick multiple options: <input type="checkbox"/> gynaecologist <input type="checkbox"/> general practitioner <input type="checkbox"/> friend <input type="checkbox"/> family <input type="checkbox"/> media <input type="checkbox"/> internet <input type="checkbox"/> other

milk. Most women of childbearing age have received a pertussis vaccine in their childhood, but neither vaccine nor post-infection immunity provides lifetime or at least long term protection (8). By giving the vaccine in pregnancy, higher levels of specific antibodies in breast milk are reaching in comparison with maternal vaccination after delivery. Another purpose of vaccination in pregnancy is to induce protection in mothers, thus reducing the risk of infection transmission to unvaccinated neonates and infants. No increase in post-vaccination adverse reactions has been reported in either mothers or the foetus in the third trimester of pregnancy, during the delivery or in new-borns (8).

Prompted by a rise in the reported number of pertussis cases leading to several infant deaths, the United States of America (USA) and UK were the first countries to recommend the administration of pertussis-containing vaccines during pregnancy (from 2011 and 2012, respectively) (3, 9, 10).

Although vaccination of pregnant women against pertussis in the Czech Republic (CZ) has been recommended since 2015 by the National Immunization Committee with an update in June 2021 (8), data on vaccination coverage in pregnant women are not available. Vaccination of pregnant women in CZ is recommended with a single dose of combined Tdap vaccine during pregnancy. The best timing of vaccination is from the 27th gestational week. Vaccination is recommended at every pregnancy. Women who have not been vaccinated against pertussis during pregnancy are recommended to receive a single dose of Tdap vaccine immediately after delivery. Pertussis vaccination is also safe for breast-feeding women (8).

In CZ, vaccination against pertussis in pregnancy is recommended only, the vaccine and administration are not covered by health insurance and must be paid by the vaccinated person.

The main goal of the project was to analyse the information obtained from questionnaires regarding the vaccination of pregnant women against pertussis, as a vaccination registry was not available in CZ.

Our aim was to use source data for activities addressed to professionals and public, e.g., emphasizing the benefits of this vaccination and including maternal pertussis vaccination in routine prenatal practice.

## Methods

We performed a prospective observational hospital-based study in the maternity ward of the Institute for Mother and Child Care (UPMD in Czech language) in Prague.

Potential participants were informed about the aim and course of the study through informed consent. If they agreed to participate in the study, they were asked to sign an informed consent and fill out a questionnaire. Health care workers provided both documents to potential participants in the survey in UPMD. The questionnaire was distributed to pregnant women in prenatal outpatient care, upon admission for given birth or before leaving UPMD. All participants were asked to complete the questionnaire regarding their experiences and history of vaccination against pertussis from 1st September 2020 to 31st August 2021.

The questionnaire (Tab. 1) and informed consent were available in Czech or English language to include as many patients as possible. All participants were Czech residents or foreigners living in CZ and giving birth in UPMD.

All available self-completed paper-based questionnaires were transferred to National Institute of Public Health for data entry and analysis. Data analysis concerns answers from all completed questionnaires. The patient survey contained questions on demographics (date of birth, education, number of children) and vaccination-related questions. To assess the knowledge of pregnant women regarding pertussis, they were asked if they were aware of information to be vaccinated during pregnancy. In case they were aware, their information source was asked for.

Collected data were analysed anonymously. The results are presented as proportions and percentages of respondents to individual

questions, excluding nonresponses from the denominators. Mean or median were estimated for continuous variables. Fisher's exact test was performed to analyse the associations between categorical variables. Estimate of pertussis vaccine uptake was calculated with 95% confidence interval. Findings were reported as significant at  $p < 0.05$ .

Statistical analyses were performed in STATA version 17 (StataCorp LLC, College Station, Texas, USA).

## Results

Of the 5,475 women who gave birth during the one-year study period, 4,617 (84 %) completed the questionnaire and were included in the analysis. The participants were mainly from Prague and the surrounding area, but the place of residence was not part of the survey.

The median age of study participants ( $n = 4,592$ ) at the end of the study was 33 years (range: 18–51 years, IQR 6); the most represented was age group 30–34 years (42%) (Tab. 2). The most of participants completed university education (69.7 %) and roughly, 60 % were childless before the start of the study (Tab. 2).

As can be seen from Table 3, self-reported pertussis vaccination coverage during pregnancy was only 1.6 % (95% confidence interval, 1.3–2.0 %). Half of the study participants believed vaccination against pertussis during pregnancy is useful and only 13% of the women were convinced of the importance of vaccination. Two thirds of participants were not vaccinated against pertussis in adulthood. Of the 300 women who were vaccinated against pertussis in adulthood, 272 reported the date of vaccination (between years 2000–2021) and 28 did not remember or did not report this information.

Of the 75 women who were vaccinated against pertussis in pregnancy, 63 reported the date of vaccination (between years 2016–2021) and 12 women did not remember or did not report this date. Only 48 of the 75 women filled in the week of pregnancy when they got vaccination against pertussis and 27 women did not remember or did not report this detail.

Only about 13 % of all participants ( $N=579$ ) were aware of the possibility to be vaccinated against pertussis in pregnancy (Tab. 3). The most frequent source of information about pertussis vaccination in pregnancy was the Internet, followed by a general practitioner (GP). When we counted GP and gynaecologist as a one category, they represented roughly a one third of responses received.

Of 579 pregnant women who had information about pertussis vaccination during pregnancy, only 12.1 % (70/579) were vac-

inated, while among those who did not have this information, only 0.1 % (5/4,038) were vaccinated during pregnancy (Fisher's exact test,  $p < 0.001$ ). Among women who reported being vaccinated against pertussis in childhood, 2.9 % (60/2,063) were vaccinated

**Tab. 2. Demographic characteristics of surveyed pregnant women in the Czech Republic.**

n = total number of completed surveys	Number of pregnant women	Percent of pregnant women (%)
Age in years ( $n=4,592$ )		
18–24	147	3.2
25–29	941	20.5
30–34	1,919	41.8
35–39	1,248	27.2
40–44	308	6.7
45–51	29	0.6
Education level ( $n=4,617$ )		
University education	3,218	69.7
Secondary school	1,316	28.5
Primary school	83	1.8
Number of children ( $n=4,617$ )		
0	2,702	58.5
1	1,500	32.5
2	353	7.7
3	49	1.0
4	9	0.2
5	4	0.1

**Tab. 3. Pertussis vaccination characteristics of surveyed pregnant women in the Czech Republic.**

n = total number of completed surveys	Number of pregnant women	Percent of pregnant women (%)
<b>In your opinion, pertussis vaccine in pregnancy (<math>n=4,617</math>)</b>		
is important	595	12.9
is useful	2,268	49.1
is useless	1,110	24.0
should be prohibited	179	3.9
I do not know	465	10.1
<b>Have you received pertussis vaccine in childhood? (<math>n=4,617</math>)</b>		
Yes	2,063	44.7
No	380	8.2
I do not know	2,174	47.1
<b>Have you received pertussis vaccine in adulthood? (<math>n=4,617</math>)</b>		
Yes	300	6.5
No	3,441	74.5
I do not know	876	19.0
<b>Have you received pertussis vaccine in pregnancy? (<math>n=4,617</math>)</b>		
Yes	75	1.6
No	4,542	98.4
<b>Were you aware of the possibility to get vaccinated against pertussis in pregnancy? (<math>n=4,617</math>)</b>		
Yes	579	12.5
No	4,038	87.5
<b>Source of information regarding vaccination against pertussis during pregnancy (<math>n=579</math>)</b>		
*Multiple answers were allowed in this question, so the total exceeds 100%.		
Internet	173	29.9
general practitioner	138	23.8
gynaecologist	77	13.3
friend	54	9.3
family	42	7.3
media	37	6.4
other	116	20.0

against pertussis during pregnancy, compared to only 0.6 % among others (Fisher's exact test,  $p < 0.001$ ).

## Discussion

To the best of our knowledge, this study was the first single centre survey analysing pertussis maternal vaccination uptake among pregnant women in CZ.

UPMD is one of the largest maternity hospitals in CZ, in 2021 there were 5,598 births, 5,761 children, 159 twins and 1 triplet were born; in 2020, there were 5,164 births, with 5,330 children and 166 twins (11).

A total number of 111.8 thousand children were born alive during the year 2021, by 1.6 thousand more than in 2020 in CZ (12). Therefore, our study represents a group of 5.2 % of all children born in CZ.

The average age of mothers at birth in CZ in 2020 was 30 years (13), which was 3 years less than we found in our study. The peak of fertility also shifted over time to an older age of 30–34 years (13), which corresponds to the age distribution of our study participants. In the period between 2011 and 2018, total fertility increased from 1.4 children per woman to 1.7 children (13).

Women before the start of the study were childless or had one child, which is considerably different with the 2021 Census results organized in CZ every ten years. Among the 4.4 million women aged 15 years and over with a known number of children born alive, 1.9 million women had two children and accounted for 43.2 % of the total; the number of women without children was almost 1.0 million (22.5 %), the third highest number of women with one child born alive was over 0.8 million (18.6 %). The average number of children born alive per woman aged 15 years and over with a known number of children was 1.57 (14).

University education was highly overrepresented in our study cohort (69.7 %), while the proportion of the population with university education was 18.7 % based on the 2021 Census (14). In the 2021 Census, 53.1 % of the population aged 15 years and older whose educational attainment was recorded had at least a secondary education or higher. Prague stood out significantly with the highest share of people with university education (35.9 %) and also had an above-average share of inhabitants with secondary education (37.3 %) (14). Pregnant women with a lower education and those with a foreign origin were more vulnerable for non-vaccination in Belgium study (15). Therefore, we can speculate that the total vaccine coverage rate among pregnant women in the Czech Republic is most probably even lower.

Our study showed that almost half of the women did not know if they had been vaccinated against pertussis in childhood. It was a significant difference in comparison with results of Psarris et al. who reported that the majority of women (92.9 %) were immunized during childhood according to Greek national immunization guidelines (16). Vaccination against pertussis in childhood is mandatory in CZ since 1958 and therefore most of mothers can be assumed to have been vaccinated against pertussis in childhood.

Vaccination programs for pregnant women are in place in 28 (of 42) European countries for pertussis (17). Where recommenda-

tions are in place, information on vaccine coverage is not always available or varies widely, ranging, for example, from 53.5 % in 2020–2021 to 44.0 % in 2021–2022 in USA and 93.7 % in the Bizkaia province of Spain (18–20). However, even though pertussis vaccine has been recommended for pregnant women since 2015 in CZ, the coverage remains significantly below rates reported by other countries like Italy (61 %) (21), UK and Spain with figures of 73 % and 80 %, respectively, in 2018 (3, 19) and USA (54 % in 2018) (22). The lowest value 0% pertussis vaccination rate among pregnant women was reported in Greek study performed in 2018 evaluating routine immunization during pregnancy, physicians' compliance and patient hesitancy (16).

Based on Belgian study, the most important reasons for non-vaccination were the absence of a recommendation by medical staff (9.6 %) and delay in vaccination (8.4 %) (15). The GP was the most important vaccinator (15).

Our study demonstrates that the role of HCWs was not an essential source of information for the pregnant women. Inversely, the most frequent (almost one third) source of information was internet, which is not in line with studies published on this topic (15, 23, 24).

More than half (65.5 %) of Greek study participants responded that they would have been vaccinated during pregnancy if their physician had recommended it, but in 73.6% of cases, their physician did not do so (16). In few cases women in our study mentioned in the questionnaire, the physician recommended not to vaccinate in pregnancy.

The work of Czech authors Macounová et al, which included a questionnaire survey with 369 respondents, did not show a better awareness of pertussis prevention among pregnant women and mothers of children under 1 year (25). Only less than 12 % of respondents showed sufficient knowledge of pertussis prevention ( $\geq 50\%$  correctness of answers) (25). Work or study in health care was the only statistically significant factor for better knowledge (25).

The total of 93 % respondents knew that pertussis is preventable by vaccination (25). When Czech authors asked whether it is possible to vaccinate pregnant women against pertussis, there was a strikingly high proportion of respondents choosing the answer "no, during pregnancy is vaccination dangerous" for all groups – for health professionals and pregnant women and mothers, 36 % each (25). On the contrary, the largest part of pregnant women and mothers (59 %) chose the correct answer that vaccination against pertussis is recommended for pregnant women, ideally in the 3<sup>rd</sup> trimester, while health professionals (23 %) did not demonstrate the assumption of knowledge of the issue (25). The questionnaire contained a question from where the respondents obtain information about the vaccination, where the option from a physician was the second most common answer (after the internet), but the overall results of the questionnaire survey did not demonstrate public awareness (25).

Given the low knowledge of public, especially pregnant women and mothers of children under 1 year of age about the importance of pertussis vaccination during pregnancy, it would be appropriate to focus on spreading awareness, in which primary care physicians should be involved (25).

An increasing number of countries have issued recommendations for the use of pertussis vaccines during pregnancy and are offering these vaccines free of charge. However, even in such countries, despite the demonstrated effectiveness and strong safety profile of maternal pertussis vaccination, vaccine uptake has remained suboptimal (3). In CZ, women can get a pertussis vaccine directly from their GP or prenatal HCW (for a fee), or women must obtain a prescription for the vaccine from a physician, purchase the vaccine at a pharmacy and then return to the physician for vaccination. This process could be a significant barrier to vaccine uptake.

As part of its benefits, health insurance companies (HICs) offer their insured persons in CZ reimbursement of vaccinations not covered by public health insurance based on a completed application and proof of payment. A contribution is paid from the prevention fund of HICs, which covers part of the costs of a vaccination of persons against pertussis.

The observation in Belgium study that multiparous women were less likely to be vaccinated (23, 26) could be attributable to a lack of knowledge regarding the benefits of booster vaccines in each pregnancy.

Gynaecologists and other HCWs play a major role in correctly informing pregnant women on preventive interventions (23, 24). We agree with the results of a multi-centre survey study in Italy that receiving a HCW's vaccine advice and the availability of vaccines during prenatal care visits might improve vaccination coverage among pregnant women (21).

The self-reported pertussis vaccine uptake among pregnant women for the 2018–2019 season in Italy was 61 % (294/483) (21) when a previous report during the 2017–2018 season found 4.8 % of maternal pertussis vaccination coverage. The lack of HCW vaccine recommendation was identified as the most important vaccination barrier among pregnant women. The difficulty of access to maternal immunization at prenatal consultations could represent a barrier to achieve optimal vaccination coverage as many vaccination opportunities were missed (21, 27).

In an Irish study 71.8 % of women were recommended pertussis vaccination from their GPs, followed by obstetricians or midwives (14.6 %) or other HCWs in remaining percentages (28). In the same Irish study, the majority of women (69.9 %) reported being aware of the current campaign promoting pertussis vaccine during pregnancy, and the main cited sources of information were health care setting (76.5 %) and poster/leaflets (41.2 %) (28). Based on Ireland results, pregnant women not aware of the current pertussis vaccine campaign were less likely to be vaccinated compared with women aware of the campaign (28). The combination of HCW recommendation and educational materials was significantly predictive of Tdap vaccine acceptance (29).

A 2014 systematic review found that a significant barrier to vaccination was lack of HCW recommendation. The use of educational materials was not examined as a predictor of vaccine uptake in the systematic review (29, 30). The USA study suggests that providers can improve Tdap vaccination acceptance in pregnancy by recommending the vaccination in combination with provision of educational materials on the vaccines (29). In the USA study, although all providers reported recommending the Tdap vaccines

in pregnancy, about 30 % of women did not recall receiving a recommendation (29).

Pregnant women should be informed about all aspects of vaccination (i.e., on disease-associated risks, maternal vaccination costs and recommendations). In Flanders in Belgium, pertussis containing vaccines for adults are available free of charge, 69 % of pregnant women were vaccinated against pertussis in pregnancy in 2016 based on published results (23).

Immunization during pregnancy needs further integration through vaccination campaigns aimed at both HCWs and pregnant women (15).

In our study, most pregnant women did not benefit from protection offered by maternal vaccination despite being aware of possibility to get vaccination during pregnancy. This indicates that hurdles remain in the healthcare system to vaccinate pregnant women and that pregnant women can remain hesitant even if they are informed (23). This information from Belgian study (23) is in line with our study results.

It would be useful to conduct a study in order to assess pertussis vaccination coverage in pregnant women based on data available in a new nationwide electronic vaccination registry launched in CZ in January 2022. Other proposal is to perform a survey whether HCWs provide recommendation for vaccination in pregnancy.

Authors prepared the leaflet for public for pertussis vaccination in pregnancy, which started to be distributed in outpatient department of gynaecologists and GPs in autumn 2022. We believe that routine provision of educational materials (e.g., leaflets) could help to improve the pertussis vaccination rate in pregnancy.

It is necessary to engage more also HCWs and to remind them of information about vaccination in pregnancy not only in yearly held vaccinology congress in CZ, but also to inform them regularly via medical scientific societies.

In addition, the price of the vaccine could be a barrier for low-income groups of pregnant women when a one dose of the vaccine against pertussis administered in pregnancy costs currently around 40–50 EUR in CZ. Therefore, we recommend raising the awareness of pregnant women about the fact that there are contributions from HICs for vaccination.

Our results correspond with Greek study results that it is apparent that the compliance with the immunization guidelines during pregnancy is low (16). Health professionals appear to be reluctant to recommend vaccination during pregnancy (16). Women appear to trust their physicians and usually agree with their recommendations (16). Considering the conclusions of a Greek study it is evident that increasing the rate of vaccination during pregnancy is entirely up to the physicians (16). Hence, it is the responsibility of the HCWs to promote routine immunization during pregnancy (16). The adoption of national guidelines for vaccination during pregnancy in accordance with the recommendations of scientific bodies such as WHO, CDC and others may help encourage physicians to follow the right path and lead to better perinatal outcomes (16).

To help increase uptake, practitioners should recommend maternal pertussis vaccination to their patients during the first prenatal visit (3). They should give information about the effectiveness and

safety of maternal immunization, and about the risk of infection and severity of the respective diseases in the absence of vaccination (3). Ideally, vaccines should be offered on-site during one of the routine prenatal visits, thereby maximizing convenience for the patient (3).

A strength of this study was the high participation rate (84%) and the study was large (4,617 participants) representing roughly 5 % of all deliveries in CZ. Survey forms were available in two languages to maximize the response. Limitations of this study are related to the nature of an observational study. The use of a self-completed questionnaire enabled us to limit the potential for recall bias. Participants were recruited from a large, specialized hospital, which provides health care primarily to patients from Prague; therefore, our study population is not a representative sample for estimation of pertussis vaccination coverage of pregnant women in CZ. Future studies should include a wider geographical area and different levels of hospitals to provide a better overview of the current situation. Vaccination status was reported by the women and therefore we can expect reporting bias, which could not be verified due to no existence of the national vaccination registry.

## Conclusions

Although CZ has recommended pertussis vaccination for all pregnant women since 2015, only 1.6 % of the mothers in our study were vaccinated. The study highlighted the fact that HCW was not a main source of vaccination recommendation. Despite the high number of women included in our study, the fact that immunization of pregnant women against pertussis has been neglected was apparent. The study confirmed the low awareness of pregnant women about the possibility of being vaccinated against pertussis during pregnancy.

Authors recommend providing vaccines and their administration free of charge to all pregnant women interested in vaccination against pertussis in order to increase vaccination coverage.

More research is necessary to explore physicians' compliance and patient hesitancy on this topic and to monitor whether physicians recommend vaccination against pertussis in pregnancy. It is necessary to increase awareness about recommendation on vaccination in pregnancy among public and HCWs, to emphasize the benefits of such vaccination and incorporate vaccination into routine prenatal care.

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